# SESAR 3 Joint Undertaking MAWP

## Multiannual work programme

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### Abstract

This document is the draft Multiannual Work Programme document of the SESAR 3 Joint Undertaking (SESAR 3 JU) for the period from 2021 to 2031.

It contains the components of the work programme and budget allocation principles for the SESAR 3 JU's activities over that period.


**This draft has been developed in view of the third workshop with candidate members of the SESAR 3 JU. It will be further developed and completed, in particular to take account of feedback from the workshop and any additional guidance to be received from the Commission.**

**INTERNAL DOCUMENT**


Founding Members

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and a seamless travel experience. All these changes make for a complex and dense airspace, one that cannot be managed or sustained using the labour-intensive procedures and systems that make up air traffic management today.

At the same time, the COVID-induced hiatus in air travel, which has put at risk an industry essential for Europe's economy and connectivity, has given renewed momentum to efforts to build a more resilient business model and infrastructure for aviation. The health crisis coupled with the climate crisis has also underlined the need to speed up efforts to make aviation more sustainable for the generations to come. Multiple technology pathways are required, one of which is the digital transformation of aviation's infrastructure (Digital European Sky), the benefits of which could already be felt in the shorter term before the energy transition, with its sustainable aviation fuels and new propulsion systems, come into play.

The digital European sky was first proposed by the SESAR Joint Undertaking in 2017 (1), and then formally defined in 2019 in the commonly agreed EU roadmap for ATM modernisation (2). Further support for the digital European sky was provided by the Wise Person's Group, established by the European Commission to provide recommendations on the future of the Single European Sky (3), and a joint declaration by industry (4).

The establishment of the SESAR 3 JU and its vision of a Digital European Sky sees the latest digital technologies ("SESAR Solutions") being leveraged to transform Europe's aviation's infrastructure (air traffic management - ATM), enabling it to handle the future demand and diversity of air traffic safely and efficiently, while minimising its environmental impact. This transformation centres on technologies that can increase the levels of automation, cyber-secure data sharing and connectivity in air traffic management, as well as the virtualisation of its infrastructure and air traffic service provision in all types of airspace, including for very-low and high-altitude operations. In doing so, these technologies enable the system to become more scalable and agile, while building resilience to disruptions, changes in traffic and diversity of air vehicles.

The SESAR 3 JU builds upon the experience of the SESAR Joint Undertaking and continues its coordination role on ATM technology in the Union to further integrate the research and innovation capacity in Europe. The coordination is expected to include development of close collaboration and synergies between the JU's actions and other Union programmes, funding instruments and relevant initiatives at Union, national and regional level, in particular with other European partnerships to achieve greater impact and to ensure the take-up of results.

It is expected that the SESAR 3 JU will contribute to strengthening the competitiveness of Europe's aviation industry (manned and unmanned), facilitating economic recovery and ultimately accelerating the market uptake of innovative solutions to establish European airspace as the most efficient and environmentally friendly sky to fly in the world.

### 1.2.2 Policy context

The SESAR 3 JU supports several important policy initiatives of the European Union. First among them is the Single European Sky (SES)[3], which seeks to reform the European air traffic management (ATM) system with the aim of improving its performance in terms of capacity, safety, efficiency and environmental impact.


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### 1.3.2 Specific objectives

The specific objectives of the SESAR 3 JU are defined in Article 143 of the Basic Act[6] as follows:

a) develop a research and innovation ecosystem covering the entire ATM and U-space airspace[7] value chains allowing to build the Digital European Sky[8] defined in the European ATM Master Plan, enabling the collaboration and coordination needed between air navigation services providers and airspace users to ensure a single harmonised Union ATM system for both manned and unmanned operations;

b) develop and validate ATM solutions supporting high levels of automation;

c) develop and validate the technical architecture[9] of the Digital European Sky;

d) support an accelerated market deployment of innovative solutions through demonstrators;

e) coordinate the prioritisation and planning for the Union's ATM modernisation efforts, based on a consensus-led process among the ATM stakeholders;

f) facilitate the development of standards for the industrialisation of SESAR solutions.

### 1.3.3 Tasks

The tasks of the SESAR 3 JU defined in Article 143 of the Basic Act are the following:

a) coordinate the tasks of the Single European Sky ATM Research (SESAR) definition phase[10], monitor the implementation of the SESAR project and amend, where necessary, the European ATM Master Plan;

b) implement the research and development aspects of the European ATM Master Plan, in particular by:

    (i) organising, coordinating and monitoring the work of the SESAR development phase in accordance with the European ATM Master Plan, including low technology readiness levels (TRL) (0 to 2) research and innovation activities;

    (ii) delivering SESAR solutions, which are deployable outputs of the SESAR development phase introducing new or improved standardised and interoperable operational procedures or technologies;

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6 Council Regulation TBC

7 U-space airspace' means a unmanned airborne system (UAS) geographical zone designated by member states, where UAS operations are only allowed to take place with the support of U-space services provided by an U-space service provider.

8 'Digital European Sky ' refers to vision of the European ATM Master Plan, seeking to transform Europe's aviation infrastructure enabling it to handle the future growth and diversity of air traffic safely and efficiently, while minimising environmental impact.

9 "architecture of the Digital European Sky" refers to the vision of the European ATM Master Plan, seeking to address the current inefficient airspace architecture in the medium to long term by combining airspace configuration and design with technologies to decouple service provision from local infrastructure and progressively increase the levels of collaboration and automation support.

10 The SESAR definition phase means the phase comprising the establishment and updating of the long-term vision of the SESAR project, of the related concept of operations enabling improvements at every stage of flight, of the required essential operational changes within the EATMN and of the required development and deployment priorities.


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## 1.5 SESAR delivery: upgrade phases of the European ATM system

The delivery of SESAR development and deployment activities contribute to the various phases of the upgrade of the ATM system as outlined in the Master Plan. These phases are depicted in the figure below.

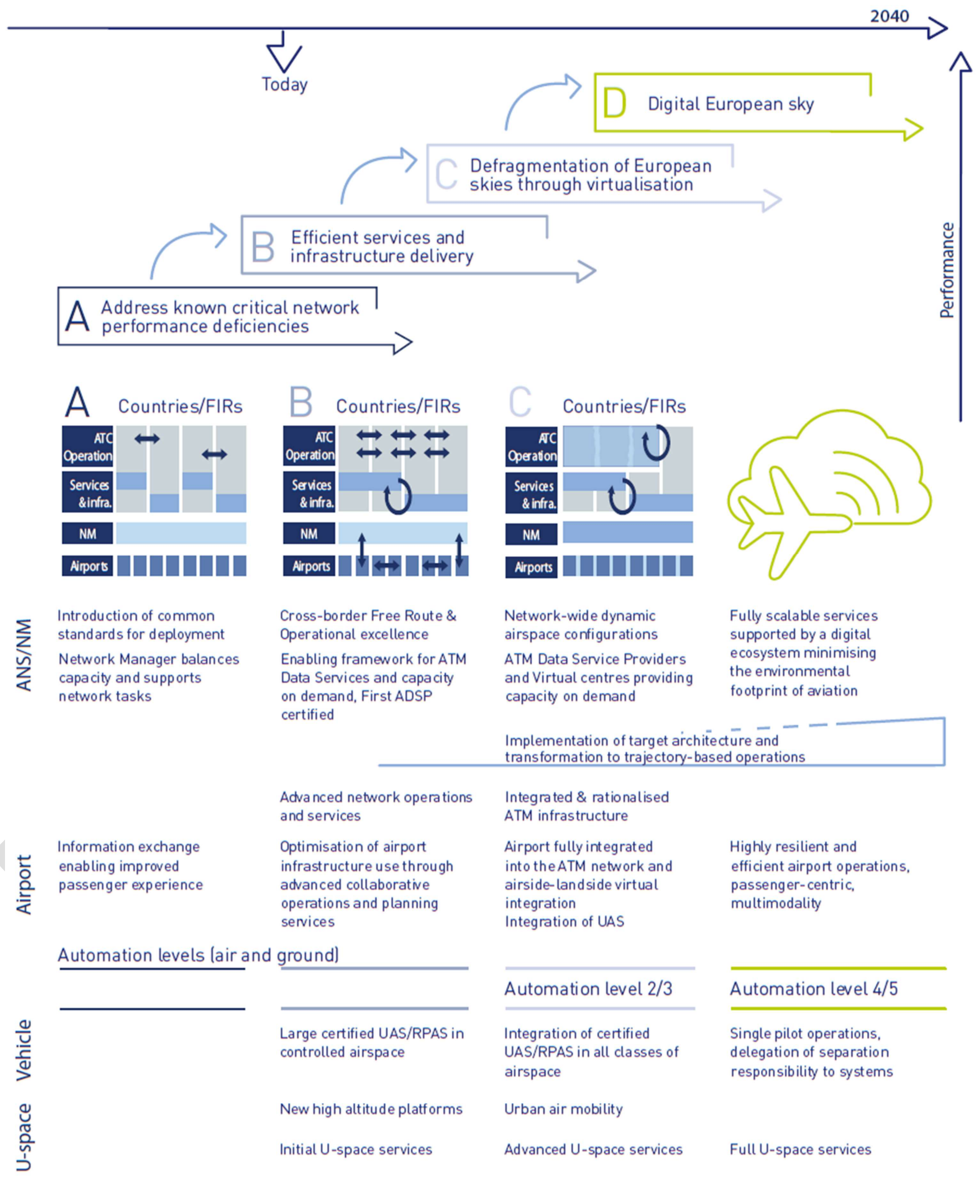


**Figure 1: European ATM system upgrade phases as per ATM Master Plan**

In relation to the European ATM Master Plan, until 2031, the primary objective of SESAR 3 is to deliver the Solutions for Phase D at TRL6 while significantly increasing market uptake for a critical mass of early movers focusing at Phase C and D infrastructure modernisation priorities.

Delivering the digital European sky will bring substantial value for every stakeholder in the aviation value chain; it will also significantly benefit the European economy and society in general at a relatively small investment cost.


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# 2 Multiannual work programme

The multiannual work programme of the SESAR 3 JU is designed to achieve the general and specific objectives set out in the JU's basic act, as detailed above in chapter 1.3 'Objectives of the SESAR 3 JU' and deliver the Solutions for Phase D of the ATM Master Plan, shown in chapter 1.5.

## 2.1 Overall plan of activities from 2021 to 2031

As depicted in the figure below, over the period from 2021 through to 2031, the SESAR 3 JU will:

- Carry out the final stage of the SESAR 2020 Programme, taken over from the SESAR JU in the course of 2021. The research and innovation activities of the SESAR 2020 Programme will be carried out under the existing regulatory framework, i.e. Horizon 2020;
- Design and implement the SESAR 3 research and innovation programme (the 'Digital European Sky Programme'), under the principles and framework laid down in this document;
- Carry out operational activities other than the Digital European Sky Programme, in relation with outreach and international cooperation;
- Deliver activities to fulfil its corporate, administrative, legal and financial obligations.

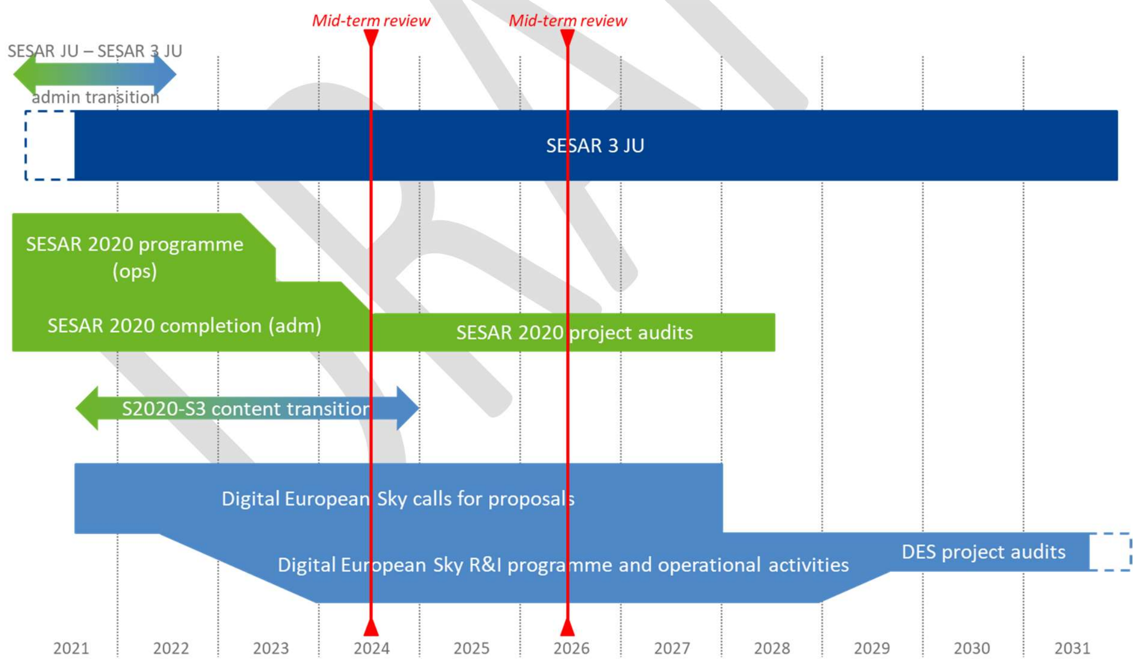


**Figure 3: Overall activity plan of the SESAR 3 JU 2021-2031**

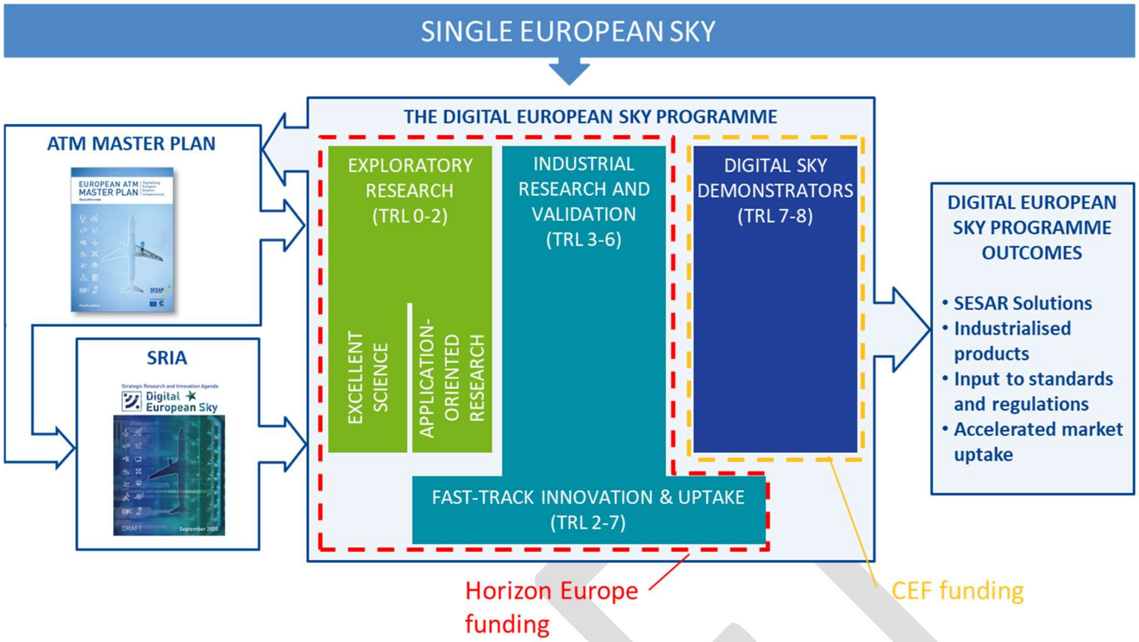


**Figure 4: The SESAR innovation pipeline**

The four categories of activity, including their full scope are shown in Figure 4 and further described below. They enable a best-practice managed approach that is suited to the needs of the SESAR R & I activities to be performed, and at the applicable research maturity. The innovation pipeline allows for both a more traditional 'waterfall' development method as well as for iterative developments, primarily focussed in 'fast-track innovation and uptake'. The innovation pipeline will make it possible to rapidly transition from exploration (low TRL) to validation, thus enabling accelerated progression to demonstration (high TRL) and transition to the market.

#### 2.2.1.1 Research maturity in the SESAR R & I Programme

The SESAR 3 JU will use Technology Readiness Levels (TRLs) to monitor progress towards a proposed exit maturity in the R & I programme and will use gates to control these exit maturity levels across the innovation pipeline. SESAR 3 JU will also communicate its achievements in delivering increased maturity/readiness externally using the same approach. As the Digital European Sky (DES) Programme is researching and developing not only technologies, but also systems and the operations, these TRLs are defined in terms of the lowest maturity level for each of the three aspects and not just for the technology. Consequently, TRLs will consistently be used in accordance with the following definition, the level of achievement and consequent maturity at each level is described below:

<u>**Exploratory Research covers:**</u>

**Pre-TRL 1 Scientific Research**: Fundamental exploratory scientific research investigating relevant scientific subjects and conducting feasibility studies looking for potential application areas in ATM, concentrating both on outreach to other disciplines as well as educating researchers and sharing experience within the scientific community.

**TRL 1 Basic principles observed and reported**: Exploring the transition from scientific research to applied research by bringing together a wide range of stakeholders to investigate the essential

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**TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or airborne)**: End of system development. Fully integrated with relevant operational systems (people, processes, hardware and software), most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification, Validation (V&V) and Demonstration completed, regulatory needs and standards are finalised.

#### 2.2.1.2 R & I activities within the innovation pipeline

**Exploratory research**

Fully funded under Horizon Europe, Exploratory Research drives the development and evaluation of innovative or unconventional ideas, concepts, methods and technologies that can define and deliver the performance required for the next generation of European ATM system. Activities cover low Technology Readiness Level (TRL) research and are divided into two distinct maturity sub-phases. The first sub-phase is 'Excellent Science' and is primarily oriented at universities and research organisations to create a coordinated body of ideas, using a knowledge transfer network, and consisting of early research that leads to the second sub-phase called 'Application-oriented Research' which takes the most promising ideas and applies them to an area of ATM where there is potential to exploit the idea(s) to deliver future operational benefit.

This research helps to mature new concepts for ATM beyond those identified in the ATM Master Plan as well as to mature emerging technologies, operations and methods to the level of maturity required to feed the applied research conducted in the Industrial Research and Validation phase. The target maturity at the end of this phase is TRL 2 and includes:

- Pre-TRL 1 Scientific Research,
- TRL 1 Basic principles observed and reported,
- TRL 2 Technology concept and/or application formulated.

**Industrial research & validation**

Fully funded under Horizon Europe, these R & I activities include Applied Research, Pre-Industrial Development and the necessary Validation activities. These activities typically start at TRL 3 and finalise with work to TRL 6, and include:

- TRL 3 Analytical and experimental critical function and/or characteristic proof-of concept,
- TRL 4 Component/subsystem validation in laboratory environment,
- TRL 5 System/subsystem/component validation in relevant environment,
- TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to end environment (ground or space).

The development methodology inherent in this approach will result in a progressive increase in assessed maturity over time, along with the required deliverable material developed to describe the anticipated SESAR Solution, its achievable performance and completion of the exit maturity that was proposed at the outset.

**Fast-Track Innovation and Uptake (Fast Track)**

Fully funded under Horizon Europe, this thread is designed to accelerate the development of high risk / high gain projects with the perspective of shortening the time to market for disruptive and highly


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- TRL 7 System demonstration in an operational environment (ground or airborne),
- TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or airborne).

The applicable TRL levels are further defined in the previous subparagraph.

#### 2.2.1.3 Exit Maturity Gates to control project delivery

To guarantee the delivery of robust SESAR Solutions, the maturity achieved during the development lifecycle will be assessed during the applicable Exit Maturity Gates. Project maturity self-assessment will also be required as input to the yearly projects review to allow SESAR 3 JU monitoring the progress of the Solutions development. A set of maturity criteria compliant with the Horizon Europe TRL definition will be used to confirm the maturity level reached by the SESAR Solution. These criteria can be found in Annex G 'Maturity criteria'.

As required by Horizon Europe, the targeted TRL of each topic will be identified together with the preferable starting TRL. The targeted TRL will represent the minimum expected maturity to be achieved by the project activities. Should the development of the Solution be faster than initially planned, a higher maturity level could be targeted by the project leading to applying the required maturity criteria accordingly. Should the expected maturity level not be achieved, the delivered maturity level will have to be duly justified and will have to be confirmed through an applicable Exit Maturity Gate.

The Maturity Gate overview is shown in the simplified diagram below.

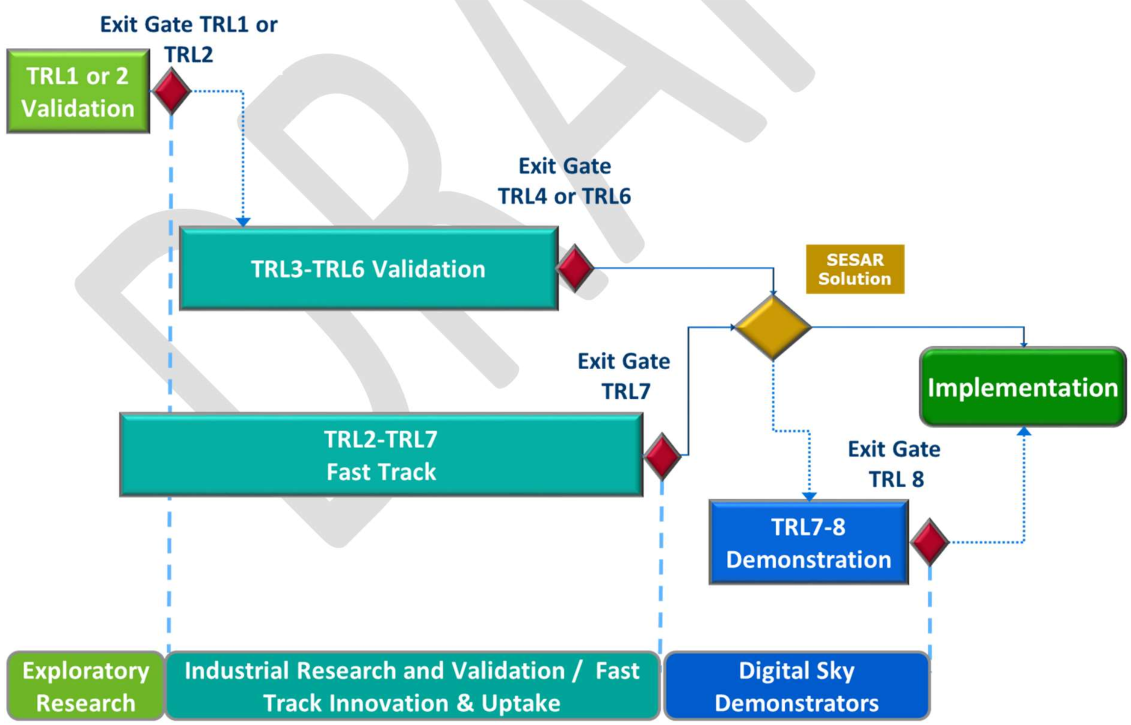


**Figure 5: Maturity Gates are used to control project delivery**

| Deliverable | Definition |
|---|---|
| CBA | *The Cost and Benefit Analysis documents the potential benefits, when deployed in the applicable environment(s), of a SESAR ATM Solution or a SESAR Tecghnological Solution (CBAT), and whether or not they are expected to exceed the costs over a given time horizon.* |
| Concept Outline | *High level description of the concept with identification of potential benefits and associated risks.* |
| Contextual Note | *The contextual note provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution in terms of scope, main operational and performance benefits, relevant system impacts, etc. When Solution is at TRL6 level it contains as well recommendations regarding additional activities to be conducted during the industrialization phase or as part of deployment. It introduces the technical data pack comprising the SESAR JU deliverables.* |
| DEMOP | *The demonstration plan describes the way in which one or more demonstration exercises or activities is to be prepared and executed in order to achieve the demonstration objectives. It includes those demonstration exercises that are required and sufficient to ensure that the SESAR Solution(s) under the scope of the project will progress from the initial maturity level to the target one. As appendix, it includes the required transversal and performance assessment plans (e.g. safety, Human Performance).* |
| DEMOR | *The Demonstration Report consolidates the results obtained by demonstration exercises. As appendix, it includes the transversal assessments (Safety, Security, Human Performance & Environment impact assessments) and any update on the requirements (SPR-INTEROP/OSED, TS/IRS) for the SESAR solutions under the scope of the demonstration project.* |
| ECO-EVAL | *The Economic Evaluation assess the potential benefits that an innovative idea or application under analysis by an exploratory research project could provide against an initial high level estimation of the costs that may imply.* |
| ERP | *The Exploratory Research Plan describes the way in which one or more validation exercises or activities are to be prepared and executed in order to achieve the validation objectives of an exploratory research project* |
| ERR | *The Exploratory Research Report consolidates the results obtained by an exploratory research projects once the validation activities, experiments, etc. have been completed.* |
| FRD | *The Functional Requirements Document represents a formal statement of a SESAR technologial solution related functional requirements. The content describes "what" the SESAR technological solution has to do but not the "how".* |
| OSED | *The Operational Service and Environment Description aims at describing the specific activities and interactions of various stakeholders related to a new concept of operations or to a new piece of existing concept.* |
| REG | *Proposed SESAR Acceptable Means of Compliance to EASA to illustrate means to establish compliance with the Basic Regulation and its Implementing Rules* |
| SPR-INTEROP/OSED | *The SPR-INTEROP/OSED contains the Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP), related to a SESAR solution, that have been defined and validated in the context of the Operational Service and Environment Description (OSED), which describes the applicable environment, assumptions, et. As appendix, it includes the transversal assessments and the performance assessment report that justify the SPR-INTEROP requirements (e.g. safety, Human Performance).* |
| STAND | *Proposed SESAR input to standardisation activities (e.g EUROCAE)* |
| TS/IRS | *The TS/IRS document provides the functional, non-functional and interface requirements related to a SESAR Solution. The Technical Specifications address the “what” and not the “how”, they aim at specifying the functional description and the necessary logical interfaces between the SESAR solution and other parts of the ATM system.* |
| VALP | *The validation plan describes the way in which one or more validation exercises or activities is to be prepared and executed in order to achieve the validation objectives. It includes those validation exercises that are required and sufficient to ensure that the SESAR ATM Solution or the SESAR Technological Solution (TVALP-Technological Validation Plan) will progress from the initial maturity level to the target one. As appendix, it includes the required transversal and performance assessment plans (e.g. safety, Human Performance).* |
| VALR | *The Validation Report consolidates the validation results for a SESAR ATM Solution or the SESAR Technological Solution (TVALR- Technological Validation Report) once the validation activities for a given maturity level have been completed.* |

**Table 2: The Digital European Sky Programme deliverables**


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### 2.2.2 R & I needs addressed in the Digital European Sky research and innovation programme

The SRIA presents the strategic research and innovation (R & I) roadmaps for the years 2021 to 2027 to deliver on the implementation of the Digital European Sky (i.e. fully scalable services supported by a digital ecosystem minimising the environmental footprint of aviation), including the integration of drones, matching the ambitions of the 'European Green Deal' and the 'Europe fit for the digital age' initiative.

The activities outlined in the SRIA to build a digitalised infrastructure are also critical for a post-COVID recovery, enabling aviation to become more scalable, economically sustainable, environmentally efficient and predictable.

To achieve the Digital European Sky (Phase D of the European ATM Master Plan), nine research and innovation flagships have been identified in the SRIA with their underlying R & I needs/challenges[18]. These will be the basis for identifying future Solutions addressing Phase D of the upgrade of the European ATM system, as targeted by the Digital European Sky. The nine flagships are listed below, with the related 59 R & I needs, which are described in more detail in the Appendix B 'SRIA flagships and their R & I needs'[19]:

- **1. Connected and automated ATM:** The Digital European Sky vision recognises that the future ATM environment will be increasingly complex, with new airspace vehicles flying at different speeds and altitudes compared to conventional aircraft. Moreover, there will be increasing pressure to reduce the costs of the ATM infrastructure while improving performance. Secure data-sharing between all the components of the ATM infrastructure and the relevant stakeholders is a key part of the Digital European Sky, together with automation using the shared data to improve ATM performance. This flagship identifies the specific research needed to realise the automation and connectivity vision of the European ATM Master Plan for the future ATM ground system
- **2. Air-ground integration and autonomy:** The future ATM needs to evolve, exploiting existing technologies as much as possible, and developing new ones in order to increase global ATM performance in terms of capacity, operational efficiency and accommodation of new and/or more autonomous air vehicles, i.e. supporting the evolving demand in terms of diversity, complexity from very low-level airspace to high level operations. This progressive move towards autonomous flying, enabled by self-piloting technologies, requires closer integration and advanced means of communication between vehicle and infrastructure capabilities so that the infrastructure can act as a digital twin of the aircraft. Ultimately, manned and unmanned aerial vehicles should operate in a seamless and safe environment using common infrastructure and services supporting a common concept of trajectory-based operations. Future operations should therefore rely on direct interactions between air and ground automation, with the human role focused on strategic decision-making while monitoring automation.
- **3. Capacity-on-demand and dynamic airspace:** For the last decades, capacity has not been available when and where needed and it has often been available when and where not needed. New airspace users including RPAS/HAO traffic will increase by 2030 and will require an

[18] The Master Plan explicitly states that the Essential Operational Changes (EOCs) are defined only for elements that are "in the pipeline towards deployment (Phase A-C) and are therefore not defined for Phase D which is the central focus of SESAR 3. The nine flagships identified in the SRIA (the how) were derived from the Phase D vision defined in the Master Plan (which focused on the why, what and when).

[19] The content of the present paragraph and of Appendix A is extracted from the section 3 of the SRIA.

demand and adaptable through more flexible air traffic management procedures. Furthermore, reducing aircraft noise impacts and improving air quality will remain a priority around airports.

- **8. Artificial intelligence (AI) for aviation:** AI is one of the main enablers to overcome the current limitations in the ATM system. A new field of opportunities arises from the general introduction of AI, enabling higher levels of automation and impacting the ATM system in different ways. AI can identify patterns in complex real-world data that human and conventional computer-assisted analyses struggle to identify, can identify events and can provide support in decision-making, even optimisation. Over recent years, developments and applications of AI have shown that it is a key ally in overcoming these present-day limitations, as in other domains. Tomorrow's aviation infrastructure will be more data-intensive and thanks to the application of Machine Learning (ML), deep learning and big data analytics aviation practitioners will be able to design an ATM system that is smarter and safer, by constantly analysing and learning from the ATM ecosystem.
- **9. Civil/Military interoperability and coordination:** The digital transformation of the European ATM network will have an impact on both civil and military aviation and ATM operations. Care must be taken to ensure a sufficient level of civil/military interoperability and coordination, especially concerning trajectory and airspace information exchange, as well as the use of interoperable CNS technologies. Therefore, a joint and cooperative civil-military approach to ATM modernisation would be the best choice to achieve the appropriate level of interoperability, also maximising synergies between civil and military research and development activities.

As a part of the Digital European Sky Programme, these flagships and the related R & I needs will be mapped with performance ambitions of the SES and further developed into candidate SESAR Solutions.

### 2.2.3 Calls for proposals

#### 2.2.3.1 Sequence of calls for proposals

The Digital European Sky Programme is delivered using range of instruments under Horizon Europe for the Exploratory and Industrial Research activities while the Digital Sky Demonstrators are secured using CEF financing framework[20].

There will be three types of calls for proposals covering three R & I Phases defined in subparagraph 2.2.1.2 'R & I activities within the innovation pipeline': Exploratory Research calls with Horizon Europe funding, Industrial Research and Validation (IR) also covering Fast-track Innovation and Uptake with Horizon Europe funding, and Digital Sky Demonstrators (DSD) with CEF funding. The funding allocation per call is outlined in paragraph 2.2.4 'Budget allocation to calls for proposals', below.

Four calls for proposals are planned for the Exploratory Research phase. The first call for Exploratory Research is planned to be published early 2022 to allowing the launch into execution of the first ER projects as of January 2023. The subsequent calls will be scheduled in order to complete the proposed ER content described in this document. The duration of the ER Projects is planned for a duration of 2.5 years including a 6-month period allowing them at the end of their life cycle to focus on the communication, dissemination and exploitation activities (as recommended by the SESAR 2020 Scientific Committee). The duration of the projects under the last ER call will be limited to a two-year

[20] CEF funding is subject to confirmation by the end of October 2021.

The SESAR Release Strategy planning the delivery of the Solutions has been developed to be independent of the respective Programme (SESAR 1, SESAR 2020 or Digital European Sky) and drives the definition of top down validation activities per Release connecting the Master Plan with the SESAR Release process. The Release Strategy reflects the maturity level of all Solutions and in particular identifies when they need to achieve end of TRL 6 maturity in order to meet the Master Plan expectations. At the end of each Release, the maturity of the proposed SESAR Solutions is assessed. The results can lead to declaring the SESAR Solution as mature enough for deployment or to requiring further validation activities to be planned in the next Release.

The definition phase of the Digital European Sky Programme is carried out in parallel with the definition of the last SESAR 2020 Release 12 content and will be finalised when Release 12 is in its early execution phase. This parallel approach enables the SESAR 3 JU and the candidate members to keep an accurate view of the evolution of the maturity of the SESAR solutions and to reflect it in regular updates of the Release Strategy. SESAR Solutions considered as not ready at the end of SESAR 2020 would be included in the Digital European Sky projects definition in order to further complete their validation.

To capture and propagate this knowledge with accuracy, the programme closure phase will also address content and material developed in SESAR 2020, ensuring that it is:

- made available to the SESAR Deployment Manager for use in the deployment programme;
- transferred to the Digital European Sky Programme for further development or;
- archived in line with the legal requirements.

The update campaign of the Master Plan in 2019 in parallel with the definition of the Wave 2 and Wave 3 calls preparation offered a good opportunity to the SESAR JU to already consider a first mapping between the SESAR 2020 Programme and the Essential Operational Changes and the phased evolution of the high level architecture as defined in the 2020 edition of the Master Plan endorsed by the Administrative Board of the SESAR JU in December 2019. It was also a way to already prepare the bridge between the Digital European Sky Programme content and the final deliveries of the SESAR 2020 Programme.

A consistent transition between the two Programmes has therefore been ensured by guaranteeing the consistency between the main drivers such as the Release Strategy, the Digital European Sky Programme and the ATM Master Plan 2020. In addition to this consistency, clear reference to SESAR 2020 deliverables will be made in the description of the Digital European Sky projects. The aim is to ensure that the Digital European Sky Programme will start building on the foundation resulting from SESAR 2020 validation activities, where required.

In addition to the transfer of outcomes from SESAR 2020 Programme into the Digital European Sky Programme, the optimisation of the sequence of calls also guarantee the consideration of the outcomes stemming from an R & I pillar for further feeding the preparation and the technical specifications for calls in other pillars.

The following picture presents all the dependencies that can be identified across the different pillars and calls demonstrating the possible transfer of results from a call to another:

- Demonstrating a significant contribution to the finalization of the SESAR Phase C as developed in SESAR 2020 (for the first IR and DSD calls only);
- Demonstrating the need for finding a common solution across the European Network (vs local) with a clear need for standardisation;
- Demonstrating a clear breakthrough potential (vs business as usual) in a medium (2025) and long (2028-2029) terms;

### 2.2.4 Budget allocation (EU contribution) to calls for proposals

The budget allocation to calls for proposals (EU contribution) is based on the EU budget assumptions set out in section 4 below. This allocation aims to combine several factors:

- the timing of the delegation of funds from the EU,
- the need to launch Digital European Sky Programme activities as early as possible after the adoption of the SESAR 3 JU basic act,
- the need to secure continuity of operations with the SESAR 2020 Programme where relevant,
- the expected investment capacity of the industry.

The total amount dedicated to the Exploratory Research (ER) grants, fully funded under Horizon Europe, is EUR 95 million. It will be evenly divided into four calls for proposals of EUR 23.75 million each.

As for the total amount dedicated to Industrial Research (IR, also covering Fast-Track Innovation and Uptake) calls, i.e. EUR 427 million fully funded under Horizon Europe, it could be used in two first calls of EUR 171 million each (Wave 1 and Wave 2), while a third call could be organised later on with the remaining EUR 85 million and the unused appropriation from the two first calls. For each call, it is expected that 70% of the budget would be allocated to traditional IR activities, and 30% to Fast-Track Innovation and Uptake activities.

The amount dedicated to the Digital Sky Demonstrators will depend on Delegation Agreements (DA) with the European Commission for the management of CEF funds. One DA with a value of EUR 171 million (operational funds only) is to be confirmed in October 2021 and would take place in 2022; it could be followed by a second DA of the same value in 2024 or 2025.

### 2.3.1 Synergies

**Maximising synergies across Horizon Europe**

The SESAR 3 JU will put in place measures to maximise its impact using all possible synergies with other European partnerships and related national activities. Beyond the involvement in the overall coordination of Horizon Europe, the SESAR 3 JU will in particular focus on capturing synergies across the following two clusters:

- **Synergies within the "Climate, Energy and Mobility" cluster:** In this thread, the JU will reach out to other mobility JUs with the aim to build consolidated roadmaps and action plans for climate neutral mobility solutions. This will also address common sectorial issues such as multi-modality transport, automated vehicles and the decarbonisation of the sector. In particular, a specific coordination with the European Partnership for Clean Aviation is believed to be essential for the aviation sector. This is covered by a dedicated section.
- **Synergies with the "Digital, Industry and Space" cluster:** Considering that the digital transformation of aviation is at the core of the JU's goals, it strongly echoes the ambition of the "Digital, Industry and Space" cluster. It is in many ways complementing this cluster by addressing aviation-critical applications. Therefore it is essential to put in place synergies with all relevant digital initiatives outside the "Climate, Energy and Mobility" cluster. For example artificial intelligence, cyber-security and high-performance computing are cross sectorial issues that require deep coordination especially for the development of use cases and the application of European standards. In addition, the partnership will contribute to the achievement of the European space policy. According to the European ATM Master Plan, satellite communication, navigation and surveillance services are considered essential enablers to the Digital European Sky. Therefore, the partnership will build on the achievements of SESAR 2020 in the space domain to further engage the space actors in the innovation ecosystem.

**A coordinated action with the European Partnership for Clean Aviation**

The Clean Aviation and SESAR 3 JUs will play an essential role to successfully drive the aviation sector to achieve environmental and mobility goals set out for Europe's aviation, while contributing to the objectives of the European Commission. These goals will be attained through the research and development of key innovative technologies for the decarbonisation/energy transition and digital transformation of the aviation sector.

Opportunities will be actively sought for running joint demonstration activities. This would enable the two programmes to show in practice the complementarities and synergies between them. It could also allow the programmes to evaluate the combined benefits and impact of particular solutions, in particular, for example, the measurement of the aggregated effect of green operations and green aircraft on the achievement of the overall decarbonisation goal. In order to facilitate joint demonstration activities, there will need to be a sufficiently flexible funding framework in place.

A first set of potential areas to demonstrate the synergy effects has been identified (this list is not exhaustive):

- Combined simulations
- Performance and impact assessment
- Autonomous operations
- Airport infrastructure for new vehicles

relevant subsystem and the strengthening and development of capabilities and skills at the overall system level.

The synergies identified above will be subject of specific activities defined in future Annual Work Programmes of the SESAR 3 JU.

### 2.3.2 Stakeholders engagement

The SESAR 3 JU is responsible for securing support and buy-in from all stakeholders in the ATM value chain for the definition (European ATM Master Plan) and development of SESAR technologies and procedures (SESAR solutions). This requires continued and extensive outreach in the form of communications and external relations (including international affairs), supported by the core SESAR membership, and cooperative arrangements with specific stakeholder groups.

The SESAR 3 JU's outreach work will target and involve a wide range of SESAR 3 JU member and stakeholder organisations. This outreach aims to secure the involvement of stakeholders in the SESAR 3 JU's R & I activities, including in support of validating SESAR solutions, as well as to ensure close coordination and, where appropriate, alignment with activities delivered by other organisations but which are of strategic importance to the success of the SESAR project, such as standardisation.

**Institutional stakeholders**

The SESAR 3 JU will maintain close relations with its key institutional stakeholders such as the European Commission, the European Parliament, and the European Council, along with EUROCONTROL, in order to ensure that its activities are aligned with and take into account developments in the EU's policy towards ATM. It will also establish appropriate cooperation and coordination with the following organisations, including through formal cooperative arrangements where appropriate:

- **European Union Aviation Safety Agency (EASA)** - to secure close collaboration with EASA in order to ensure an early exchange of knowledge on new technologies being developed, thereby facilitating the certification process of resulting products and services, and ultimately accelerating market uptake of SESAR solutions. The arrangements will provide for EASA to contribute expertise in support of key SESAR project activities and, at the same time, cater for the SESAR JU to provide support to EASA in European and international activities that relate to securing the necessary safety, security and regulatory arrangements.
- **European Defence Agency (EDA)** - to secure support and buy-in from the military community (in their roles as ANSPs, airport operators, airspace users and regulators) in relation to SESAR 3 JU activities and the ATM Master Plan. In particular, areas of common interest include the ATM Master Plan, regulations, space-based systems, the integration of unmanned aerial systems, cybersecurity threats and vulnerabilities of ATM and the development of aviation/ATM standards.
- **European Space Agency (ESA)** - to focus on strategic cooperation to coordinate roadmaps, specifically in relation to the integrated CNS strategy defined in the ATM Master Plan, defining the role of satellite communications as an element of importance for the future enabling CNS infrastructure for ATM.
- **European Union Agency for the Space Programme (EUSPA)** – to ensure coordination in relation to the role of EGNOS and Galileo in the future multi-frequency, multi-constellation GNSS system.


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#### 2.3.3.1 Cooperation with ICAO

ICAO is the global body responsible for developing international civil aviation standards and recommended practices and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. A key objective of the SESAR 3 JU's international engagement is to ensure an alignment between its priorities and those established at ICAO level. It is particularly important to ensure that the European ATM Master Plan and industry standardisation initiatives remain aligned with the relevant ICAO provisions and their future evolution. For this reason, the SESAR 3 JU will work closely with the European Commission and other European institutions and partners, notably EASA and EUROCONTROL, to promote European positions and global interoperability. The SESAR 3 JU will participate in European ICAO coordination meetings, chaired by the European Commission, as a means to define European priorities and to plan accompanying actions and inputs to ICAO. The SESAR 3 JU will also participate in the broader European Safety and Air Navigation Coordination Group, which ensures coordination with the 44 European Civil Aviation Conference (ECAC) states.

In 2022–2023, the SESAR 3 JU's ICAO-related activities will involve engagement on the future evolution of the GANP and the aviation system block upgrades through participation in relevant groups such as the ICAO GANP Study Group. A particular milestone over the period will be the 41st ICAO Assembly that will take place in 2022. The SESAR 3 JU will also seek to work closely with ICAO as it develops policies in strategically important domains, such as integrated communications, navigation and surveillance, drones, higher airspace operations and environmental targets.

By continuing to engage closely with such activities, the SESAR 3 JU is able to ensure that policies, standards and provisions being established at the global level are interoperable and harmonised with those being developed through the SESAR R & I pipeline, recognising that this is a vital prerequisite for a safe, secure, efficient and sustainable global ATM system. This in turn will help maintain and further strengthen SESAR 3 JU's position as a global leader in aviation and ATM modernisation, which also serves to promote the competitiveness and global market shares of the European aviation and ATM industry.

#### 2.3.3.2 Cooperation with international partners

In addition to its direct participation and involvement in ICAO activities, the SESAR 3 JU will cooperate with a number of key international partners. The JU has cooperated since 2011 with the US Federal Aviation Administration (FAA) / NextGen programme under the EU–US MoC on ATM modernisation, civil aviation R & I and global interoperability. The FAA's NextGen programme and SESAR are the two largest ATM modernisation initiatives in the world. As such, it is essential that the two programmes are closely aligned to ensure that global interoperability and harmonisation can be maintained, not only for the present but for the future too. Maintaining regular dialogue across a range of topics and domains allows the two sides to identify any risks, issues or opportunities that may arise in relation to global interoperability.

The SESAR 3 JU will also secure cooperation with a number of other key international partners through a range of instruments, building on cooperative arrangements established previously by the SESAR JU, for example with Singapore, Qatar, the United Arab Emirates, and Georgia, as well as seeking opportunities for new cooperative arrangements where these can add value consistent with the EU's broader external aviation policy. To this end, the SESAR 3 JU will work in close coordination with the European Commission. The SESAR 3 JU will also work closely in support of EASA on the ATM-related elements of EU technical cooperation projects with third countries and regions. Conducted within the


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exploratory research, industrial research, fast-track innovation and uptake, and the Digital Sky Demonstrators, over a 12-month period.

### 2.3.5 Data and dissemination

#### 2.3.5.1 Dissemination of programme results

The SESAR 3 JU will systematically collate data from completed and ongoing projects with the aim to obtain a comprehensive overview of the progress achieved in each financed project against the targets outlined in the SESAR 3 JU's multiannual work programme. Such data collection will enable a holistic view of the Digital European Sky Programme activities and their impact.

Data will include output from projects, such as standardisation material, publications and patents, will be made available on the SESAR 3 JU's website (via either uploaded documents or links to relevant websites) and through direct dissemination of material to the appropriate bodies in support of the preparation for deployment. In addition, the SESAR 3 JU will continue to publish and promulgate SESAR solutions once they are available and validated through the release process.

The Digital European Sky Programme will comply with all provisions of the Horizon Europe programme related to dissemination, set forth in Title II of the Horizon Europe Regulation ([23]), in particular its Article 39 and the Horizon Europe work programme 2021-2022, annex 13, General Annexes, Section G ([24]). This involves monitoring the dissemination activities of beneficiaries to ensure that they provide (digital or physical) access to data or other results needed to validate the conclusions of scientific publications, to the extent that their legitimate interests or constraints are safeguarded (and unless they already provided the (open) access at publication).

As an exception, if providing open access would be against the beneficiaries' legitimate interests, the beneficiaries must grant non-exclusive licences, on fair and reasonable conditions, to legal entities that need the research output to address the public emergency. These legal entities must commit to rapidly and broadly exploiting the resulting products and services on fair and reasonable conditions. This exception is limited to 4 years after the end of the action.

#### 2.3.5.2 SESAR Digital Academy

The vision of the SESAR Digital Academy is to become a recognised learning initiative supporting Europe's future aviation and ATM workforce. The mission is to nurture Europe's brightest minds and advance learning, scientific excellence and innovation in aviation and ATM, to promote student mobility and a whole spectrum of learning opportunities, from fundamental research to industry-focussed applied research, and to enhance the knowledge, skills and employability of aviation professionals.

The SESAR Digital Academy seeks to bring together under one umbrella SESAR exploratory research activities and outreach, relating to education and training, as well as professional learning opportunities offered by research centres, universities, industry partners and other entities within the ATM/aviation domain.

Linked with the Knowledge Transfer Network, the initiative increases the accessibility and visibility of existing SESAR outreach and will continue to highlight relevant events, such as the SESAR Innovation

[23] REGULATION (EU) 2021/695 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013.

[24] European Commission Decision C(2021)1940 of 31 March 2021.


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- Strategic area of operation **5 – Deliver SESAR outreach**. The SESAR 3 JU ensures global outreach relating to the ATM Master Plan and the ongoing and planned SESAR activities, in full coordination with the European Commission and EUROCONTROL.
- Strategic area of operation **6 – Deliver effective financial, administrative and corporate management**. The SESAR 3 JU must ensure it operates fully in accordance with its obligations, while also striving continually to improve its financial, administrative and corporate management as these elements of the SESAR 3 JU's operations remain an integral part of the delivery of its mission and values.

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His or her tasks are defined in Articles 18 and 152 of the Commission's Proposal for the SESAR 3 JU's basic act.

## 3.3 Advisory bodies

### 3.3.1 Scientific Advisory Body

The Scientific Advisory Body supports the SESAR 3 JU's Governing Board in ensuring the scientific excellence of the Digital European Sky Programme.

Its role is defined in Articles 19 and 153 of the Commission's Proposal for the SESAR 3 JU's basic act and its implementation may refer to it as the Scientific Committee.

### 3.3.2 States' Representatives Group

The States' Representatives Group supports the SESAR 3 JU's Governing Board in monitoring the programme progress of the Joint Undertaking, in updating strategic orientation in line with the Horizon Europe strategic planning and with other Union and member states funding instruments, and in maintaining links to Horizon Europe and other Union, national and, where relevant, regional initiatives, including cohesion policy funds in line with smart specialisation strategies.

The representatives of the member states shall also present a coordinated position, taking into consideration the views expressed in the Single Sky Committee.

Its role is defined in Articles 20 and 154 of the Commission's Proposal for the SESAR 3 JU's basic act.

sources of Union funding (CEF) that will be used to realise this specific objective (via separate delegation agreements) to match the ambition defined in the SRIA.

Indeed, a strengthened JU that will stretch all the way to facilitating the deployment processes with demonstration activities and ensuring the delivery of technical solutions able to advance smoothly through standardisation and certification processes should be able not only to advance technology readiness but also to stimulate digital aviation infrastructure investments in Member States throughout the duration of the next MFF 2021-2027.

## 4.2 Financial resources (revenues)

### 4.2.1 Union financial contribution

The Union financial contribution from the Horizon Europe Programme to the SESAR 3 Joint Undertaking, including EFTA appropriations, to cover administrative costs and operational costs, shall be up to EUR 600 000 000, including up to EUR 30 000 000 for administrative costs. This amount is split between:

- Exporatory Research (ER): EUR 100 000 000 and
- Industrial Research (IR): EUR 500 000 000.

This amount could be later complemented with additional Union financial contributions coming from the Connecting Europe Facility (CEF) fund, possibly in two Delegation Agreements, with a first one of EUR 180 000 000 as of 2022.

Each of these envelopes (ER, EUR 100 million; IR, EUR 500 million; CEF, EUR 180 million) will include up to 5% for the running costs of the SESAR 3 JU. The overall Union contribution to the running costs of the SESAR 3 JU could amount to EUR 30 million or EUR 39 million with a first CEF Delegation Agreement.

Participation in indirect actions funded by the SESAR 3 JU under Horizon Europe should comply with the rules set out in the Horizon Europe Regulation. A single funding rate per type of action shall apply for all activities it funds. The maximum rate per type of action shall be fixed in the Annual Work Programmes ([26]).

### 4.2.2 Contributions from members other than the Union

The Union financial contribution under the Horizon Europe Programme for Industrial Research is mirrored with a contribution of EUR 500 000 000 of the private Members and with a contribution of EUR 500 000 000 of EUROCONTROL. These two contributions include EUR 25 000 000 (5%) each for administrative costs.

The contributions of private Members consist in:

- In-kind contributions to operational activities;
- In-kind contributions to additional activities, approved by the Governing Board;

[26] Article 34, REGULATION (EU) 2021/695 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013.

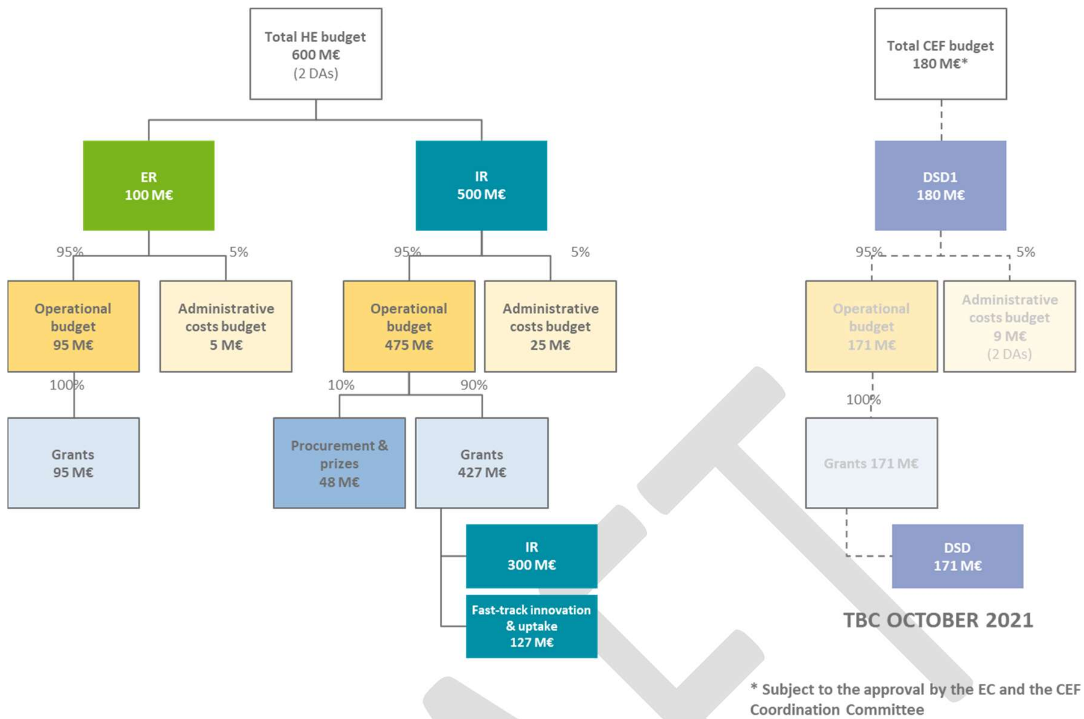


**Figure 11: SESAR 3 JU budget allocation (EU part) per phase of the innovation pipeline**

The planned amount per call is provided in paragraph 2.2.4 above.

It should be noted that, out of the EUR 475 million of operational appropriations for IR, an amount corresponding to about 10% could be reserved for actions through procurements (support and advisory services) and prizes.

Joint Undertakings under the Horizon Europe Programme; SESAR 3 JU **key performance indicators**, linked with the general objectives and principles, used consistently throughout the life of the Digital European Sky Programme and with a target to be achieved by the end of the Programme; **yearly indicators related to the work programme** (in relation with operational objectives).

Reporting on the indicators and the achievement of the objectives will be done in the context of the consolidated annual activity report submitted by the Executive Director and assessed by the SESAR 3 JU Governing Board, in accordance with Articles 16 (n) and 18-4.(e) of the SESAR 3 JU's basic act.

#### 5.2.2.1 Cross-cutting indicators

**Cross-cutting indicators** will be defined on the basis of Horizon Europe guidance.

#### 5.2.2.2 Key performance indicators

**Key performance indicators** of the Digital European Sky Programme / SESAR 3 JU are defined in relation with the general objectives of the Joint Undertakings, and with additional general and specific objectives of the SESAR 3 JU (see above in chapter 1.3 'Objectives of the SESAR 3 JU').

Indicators will be defined in next versions of the document in accordance with European Commission's guidance to come.

#### 5.2.2.3 Yearly indicators related to the work programme

**Yearly indicators related to the work programme** will be defined in the context of Annual Work Programmes.

Indicators will be defined in next versions of the document in accordance with European Commission's guidance to come.

### 5.2.3 Risk management

Risk management aims at fulfilling the SESAR 3 JU's mission, strategic and operational objectives by anticipating, proactively identifying, analysing, treating, monitoring and controlling risks.

The objectives are to:

- enable informed decision making at any level of the SESAR 3 JU activities, including information on risks and opportunities and how to best manage them,
- mitigate the impact of risks, defining and ensuring the implementation of appropriate action plans,
- seize opportunities and enhance their benefits,
- meet legal and regulatory requirements,
- establish and implement internal control.

This activity is connected to the multi-annual and annual programming cycle for which it provides up-to-date information on critical risks affecting the strategic objectives of the SESAR 3 JU (as documented in the Multiannual Work Programme and subsequent Annual Work Programmes). Moreover, it feeds a corporate reporting process for which it provides up-to-date information on the response to critical risks and the completion of action plans (as documented in the consolidated annual activity report).

The IAC provides the Executive Director with assurance as to the effectiveness and efficiency of the governance, risk management and control processes in the SESAR 3 Joint Undertaking taking into account the specific nature and contributions of its private partners and a pan-European Organisation (EUROCONTROL). Thereby it promotes a culture of ethics and efficient and effective management within the SESAR 3 Joint Undertaking.

This is done with special reference to the following aspects:

- Risks are appropriately and continuously identified and managed,
- Significant financial, managerial, and operating information is accurate, reliable, and timely,
- The SESAR 3 Joint Undertaking's policies, procedures, and applicable laws and regulations are complied with,
- The objectives of the SESAR 3 Joint Undertaking are achieved effectively and efficiently,
- The development and maintenance of high-quality control processes are promoted throughout the SESAR 3 Joint Undertaking.

To this end, the IAC can perform both assurance and consulting engagements.

With this, the IAC will assist the Executive Director to implement his tasks as described in article 18 of the Council Regulation establishing the joint undertakings under Horizon Europe, notably to:

- ensure sustainable and efficient management of the joint undertaking;
- establish and ensure the functioning of an effective and efficient internal control system
- protect the financial interests of the Union by applying preventive measures against fraud, corruption and any other illegal activities by means of effective checks

## 5.3 Efficiency gains

The SESAR 3 JU develops a strategy to secure efficiency gains.

It will benefit from efficiency measures and synergies already implemented in the context of the SESAR 3 JU over the period from 2008 until 2021, which will be continued. These are:

- **Collaboration with EUROCONTROL**: considering that EUROCONTROL possesses an appropriate infrastructure and the necessary administrative, IT, communications and logistics support services, the SESAR 3 JU should benefit from such infrastructure and services. In this context, there are few potential synergies that could be gained from pooling administrative resources with other Joint Undertakings through a common back office. For this reason, the SESAR 3 JU has opted out from the common back office functions established by the Single Basic Act.
- **Collaboration with the European Commission**: the SESAR 3 JU will leverage synergies from the use of European Commission's ICT systems and services (such as contracts with ICT service providers and suppliers). ICT systems supplied by the Commission are in particular related to:
    - Financial management and accounting systems (ABAC),
    - Human resources management (Sysper),
    - The management of Horizon Europe calls for proposals and grants,
    - Procurement (e-procurement),

# 6 Annual Work Programmes development and adoption process

As stated in the introduction (section 1 above), the present Multiannual Work Programme will be implemented through Annual Work Programmes developed by the SESAR 3 JU and adopted by the Governing Board each year. Each Annual Work Programme will detail the principles set in the present Multiannual Work Programme and further define them into concrete activities and provisions, e.g. the call conditions of each call for proposals as per the framework set in paragraph 2.2.3. 'Calls for proposals' above. Annual Work Programmes will also serve as financing decisions for these calls for proposals.

To ensure the alignment with the Digital European Sky Programme overall objectives, the SESAR 3 JU will, from 2022 onwards (i.e. starting from the development of the Annual Work Programme for 2023), follow a clear and coordinated procedure in developing its Annual Work Programmes, which includes consultation with the industry, the scientific community and the Member States. This procedure aims to support the SESAR 3 JU in the Annual Work Programme development and the Governing Board in its adoption decision.

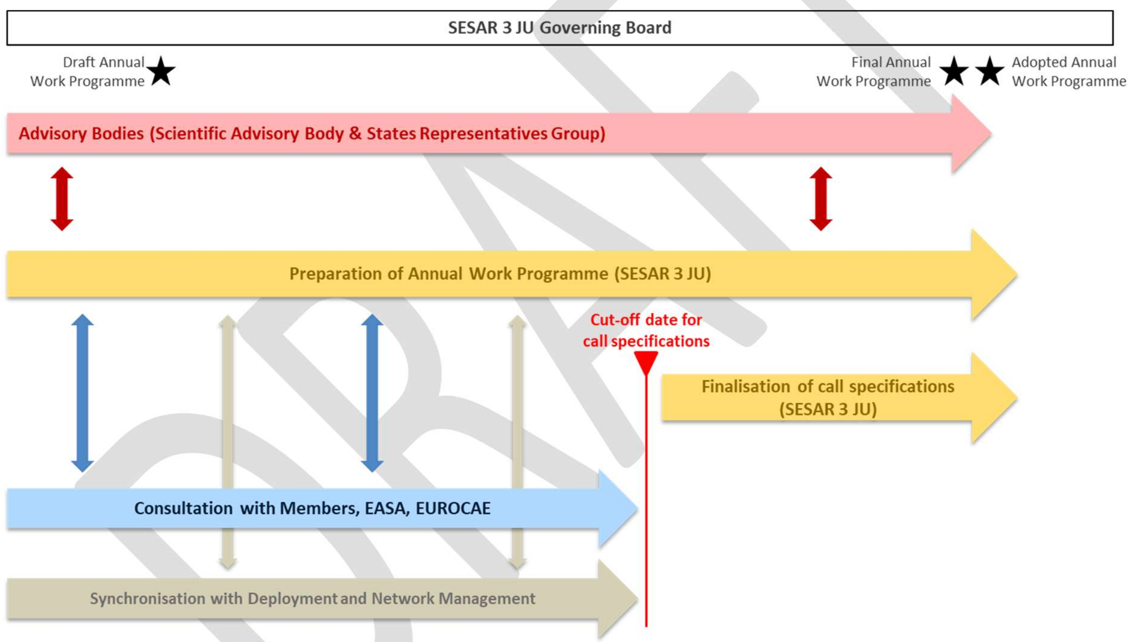


**Figure 12: Development and adoption of Annual Work Programmes**

In the **preparation of Annual Work Programme**, the SESAR 3 JU defines the annual objectives and the related activities and resource plan (including financial resources and budget for the given year). When relevant, this includes call conditions of the call(s) for proposals to be launched in the year, in which the Topics to be addressed are identified and described on the basis of the R & I needs defined in the nine SRIA flagships (see above in paragraph 2.2.4. 'R & I needs addressed in the SESAR 3 research and innovation programme', and in Appendix B 'SRIA flagships and their R & I needs'). This initial list and high-level description of Topics (at this stage, not at Solutions or Projects level) is accompanied with other call conditions, namely:

- Reference to the basic act and the budgetary line,
- Overall call budget (at this stage, indicative),


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# 7 Bi-annual work programme 2021-2022

***This part includes information which is meant to become part of the SESAR 3 JU's Annual Work Programme (especially, the Annual Work Programme for 2022), to be adopted by the Governing Board as <u>separate documents</u>. Further guidance is expected from the Commission on this procedure.***

## 7.1 Strategic area of operation 1: Provide strategic steering to the Digital European Sky programme

## 7.2 Strategic area of operation 2: Deliver Exploratory Research

We plan to award projects that hold the promise to deliver 25% of the ER activities required for Phase D.

## 7.3 Strategic area of operation 3: Deliver Industrial Research and Validation

We plan to award projects that hold the promise to 1) complete critical Phase C IR activities needed for the realisation of the MP Phase D objectives 2) deliver 35% of the IR activities required for Phase D.

## 7.4 Strategic area of operation 4: Deliver Very Large-Scale Demonstrations

We plan to award projects that hold the promise to stimulate 5-10% market update on Phase C of the MP focusing at a targeted set of topics that are considered EU policy priorities.

## 7.5 Strategic area of operation 5: Deliver SESAR outreach

## 7.6 Strategic area of operation 6: Deliver corporate, financial and administrative management of the SESAR 3 JU

This chapter outlines the activities that will be carried out to deliver the objectives of the SESAR 3 JU relating to financial, administrative and corporate management.

### 7.6.1 Calls for proposals and grants management

The following activities are scheduled to take place in 2022 in relation to the calls for proposals

- The management of grant agreements, monitoring project implementation and execution of payments in accordance with the financial circuit for the grant agreements within the H2020 set

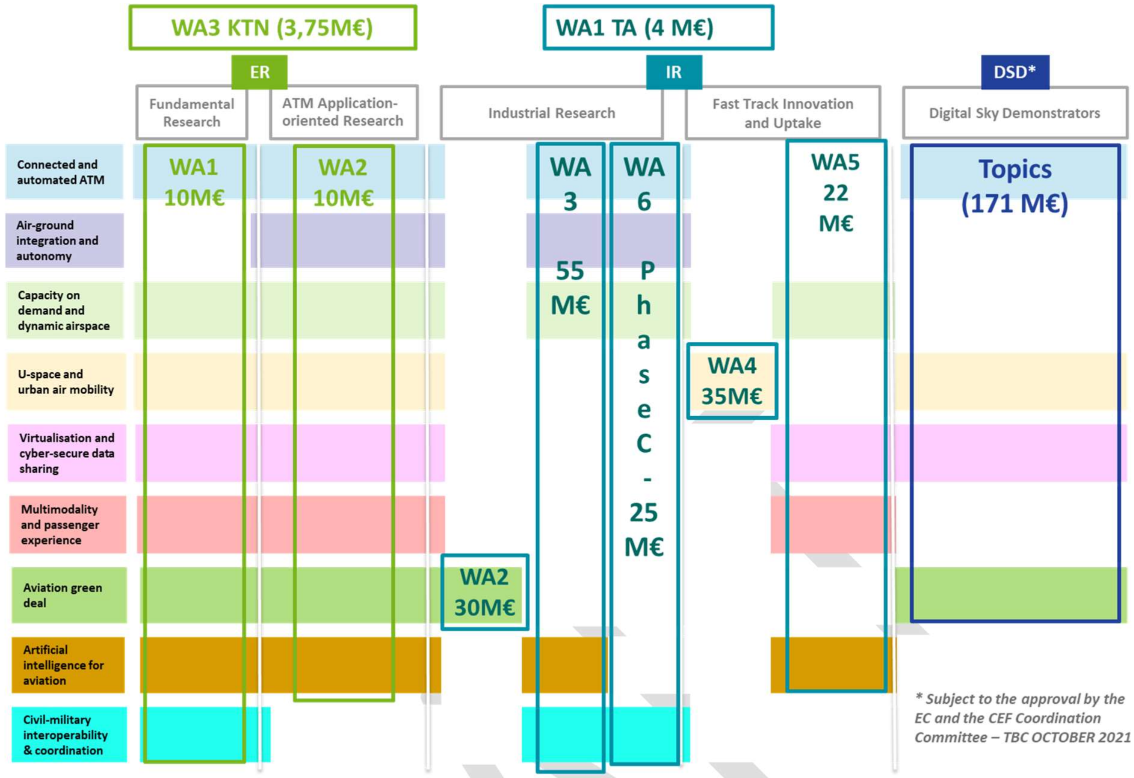


**Figure 13: Coverage of the SRIA flagships through the first set of calls for proposals of the Digital European Sky Programme**

### 7.6.2 Horizon Europe (HE) calls for proposals

In 2022 the following calls will be launched under Horizon Europe Programme:

- The open DES ER1 call for proposals with call identifier HORIZON-SESAR-2022-DES-ER-01;
- The open DES IR1 call for proposals with call identifier HORIZON-SESAR-2022-DES-IR-01.

Those calls will follow the general conditions laid down in Horizon Europe Work Programme 13. General Annexes, adopted by the European Commission[28].

Specific conditions will be indicated in the call and topic description.

[28] European Commission Decision C(2021)1940 of 31 March 2021

#### 7.6.2.1.5 Specific conditions for call HORIZON-SESAR-2022-ER-01

##### 7.6.2.1.5.1 Eligibility conditions

##### 7.6.2.1.5.2 Duration and key milestones

Work Areas 1&2:

The awarded projects will start preparing and executing their research activities between Q1 2023 and Q4 2024. Research activities should be completed not later than end of Q4 2024. It will allow the Project to undertake Communications, Dissemination and exploitation activities on the research results for a 6 month period (maximum project duration of 30 months).

Work Area 3:

The awarded project will start executing its activities between Q1 2023 and Q4 2026, and shall deliver their full results no later than end of Q4 2026 (maximum project duration of 48 months).

##### 7.6.2.1.5.3 Budget

Work Area 3

Beneficiaries may provide financial support to third parties. The support to third parties can only be provided in the form of grants. The maximum amount to be granted to each third party is EUR 60 000.

##### 7.6.2.1.5.4 Award criteria

**Exploratory Research (WA 1 & 2)**

| Type of Actions | **Excellence**<br><br>*(The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme)* | **Impact** | **Implementation** |
|---|---|---|---|
| Research Innovation Actions (RIAs) | 1. Clarity and pertinence of the proposal: degree to which the objectives, scope and requirements defined in the Technical Specifications are well understood and fully addressed.<br><br>2. Feasibility, adequacy and scientific quality of the proposed methodology, including elaboration of the research questions and hypotheses, as well as explicit justification of the assumptions essential to the research. It also includes appropriate consideration of | 1. Credibility of the pathways to achieve the expected outcomes and impacts specified in the technical specifications, in particular demonstrating compliance with the **specific technical criteria defined here after.**<br><br>2. Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, | 1. Quality and effectiveness of the work plan : degree to which the proposed plan and schedule are compliant with the Programme Execution framework, including assessment of risks.<br><br>2. Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise |

| Type of Actions | **Excellence** *(The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme)* | **Impact** | **Implementation** |
|---|---|---|---|
| Coordination and support Actions (CSA) | 1. Clarity and pertinence of the project's objectives.<br>2. Quality of the proposed coordination and/or support measures, including soundness of methodology | 1. Credibility of the pathways to achieve the expected outcomes and impacts specified in the Technical specifications, and and on ATM research.<br>2. Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities. | 1. Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall.<br>2. Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise. |

#### 7.6.2.1.6 **Activities covered by this call for proposals**

The HORIZON-SESAR-2022-DES-ER-01 call for proposals covers topics related to three Work Areas:

- Work Area 1 - ATM Excellent Science & Outreach. Type of action: Research and Innovation action (RIA).
- Work Area 2 - ATM Application-Oriented Research. Type of action: Research and Innovation action (RIA).
- Work Area 3 - Knowledge Transfer Network. Type of action: Coordination and support action (CSA).

Research activities across these three Work Areas are described in the paragraphs below.


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- **Combined and integrated KPIs and performance structure for technological solutions/ CBAs**: this element covers the definition of performance frameworks (e.g. KPAs, KPIs, etc.) to support the performance assessment for technological solutions and facilitate the elaboration of CBAs that can help justifying the deployment of future technologies (*R&I need: Enabling the deployment of a performance-based communications, navigation and surveillance (CNS) service offer*);

- **Moving from magnetic to geographic bearings**: in order to enable a performance-based communications, navigation and surveillance (CNS) service offer, research on moving from magnetic to geographic bearings is required. The objective is to study what would be needed from a CNS perspective, how to transition from one to another and what the benefits would be (*R&I need: Enabling the deployment of a performance-based communications, navigation and surveillance (CNS) service offer*);

- **Land behind without runway vacated**: the scope is to investigate the European "land behind without runway vacated" concept, similar to the FAA “land behind” clearance. Today, in the case of long runways, landing aircraft are allowed to use the runway simultaneously under certain circumstances, or the clearance to land may be delivered before the previous aircraft has crossed the threshold (*R&I need: Runway use optimisation through integrated use of arrival and departure time-based separation (tBS) tools);*

- **Use of Slant Visual Range (SVR) beyond RVR**: this research is about the technical and operational use of Slant Visual Range (SVR) beyond RVR. In fact, RVR, even if used for decades already, does not take into consideration important variables (e.g. reduced visibility from other factors, such as rain on the windshield of the aircraft, etc) (*R&I need: Runway use optimisation through integrated use of arrival and departure time-based separation (tBS) tools);*

- **Auto-steer aircraft taxi operations at airport**: scope is to investigate the integration of automotive into aviation technology for taxiways (‘Green Taxiing’), towards a fully automated system for the whole surface operations. The investigation should cover bot the technology and the operational challenges (*R&I need: Airport automation including runway and surface movement assistance for more predictable ground operations);*

- **Seamless connectivity between ground and aircraft via high capacity network:** this element covers the seamless connectivity between ground and aircraft via high capacity network for transmitting virtual guidance, warnings and stop bars to aircraft (*R&I need: Airport automation including runway and surface movement assistance for more predictable ground operations);*

- **Automated ATC in medium/high-density En-Route airspace** (including the evolution of human role in an environment with higher levels of automation): this research about the automated ATC in medium/high-density En-Route airspace moves from executive to supervisory control, addressing the challenges on the role of the human to ensure that the proposed solution is fully consistent with human capabilities. It develops operational concepts for higher levels of automation in ATM (e.g. delegation of control to the automation) both at aircraft and ground level and addresses the specific challenges that hinder the application of machine learning, artificial intelligence methods for the further automation of ATM (e.g. transparency, generalization, etc.). It also addresses the recommendations provided by the Expert Group on the Human Dimension of the Single European Sky reviewing all the roles, the responsibilities and tasks of the different actors (airborne and ground, ATM and U-space,

- New training requirements and programmes for ATCOs and other ATM personnel that takes into account the implications of the expected future role of the human and the foreseen introduction of new support tools;
- Application of psychophysiological measurements (e.g. neuro-metrics or the detection of facial expressions) for applications like stress management systems, fatigue declaration, new training techniques or adaptive automation;

(*R&I need: On-demand air traffic services);*

- **Legal and regulatory challenges in an ATM environment with higher levels of automation:** this element covers the challenges related to the means of approval/certification of novel ATM-related airborne and ground systems that enable higher levels of automation, (e.g. in particular those systems based on machine learning techniques) by considering both legal and regulatory aspects (including privacy), along with the technical aspects (e.g. architecture, system performance, reliability, etc.). Also, the assessment of the potential changes to ATCOs licences and training will be addressed, including the use of conflict detection and resolution support tools by ATCOs in order to ensure capacity growth, against a trend of creating smaller sectors where capacity benefits reach a finite limit (*R&I need: On-demand air traffic services);*
- **Increasing the use of middle airspace**: this element addresses the potential business case of increasing the use of middle airspace (approximately between 15.000 ft. and 25.000 ft.) by jet engine aircraft and the trade-offs between the increase of capacity (and reduced delays) through the provision of ATFM slots for flights in the middle airspace versus the increased fuel consumption and environmental impact (*R&I need: On-demand air traffic services);*
- **Integration of air vehicles and personal air vehicles (PAV):** in the future, new unmanned air vehicles and personal air vehicles (PAV) will fly long range and at higher altitudes to feed airports. This research will investigate the necessary seamless integration of those PAV into a higher automated ATM *(R&I need: On-demand air traffic services);*

#### 7.6.2.1.7.3 Topic DES-ER1-WA1.3: Fundamental Science and Outreach for U-space and Urban Air Mobility

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- Environment: project results are expected to demonstrate that there is no negative impact of the proposed solutions on the environment (i.e. emissions, noise and/or local air quality) or on potential improvement of the environmental footprint.
- Safety: project results are expected to maintain, at least, the same level of safety of the current ATM system.
- Security: project results are expected to maintain, at least, the same level of security of the current ATM system.



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- **Space-based CNS services**: the provision of CNS services using space-based technology will be researched. The purpose is to determine the effectiveness of space-based CNS services (e.g ADS-B, LDACS) to fulfil the requirements of ATC operations in upper and lower routes, and its potential implementation and use at the regional level. The research should refer to the ICAO Global Air Navigation Plan (GANP) and use the ASBU methodology *(R&I need: Infrastructure as a service);*
- **Digital Voice:** communication services are moving towards an IP-based approach. There is the need to further investigate how the dynamic allocation of IP connections may reduce the need for VHF channels on the ground side and the need for the airborne side to switch frequencies several times during the flight *(R&I need: Infrastructure as a service);*
- **Hardening the ATC systems:** this element covers the use of AI for systems hardening in ATC: using AI-based penetration testing to identify vulnerabilities during the development, deployment and industrialisation phase of new systems *(R&I need: Infrastructure as a service);*
- **Enhanced techniques to empower NM operations:** this element covers the enhancement of the data structure and data storage to empower the big data exploitation and analytics for improving NM strategic operations *(R&I need: Free flow of data among trusted users across borders).*
- **Application of Business Intelligence (BI) to the NM organisation:** this element aims at investigating on how to apply Business Intelligence (BI) strategies and technologies to improve the efficiency, stability and resilience of the Network via the data analysis of the business information *(R&I need: Free flow of data among trusted users across borders);*
- **Identification and resolution of new (cyber) threats:** The evolving ATM scenario, where digital infrastructures, platforms and service provision will be closely interconnected, will generate emerging cyber threats, mostly linked to a very high number of connected devices and data sharing. This situation will require the identification (and resolution) of new cyber threats, which represent the aim of this research element *(R&I need: Cyber resilience);*
- **Nurturing the (cyber)security culture:** Building the education and awareness of cybersecurity issues by humans using the technology. There is a need for the ATM to become cyber-resilient and investments in humans, as the users of the systems, are necessary since this is the easiest entry point of propagating the attack, and the cyber-aware culture is sorely needed. ATM system has to have the technology, processes and human aspects *(R&I need: Cyber resilience);*
- **Conducting remote simulations/validations:** this element focuses on remote simulations as a means of boosting participant numbers by being location and time-zone independent and allowing for a more flexible and iterative design process, especially for design evaluation in the lower maturity phases of system development. As this area is in the very first steps, research should determine how its potential can be explored, so that, for example, the problem of the shortage of participants can be circumvented, contributing also to the availability of a wider range of experts globally. With a possible decreased mobility demand and flexibility both in time and space due to post pandemic effects, this solution can provide both methodological and organizational benefits to the ATM community and research. Some aspects such as cultural/local ATM operational differences should also be studied, and more complex network effects analysed by enabling cloud based remote HITL (Human In the Loop) multisite simulations, in a direction which may have additional synergies with that of ATM virtualization. Technical and operational challenges related to cloud-based distributed simulations, especially in the case of HITL experimentation, should be addressed in relationship to the need to temporally



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- **Understanding the passengers expectations:** understanding passenger expectations (origin-destination, travel time, comfort, ecological impact, reliability) is a continuous activity linked to the flexibility/change over time of the demand vs request of each transport mode. How can aviation monitor the passengers expectation to improve its offer? How do changing passenger preferences will shape the future multimodal transport system (e.g. airport products and services and the airport as a multimodal node) *(R&I need: Passenger experience at the airport);*
- **Anticipating the disruptions**: this research covers the predictive and prognostic disruption forecast methods in support of pro-active mitigation and research on suitable management and recovery mechanisms *(R&I need: An integrated transport network performance cockpit);*

#### 7.6.2.1.7.6 Topic DES-ER1-WA1.6: Fundamental Science and Outreach for Aviation Green Deal

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- Environment: project results are expected to contribute to the achievement of the objectives of a 55% reduction by 2030 looking forward to net-zero greenhouse gas emissions by 2050, from a gate to gate perspective, by introducing new concepts enabling proper modelling of non-CO2 emissions and their impact on optimum green trajectories, also including the expected interoperability with new entrants (e.g. U-space flights).
- Capacity: project results are expected to contribute also to the issue of sector capacity by taking into account the same new entrants (e.g. U-space flights).

*Scope*

To successfully address the expected outcomes, the SJU has identified the following innovative research elements. The list is not intended as prescriptive, therefore proposals for work on areas other than those listed below are welcome provided they include adequate background and justification to ensure clear traceability with SRIA content.

- **Atmospheric physics for aviation:** this element covers the research in order to increase the body of knowledge into the physics of the atmosphere, to better understand the impact on global warming of non-CO2 emissions (NOx, SOx, H2O, particulate matter, etc.), including contrails and aviation induced cloudiness (R&I need: Non-CO2 impacts of aviation).
- **Comparative study on potential metrics to be adopted in the ATM domain to aggregate non-$CO_2$ and $CO_2$ impacts on climate change**: e.g. GWP 100, ATR 20, ATR 100 or alternative metrics. The project should start with a state of the art of environmental metrics and engage with all relevant stakeholders, in order to provide insight into the pros and cons of each potential metric and aim at formulating informed recommendations for the way forward, including identification of additional research needs, if applicable. This research should build on the work on Environmental Change Functions in SESAR ER project ATM4E *(R&I need: Non-$CO_2$ impacts of aviation)*.
- **Development of the environmental performance monitoring toolset to include new entrants:** this element covers the expansion of the ATM aircraft performance models (emissions and noise) to include new entrants and new aircraft types/fuel: research into the impact on the environment of new fuels and/or new aircraft types (hydrogen, electric, sustainable aviation fuels, new hyper/supersonics with consideration of sonic booms), including the development of new models to assess the impact that ATM operational changes may have when these aircraft


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- **AI for higher automation:** this element covers the development of an AI-powered cloud infrastructure and services (Automation levels 2 & 3 and potentially higher). Also, the aim is to develop automation of ATM processes for which analysis and prediction are susceptible to obtain a greater benefit from AI (Automation levels 2 & 3 and potentially higher), and to develop AI-powered ATM environment requirements, infrastructure and common regulation & certification guidelines *(R&I need: AI Improved datasets for better airborne operations)*;

- **Datasets**: datasets are essential for AI-based application development. Starting from an assessment of the state-of-the-art, this element is about researching on new ideas to generate and enable the automation of such aviation-specific data sets from a large variety of on-board and ground communication across the network, which could then enable broad range of AI-based applications for aviation. The research will cover also the legal (e.g. liability), financial and regulatory aspects. (*R&I need: AI Improved datasets for better airborne operations);*

#### 7.6.2.1.7.8 Topic DES-ER1-WA1.8: Fundamental Science and Outreach for Civil/military Interoperability and Coordination

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- **Civil-military coordination**: project results are expected to improve the civil-military coordination at Network Manager level, with sharable data of mission trajectory for better traffic prediction;

- **Security**: while assuring a better coordination, project results will ensure that the new data formats and information exchange services will, at least, maintain the current level of confidentiality, integrity and availability of information;

*Scope*

To successfully address the expected outcomes, the SJU has identified the following innovative research elements. The list is not intended as prescriptive, therefore proposals for work on areas other than those listed below are welcome provided they include adequate background and justification to ensure clear traceability with SRIA content.

- **Enhancing civil-military operations**: based on a survey of the existing procedures and services, this element aims at identifying new challenges related to the development of collaborative decision-making processes for improved civil/military coordination, both for manned and unmanned military assets.

- The research will investigate on procedures, data formats (including the necessary levels of cybersecurity and data-protection) and information exchange services. An assessment of the relevant performance measurements will be also performed *(R&I need: access to airspace & System-wide information management (SWIM))*;

- **Performance management** : Environmental sustainability, cost efficiency or delays imposed by inefficient use of available capacity represent a concern against which all aviation stakeholders have to assume responsibility. The complex interdependencies between civil and military stakeholders need to be examined to enable appropriate performance measurements in a spirit of balanced consideration between commercial needs and security and defence requirements *(R&I need: performance orientation & System-wide information management (SWIM))*


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The dynamic weather and geometry-dependent pair-wise distance/time based separation minima for En-Route and TMA will allow the reduction of the minimum separation applicable between two aircraft under certain weather conditions (e.g. location of the tropopause, wind, etc); the separation to be applied will be the greatest of the Minimum Radar Separation (MRS) and the Minimum Wake Separation (MWS). The operational improvement also covers combined separation minima and the consideration of flight-specific data *(R&I need: Advanced separation management (u-space integration and new separation modes))* .

- **Use of advanced MET information and capabilities**: this research covers the needs for:
    - Incorporating the ensemble weather information into decision-support tools, adapted for different ATM stakeholders;
    - Producing very high-resolution, very short-range weather forecasts using numerical weather prediction models and observational data assimilation.

  *R&I need: Advanced separation management (u-space integration and new separation modes))* .

- **Enhanced arrival/departure runway occupancy time:** scope is to enhance the arrival runway occupancy time calculation, thanks to efficient runway turn-off and combination of existing optimized braking to vacate solutions, at a pre-selected runway exit, by using new applications for assisting the flight crew in achieving an efficient turn-off until aircraft has left runway protected area on the runway exit. Similarly, the research should also enhance the departure runway occupancy time calculation, thanks to efficient line-up and take-off. The research shall address potential on-board applications to assist the flight crew of a departing aircraft for a more efficient (fast, accurate, reliable and safe) line-up and take-off *(R&I need: Runway use optimisation through integrated use of arrival and departure time-based separation (tBS) tools);*
- **Optimised and resilient runway throughput:** this element investigates how to enhance MET resilience to LVP and thunderstorms, and revisiting SOIR (Parallel or Near-Parallel Instrument Runways ) separations in light of advanced technology and surveillance capabilities, integrated with coupled AMAN/DMAN and TBS toolsets for both arrival and departures *(R&I need: Runway use optimisation through integrated use of arrival and departure time-based separation (tBS) tools);*
- **Ground and airborne safety nets are adapted to new separation modes:** and advanced separation management that will require close conformance monitoring of the negotiated and authorised flight trajectories throughout the execution phase, so that operations are not disturbed by unnecessary resolution advisories, in particular if lower separation minima is introduced/considered. Consideration as to the level of independence of the safety nets from the other aspects of control will be critical as the levels of autonomy of detection, classification, resolution and monitoring of conflicting profiles in the planning and tactical phases of ATM will significantly increase *(R&I needs: Integration of safety nets (ground and airborne) with the separation management function);*
- **TBO Machine-to-machine flight-deck-ATC negotiation:** this element covers the machine-to-machine negotiation-based conflict resolution; the development of mechanisms and tools for creating negotiation-based resolutions at conflict resolution and collision avoidance levels (e.g. what-if EPP based tools, or ATC offering a choice to the FMS of two potential cruising levels, etc) will be addressed. This is a flight-deck to ATC solution (i.e. AOC involvement) *(R&I need: Advanced separation management (u-space integration and new separation modes));*

- **Application of physiological measurements to air traffic control:** the aim is to research on the application of physiological measurements to air traffic controllers (e.g. measuring of brain waves to assess the level of attention, use of speech recognition combined with physiological measurements to monitor stress, correlation of eye-movement patterns with the occurrence of events that are potentially safety relevant) *(R&I need: role of the human);*
- **Trajectory broker in all phases of ATFM operation:** this element covers the trajectory broker layer, on how to make better use of available capacity in all phases of ATFM operation (long-term, medium-term, short-term and execution phases) and in all areas (airport, TMA, En-Route) addressing technical aspects but also taking on-board the necessary regulatory/organisational changes *(R&I need: network-wide synchronisation of trajectory information);*

#### 7.6.2.1.8.2 Topic DES-ER1-WA2.2: ATM applications-oriented for Air-Ground Integration and Autonomy

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- **Capacity**: project results are expected to contribute to capacity by enhancing the management of separation minima, both for En-Route and TMA and the provision of meteorological information. At airport level the solutions will enhance the arrival runway occupancy time calculation and the resilience of runway throughput to meteorological disruptions, enhanced departure queue management, improved visual separation procedures for the aerodrome circuit and fully automated airport operations through improved predictability.
- **Cost efficiency**: project results are expected to demonstrate that, with new services supported by ground-ground and air-ground connectivity, cost efficiency is expected to be improved.
- **Operational efficiency**: projects results are expected to contribute to the improvement of the operational efficiency thanks to advanced communication means and increased automation (e.g machine-to-machine communication). Also the trajectory management is expected to improve.
- **Safety**: project results are expected to maintain, at least, the same level of safety of the current ATM system.
- **Security**: project results are expected to maintain, at least, the same level of security of the current ATM system.

*Scope*

To successfully address the expected outcomes, the SJU has identified the following innovative research elements. The list is not intended as prescriptive, therefore proposals for work on areas other than those listed below are welcome provided they include adequate background and justification to ensure clear traceability with SRIA content.

- **Frequency management:** this research will investigate, from a gate-to-gate perspective, the air to ground (A/G) automation to ensure the use of automatic link and frequency selection for communications by the pilot and ATC. This is expected to support also single-pilot and cross-border operations *(R&I need: Enabling greater ground and airborne integration and wider performance);*
- **Machine to machine communication:** besides controller-pilot datalink communications (CPDLC) and human-to-human communication, datalink will also support machine-to-machine communication. Technical and operational requirements, as well as use cases and initial


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- The integration of network and local tools e.g. AU, Airport and ANSP (FMP/INAP) in a rolling and dynamic process, including further automation support in the coordination of DCB actions from long-term to execution phases;
- The hot spot management using traffic monitoring values, standing for different objectives (safety, rate optimisation, critical situations, etc.) to define and address different types of spots (regions of interest);
- The usage of modelling and operational data to understand typical resolutions to network planning and traffic management problems to develop optimisation capabilities which are less human centric;

- Future Digital network services: the research will address:
  - Machine learning to identify and exploit information patterns, and artificial intelligence to identify and design new elementary basic sector volumes for complexity detection and resolution, balancing workload and resources optimisation;
  - The use of Big Data analysis, machine learning and digital-twin techniques for better planning the reactions of the actors (ATCOs, FMPs, AUs) to potential operational improvements based on the emerging trends (e.g. incentives, etc.).
  - Innovative DCB resolution algorithms, e.g. using radically different algorithms to what is currently in use, or using alternative approaches;
  - Use of new data sources (e.g. Big Data), machine learning algorithms (including neural networks), AI-based decision support tools, behavioural economics, improved market modelling, complexity science, etc. to support network operations (e.g. models and methods for improving demand, flow and complexity forecasting and resolution).
  - Use of Big Data and machine learning to identify best practices regarding regulation strategies for particular traffic load patterns based on historical data, and development of optimized strategies for the most frequent traffic load situations in the European ATFCM network.

  *(R&I need: On-demand air traffic services);*

- **Digital Airlines Operations:** this element will cover the improvements of airline operations based on the use of digital technologies (e.g. big data, machine learning algorithms, AI, IoT, behavioural economics, improved market modelling, complexity science, etc.) to support the airline decision making processes in disruption scenarios, the integration of airline operations into the network, the collaboration between FOCs, network management function and ATC and the better consideration of airspace users' preferences in the DCB and sequencing processes. The use of new data sources (big data), machine learning algorithms, AI based decision support tools, etc. to support airline decision making in disruption scenarios is expected to improve the resilience of the system *(R&I need: On-demand air traffic services);*

- **New trajectory pricing schemes**: this element will cover the development and initial validation of new trajectory pricing schemes to support a more flexible distribution of the demand *(R&I need: On-demand air traffic services);*

- **Flexible Flight Level (FL) structure:** aim of the research is to develop NM calculation of most optimal division FL structure for specific periods of time, processes for agreement with ATC's

#### 7.6.2.1.8.4 Topic DES-ER1-WA2.4: ATM applications-oriented for U-space and urban Air Mobility

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: project results are expected to demonstrate that there is no negative impact of the proposed solutions on the environment (e.g. noise) or on potential improvement of the environmental footprint.
- **Passenger experience**: projects results are expected to improve the citizens wellbeing with the validation of operational and technical requirements linked to UAM, while protecting their privacy and contributing to the social acceptance of the new entrants.
- **Capacity**: project results are expected to demonstrate that capacity is not affected by the possible development of new U-space services or the validation of operational/technical requirements. Also, the definition of indicators and metrics linked to U-space should help demonstrating that no negative impact on capacity is introduced.
- **Cost efficiency**: project results are expected to demonstrate that U-space shall not negatively affect the cost of providing ATM services. The definition of specific cost-efficiency indicator and metrics for U-space will focus on this aspect.
- **Operational** efficiency: projects results are expected to demonstrate that the requested validation of operational and technical requirements for UAM will not impact the operational efficiency of the current ATM system.
- **Safety**: project results are expected to define a safety framework for U-space, including metrics and indicators, able to demonstrate that level of safety of the current ATM system is, at least, maintained.
- **Security**: project results are expected to maintain, at least, the same level of security of the current ATM system.

*Scope*

To successfully address the expected outcomes, the SJU has identified the following innovative research elements. The list is not intended as prescriptive, therefore proposals for work on areas other than those listed below are welcome provided they include adequate background and justification to ensure clear traceability with SRIA content.

- **Validation of UAM Operational and Technical requirements:** this research will look at the development and validation of the operational concept of UAM, looking at the additional requirements for the urban environment (compared to the U-space requirements for non-urban airspace). Also, the delta from the U-space in terms of Infrastructure, C, N and S challenges in the urban airspace should be addressed *(R&I need: Enable urban air mobility (UAM));*
- **Measures to protect the privacy of the European citizen in a U-space environment**: this research aims at identifying, collecting and reviewing requirements to protect the privacy of


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- **Security**: project results are expected to contribute to the improvement of the level of (cyber)-security of both, legacy and new developed ATM services and systems, providing also the necessary standardisation and regulatory framework.

*Scope*

To successfully address the expected outcomes, the SJU has identified the following innovative research elements. The list is not intended as prescriptive, therefore proposals for work on areas other than those listed below are welcome provided they include adequate background and justification to ensure clear traceability with SRIA content.

- **Safety vs Cyber-security:** safety and Security are intricately intertwined. Identify use-cases where safety risk mitigating measures and security risk mitigating measures are conflicting, and provide guidance on how to resolve such conflicts during the design phase. Examples may include time consuming processes for systems certification (safety) versus fast processes for patch management (security), and open data exchange for surveillance, e.g. TCAS, ADS-B (increase of awareness) versus encrypted data exchange for surveillance (protect data against abuse) *(R&I need: Future data-sharing service delivery model)*;

- **New virtualisation business model:** virtualisation, i.e. decoupling the provision of ATM data services from ATS, is expected to allow a better offer of airspace capacity via collaboration between the Network Manager and the ATSUs. New and/or different business models could be identified and investigated, along with the possibility to have emerging new ATM players, which would l foster competition in the sector. Examples of questions to be addressed in this element are: how will virtualisation impact the way the ANSPs will make implementation choices? How will the new ATM services be provided? *(R&I need: scalability and resilience):*

- **Improved platforms interoperability:** this research is about how to improve the sharing and exchange of ATM data via interoperable platforms to allow the improvement of existing and new ATM services and processes, by using both, existing data exchange concepts (e.g. SWIM) and new ones. The research should consider the associated cyber-resilience aspects *(R&I need: Free flow of data among trusted users across borders);*

- **Regulatory frameworks for future ATM services:** this element covers the assessment of the need for new/updated legal and regulatory frameworks for the provision of ATM services in a SOA (Service Oriented Architecture) environment. In the specific, operating expense (OPEX) and lower capital expense (CAPEX) requirements should be addressed *(R&I need: Regulations and standards)*;

- **Evolution of route charging and cost-recovery mechanisms:** this elements investigates how the route charging and cost-recovery mechanisms should evolve in order to move towards a service oriented provision scheme that is supplier-independent *(R&I need: Regulations and standards)*;

- **Efficient application of standards:** this element covers the need for the efficient application of standards, procedures and guidelines addressing safety, privacy and cyber resilience risks, which is a key element to protect ATM information and information systems. Therefore, it is necessary to further develop cyber-resilience standards and regulations, procedures and guidelines based, also, on the ones from other domains (e.g. block-chain). *(R&I need: Regulations and standards)*;



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- **Future airport business model:** this research is about how the airport business model of the future is expected to evolve in terms of adjustments to emerging/changing passenger requirements, airline business models, integrating new procedural requirements *(R&I need: Access to /exit from the airport: Airports are obvious multimodal nodes for aviation);*

- **Multimodal governance:** this element covers the study of governance and standards to facilitate the coordination between transport modes in a multimodal environment; the need for regulation to ensure level playing field for service providers, preventing market dominance or uncompetitive pricing from limited providers, not limiting market access for others; the assessment of multimodal trip pack creation & corresponding insurance. Also, there is the need to investigate how to complement the security policies between air and other means (e.g. rail), especially keeping in mind the importance to reduce the administrative burdens *(R&I need: Access to /exit from the airport: Airports are obvious multimodal nodes for aviation);*

- **Multimodal decision making tools:** this research area covers the development of decision support systems for intermodal solutions to manage systems at tactical and/or strategic level (e.g., collaborative optimisation of passenger or goods flows across a multimodal transport chain, optimal use of available capacity, etc) *(R&I need: Access to /exit from the airport: Airports are obvious multimodal nodes for aviation);*

- **Advanced techniques for passengers flow prediction:** this element aims at developing advanced predictive models to anticipate the evolution of an airport's passenger flows within the day of operations and assess the operational impact on both airport processes and the ground transport system, with the aim of enabling real-time collaborative decision-making between airports and ground transport stakeholders and enhanced passenger information services *(R&I need: Passenger experience at the airport);*

- **Travelers behaviour analysis, modelling and simulation:** this element investigates the need for new/different big data sources for the analysis of multimodal travel behaviour (including the requirements for integrated, private data where all service providers can sell capacity into an integrated booking system, but retain their own supply privacy), the need for a better representation of multimodal trips in transport and traffic simulation models, integration of commercial sensitive data from air and ground transport operators into passenger demand models (through, for example, federated machine learning models), study on the impact of the shift from feeder flights to other transport modes (environment, D2D time, better resource allocation, free up airport slots, etc) *(R&I need: Passenger experience at the airport);*

- **Passenger travel behaviour and requirements:** this research covers the factors affecting passenger mode choice, especially the ones driving the decision for using a particular mode on different distance segments (e.g. short-haul traffic air vs. rail and complementarity between these), the requirements along the journey (travel time, comfort, price, $CO_2$ emissions, …) and how these requirements will affect future door-to-door journeys. Also, the passengers journey planning has to be considered: how to improve the D2D options/information for multimodal travel for passengers, by (for example) offering one ticket for multimodal trips; single ticketing; MaaS tickets, one-stop shops, etc. *(R&I need: Passenger experience at the airport);*

- **Integrated performance network**: this element covers the establishment of an overall transport network performance framework to improve passenger experience and planning, via an improved collaboration between different modes of transport, improved integration of data and processes, definition or GDPR-compliant requirements for the collection, analysis and geometric altimetry. In addition to the environmental benefits, it will also facilitate the approach and landing (e.g. no need to transition from barometric to geometric altimetry during the approach), with safety benefits, will facilitate the integration of manned aviation with drones that are already using geometric altimetry in current operations, and also integration with HAO (High Altitude Operations), where precision of barometric altimeters above FL800 is challenging. The research will need to consider the transition aspects. An important part of the research will have to be represented by the assessment of the benefits that the move to geometric altimetry would bring, including both benefits to the environment and also the benefits to safety (*R&I need: Optimum Green Trajectories*).

- **Evolution of separation minima and RVSM 2:** Building on the work of SESAR 2020 ER project R-WAKE, to develop and validate a concept of operations to allow the reduction of vertical separation minima to 500 ft. in a geometric altimetry environment between certain aircraft types and under certain meteorological conditions (RVSM 2 concept), which will bring increased capacity (estimated increase 20%) and reduced $CO_2$ emissions by making it possible for more aircraft to cruise at their preferred altitude. Safety benefits are also expected, because the concept also includes an increase of separation minima (e.g., vertical separation increase to 1.500 ft., or requirement to add a small (for example 1NM) horizontal separation to the 1.000 ft. separation minima for certain aircraft pairs when atmospheric conditions are known to be such that wake turbulence is specially persistent, thereby reducing the risk of wake encounters in the En-Route phase of flight. Please note that it is expected that the RVSM 2 concept will not be possible with the precision that is possible with barometric altimetry (it will require the increased precision provided by geometric altimetry described in the previous bullet point) (*R&I need: Optimum Green Trajectories*).

- **Introduction of environmental considerations in the European route charging scheme:** This element covers the research into the potential evolution of the route charging scheme to incorporate environmental considerations, such as lower charges for flying at valley hours, lower charges for flying at sub-optimal flight levels (or with longer 2D routes) to reduce non-$CO_2$ impacts, lower charges for lighter flights accepting voluntary level capping in order to make best flight levels available to heavier aircraft, higher charges for aircraft with lower load factors or for business aircraft, etc. *(R&I need: Accelerating decarbonisation through operational and business incentivisation)*.

#### 7.6.2.1.8.8 Topic DES-ER1-WA2.8: ATM applications-oriented for Artificial Intelligence (AI) for aviation

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: project results are expected to demonstrate the positive impact of AI-based solutions to operational mitigations of aviation's environmental impact.

- **Capacity**: project results are expected to contribute to capacity by addressing AI-based human operator support tools to ensure the integration of "new entrant" aircraft types

- **Operational efficiency**: projects results are expected to improve the operational efficiency by enabling a better traffic prediction and forecast, thus contributing to punctuality.



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#### 7.6.2.1.9 Work Area 3 – Knowledge Transfer Network (CSA)

***Note: Please note that the description of this Work Area 3 is not definitive and may be subject to updates during the course of finalising this MAWP.***

This work area comprises the support to the SJU to continue supporting the overarching view across ATM exploratory research established in SESAR2020, providing a coordinated exchange of research knowledge across a wide range of relevant themes, and within the context of this networking, help to further stimulate the future ATM skilled work-force. The challenge is to support and encourage collaborative research on future and emerging innovative ideas, expertise and knowledge for the benefit of the future evolution of the European ATM system and its people.

##### 7.6.2.1.9.1 Topic DES-ER1-WA3.1: Knowledge Transfer Network

*Expected Outcomes*

The expected outcomes from the Knowledge Transfer Network activities will be cross-fertilization of knowledge from other disciplines that will encourage the exploration of innovative and unconventional ideas and research directions in ATM.

The Network activities will be encouraging European research leadership of new and emerging ATM concepts and will enhance the way cutting-edge research is better linked with operational challenges faced by industry, and emerging air transport policy.

At the core of the network there should be 'thematic challenges', determined by the wider research community and supported by dedicated workshops, and 'catalyst funding' focused projects, stimulating the transfer of exploratory research results towards ATM application-oriented research and promoting cooperation between the academia and the industry.

Building on the 'knowledge hub' (i.e. the wiki) set up by the SESAR2020 ER project Engage, in which members across the research community were continuously involved and representing a one-stop, go-to source for information, a single European point of entry for ATM knowledge is expected to be provided.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Communication:** organisation of workshops and symposiums, ATM research summer schools, the development of newsletters and other actions aimed at the dissemination and sharing of SESAR exploratory research and KTN Catalyst funded projects results, potentially including the publication of a European ATM periodic academic journal and/or publishing a series of special issues in existing journals.
- **Roadmap**: building on the outcomes of the SESAR 2020 ER Engage project, keep monitoring, identifying and analysing new opportunities for innovative ATM research of relevance to the evolution of the European ATM system and the consolidation of a long-term roadmap of innovative and interdisciplinary ATM concepts.



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#### 7.6.2.2 Call HORIZON-SESAR-2022-DES-IR-01

##### 7.6.2.2.1 Indicative call timetable

| | |
|---|---|
| Publication date | January 2022 |
| Opening date | January 2022 |
| Final date for submission | April 2022 |
| Information on the outcome of the evaluation | Maximum 5 months from the final date for submission |
| Signing of grant agreements | Not later than the end of 2022 |

**Table 7: Indicative timetable for the DES IR1 call for proposals with reference HORIZON-SESAR-2022-DES-IR-01**

##### 7.6.2.2.2 Indicative call budget

The indicative budget for this call is EUR 171.000.000 amongst which EUR 121.000.000 will be allocated to Industrial Research activities and EUR 50.000.000 will be allocated to Fast Track Innovation & Uptake.

| Budget | Commitment (first estimate) | Payment (first estimate) |
|---|---|---|
| | In 2022: EUR<br>In 2023: EUR | In 2023: EUR |

**Table 8: Indicative budget for the DES IR1 call for proposals with reference HORIZON-SESAR-2022-DES-IR-01**

##### 7.6.2.2.3 Budget to scope allocation

Taking into consideration the experience from the SESAR 2020 calls, the SESAR 3 JU will establish the allocation of budget per Work Area as shown in the table below. In addition, a maximum EU requested contribution per proposal (capping) will be allowed to ensure the possibility to award multiple projects and avoid getting a single project proposal asking for a substantial part or total of the Work Area budget.

These conditions are intended to allow the specific Topics to be addressed appropriately.

| DES IR1/FTIU | Maximum Budget | Capping per Proposal |
|---|---|---|
| | 171 M€ | |
| **IR1** | **121 M€** | |
| WA 1 | 4 M€ | 2 M€ |
| WA 2 | 30 M€ | 5 M€ |
| WA 3 | 55 ~~62~~ M€ | 10 M€ |
| WA 6 | 25 M€ | 5 M€ |
| **FTIU** | **50 M€** | |
| WA 4 | 35 M€ | 7 ~~5~~ M€ |
| WA 5 | 22 ~~15~~ M€ | 5 M€ |

### Industrial Research & Validation Activities (Work Areas 2, 3 & 6)

| Type of Actions | **Excellence**<br><br>*(The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme)* | **Impact** | **Implementation** |
|---|---|---|---|
| Research Innovation Actions (RIAs) | 1. Clarity and pertinence of the proposal: degree to which the objectives, scope and requirements defined in the Technical Specifications are well understood and fully addressed.<br><br>2. Soundness of the proposed methodology : degree to which the proposed methodology is feasible and adequate to develop the SESAR solutions from their initial to their target maturity level). It also includes appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end-users where appropriate.<br><br>3. Level of awareness of the state-of-the-art: degree to which the proposal demonstrates knowledge of current operations and relevant previous R&D work (both in and outside of SESAR) and explains how their proposed work is beyond the state of the art, and demonstrates breakthrough innovation potential. | 1. Credibility of the pathways to achieve the expected outcomes and impacts specified in the technical specifications, and in particular demonstrating compliance with **the specific technical criteria** defined here after.<br><br>2. Appropriateness of the contribution to standardisation and regulation: the proposal demonstrates that the project will adequately contribute to the relevant standardisation and regulatory activities.<br><br>3. Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities. | 1. Quality and effectiveness of the work plan : degree to which the proposed plan and schedule are compliant with the Programme Execution framework, including assessment of risks,.<br><br>2. Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise |

| | | | |
|---|---|---|---|
| | initial to their target maturity level. It also includes appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end-users where appropriate.<br><br>3. Level of awareness of the state-of-the-art: degree to which the proposal demonstrates knowledge of current operations and relevant previous R&I work (both in and outside of SESAR) and explains how their proposed work is beyond the state of the art, and demonstrates breakthrough innovation potential | regulation: the proposal demonstrates that the project will adequately contribute to the relevant standardisation and regulatory activities.<br><br>3. Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities. | |

**Specific technical criteria for FTIU call** :

The following technical criteria are part of the Award Impact criteria and will be used during the evaluation of the proposals. The tenderer will have to describe how the proposal complies with the relevant criteria :

Demonstrating a high potential contribution to establishing Europe as the most environmentally friendly to fly in the world.

Demonstrating a significant contribution to the realization of the Digital European Sky vision (SESAR Phase D) in particular in relation to achieving:

- Fully scalable services supported by a digital ecosystem,
- Implementation of Digital European Sky target architecture and transformation to Trajectory based operations,
- Highly resilient and efficient airport operations, passenger-centric, multimodality,
- Single pilot operations, delegation of separation responsibility to systems,
- High and Full Automation (level 4/5),
- Full U-space services;

Demonstrating the need for finding a common solution across the European Network (vs local) with a clear need for standardisation;

Demonstrating a clear breakthrough potential (vs business as usual) in a medium (2025) term;

line with the targets set in Flightpath 2050. To this end, a set of operational measures to improve the fuel efficiency of flights will have to be put in place. At the same time, to ensure sustainable air traffic growth, it is necessary to speed up the modernisation of the air infrastructure to offer more capability and capacity, making it more resilient to future traffic demand and adaptable through more flexible air traffic management procedures and a charging scheme that does not make it interesting to fly unnecessary distance. Furthermore, reducing aircraft noise impacts and improving air quality will remain a priority around airports.

#### 7.6.2.2.7.1 **Topic DES-IR1-WA2.1: Industrial Research Aviation Green Deal**

*Expected outcomes*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: the introduction of automation and dynamicity will enable AUs to fly trajectories that are closer to their optimal, resulting in fuel efficiencies and thus overall emission reductions. Innovative approaches such as Wake Energy Retrieval (WER) will bring additional $CO_2$ reduction.

  The proposed concept will open the door to a better understanding of climate impact of Non Co2 emissions, especially vis-a vis the trade-off with Co2. It will as well allow mitigating part of the non Co2 impact by tackling effectively contrails formation

  The concepts addressing the airport environment will allow improving the Local Air Quality (LAQ) and help reducing the noise impact on the communities neighbouring the airport.

- **Capacity**: a high level of automation will make it possible to introduce the proposed concepts without a negative impact on capacity; furthermore, the WER concept will make it possible for aircraft to be closer together in the cruise phase of flight, thereby increasing airspace capacity.

- **Safety**: the development of adequate system support for the new concepts based on a high level of automation and their validation in an operational environment will guarantee that the safety levels are either maintained or increased.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Increased flexibility in low-density en-route environments:** this element covers the development of a concept of operations for establishing more flexible clearance scheme for manned or unmanned aviation in low density continental en-route airspace or in oceanic/remote airspace. This could be applied for example at night, but also during the day for aircraft flying above the most common flight levels (e.g. FL 430, mainly business aviation, but could also be airliners or general aviation). The targeted flexibility would include free lateral or vertical route deviation (without the need to require a new route clearance) for flight optimization purposes, so aircraft could for example be cleared to cruise at any fixed geometric altitude between two flight levels (thereby avoiding the climb and descent required to maintain a fixed barometric flight level), or freedom to deviate horizontally within a certain area, allowing more effective use of favourable winds *R&I need: New Ways of Flying)*.

that AMAN builds a sequence for *(R&I need: Environmentally optimised climb and descent operations (OCO and ODO))*.

- **Introduction of dynamicity in the use of RNP route structures:** this element will develop and validate a concept for RNP route structures (trombones, point merge or other) to be activated or de-activated, e.g. depending on the time of day for noise control purposes, or depending on demand, so that the use of more complex route structures is avoided during periods of low demand. The research needs to address the en-to-end concept, including cross-border aspects and the delivery of the appropriate STAR clearance to each aircraft via voice or CPDLC. Please note this concept addresses only SIDs and STARs above 3.000 ft (where noise may be a factor, but LAQ is not a factor) *(R&I need: Environmentally optimised climb and descent operations (OCO and ODO))*.

- **Improved airport environment through dynamic standard instrument departure (SID) and noise abatement departure procedure (NADP) allocation:** this element includes the definition of new NADP concepts and a combined SID and NADP allocation concept that will be based on the optimisation of environmental impact functions that consider potential trade-offs between local capacity, LAQ, noise impacts in the area around the airport and impact on the climate at global level. It is anticipated there will be an initial concept in which the SID scheme is established in advance depending on the MET prediction, for example 4 hours in advance, and published so that AU can consider it in their flight-plan. In the longer term, the allocation will be done on a case-by-case basis and more dynamically (up to just before the aircraft leaves the gate) *(R&I need: Non-$CO_2$ impacts of aviation)*.

- **Green ATC capacity concept:** for an ANSP to be cost efficient, it needs to tailor the ATC capacity that is offered to the expected demand and avoid offering any capacity that is not going to be used, but a system operating at the limit of its capacity has less ability to be able to facilitate that AU fly their optimised trajectories. This research will investigate the concept of the green ATC capacity, whereby when the ATC capacity of a sector/airport is calibrated, in addition to the maximum capacity (including sustain and peak concepts), a (lower) maximum green capacity is used to represent the maximum sector load for which ATC can facilitate environmentally optimised trajectories. Costs and benefits will be assessed in a real world scenario. Ideally this would be a life demonstration. The Green ATC capacity is expected to support improved ANSP decision making in the area of sector configuration in real time (link to dynamic airspace configurations) and also in the area of strategic capacity planning, including the impact assessment for building new runways.

  Note that for the airport planning there is a connection to multimodality;  for example, a runway used to maximum throughput provides capacity, but this capacity is not ""green"", because maximum throughput means more ASMA time, holding, etc.), and therefore building a new runway (potential with capped capacity) may be more environmentally friendly than using the existing runway to maximum capacity and deviate the excess demand to a secondary airport, with the associated environmental impact of passengers traveling to the secondary airport instead of to the main airport). "

- **Local (airport/TMA), ATSU-level and network-wide digital environmental performance dashboards:** Building on previous environmental performance monitoring initiatives like existing airport LAQ and noise monitoring programmes and the existing European CDO/CCO monitoring dashboard, these demonstrators will accelerate the deployment of environmental performance monitoring dashboards across Europe. The aim is not only to provide visibility of

#### 7.6.2.2.8 Work Area 3 - IR Topics (SESAR-RIA)

***Note: The SESAR JU has translated the content of the SRIA into an initial list of Horizon Europe call topics and accompanying descriptions (See below). Please note that the list and description are not definitive and may be subject to updates during the course of finalising this MAWP.***

This work area will focus on the delivery of the next generation of enabling platforms and services in view of achieving the ambition of the Digital European Sky.

##### 7.6.2.2.8.1 Topic DES-IR1-WA3.1: Connected and Automated ATM

This topic addresses the research needed to achieve automation level 4 (high automation) across the European ATC platforms . As described in the European ATM Master Plan 2020, in this level, high automation supports the human operator in information acquisition and exchange, information analysis, action selection and action implementation for all tasks/functions. Automation can also initiate action for most tasks.

*Expected outcomes:*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: Improvements to the connectivity and automation of will enable ATM to facilitate more efficient ground operations and air trajectories that are closer to the optimum thus limiting emissions, decreasing noise and local air quality
- **Capacity**: The safe use of less restrictive separation modes, combined with increased level of automation support to ATC, will optimise the use of the airspace. Improvements in ground operations predictability and integration of advanced tools for arrival and departure will help to optimise runway use. Better connectivity between stakeholders, the use of shared 4D trajectories, interoperability and higher predictability brought about by increased automation will increase capacity.
- **Cost-efficiency**: The implementation of higher levels of automation, when adopted consistently, will contribute to operational harmonisation and eventually to cost efficiency. A service-based approach and a well-defined required service level (e.g. for CNS services) will also help to achieve cost efficiencies.
- **Operational efficiency**: Shared 4D trajectories and interoperability will increase the predictability, enabling the preferred trajectories to be flown with fewer tactical interventions.
- **Safety**: The performance of the system (human and automation) in an environment with increased automation includes safety, which will be maintained if not improved. The automation of some procedures shall ultimately lead to improved safety and fewer errors, which tend to be human-triggered. Additionally, the increase in data sharing will also foster the early detection of potential safety issues and their mitigation.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

   - Runway and surface movement assistance for more predictable ground operations (e.g. Automation of stand planning, taxi routing and ground de-confliction, and runway use optimisation…)
   - Runway use optimisation through integrated use of arrival and departure time-based separation tools
   - Intelligent queue management (e.g. using machine learning and big data techniques)
   - Consideration of the role of the human in the new joint human machine cognitive system.

  *(R&I need: **Airport automation including runway and surface movement assistance for more predictable ground operations;** Runway use optimisation through integrated use of arrival and departure time-based separation (TBS) tools; Intelligent queue management; Role of the human; Speech recognition for increased safety and reduced workload)*

- **Next generation applications for Network operations:** This challenge refers to the development of Level 4 automation functionalities for Network operations leveraging state of the art technologies and capabilities. It includes for example Network-wide synchronisation of 4D trajectory information and providing trajectory advice (including uncertainty considerations and improved weather forecasts) to ATCOs for human confirmation or automatic implementation.

  *(R&I need: **Network-wide synchronisation of trajectory information**)*

- **Future Connectivity and digital infrastructure:** This challenge refers to the development of hyper-connectivity solutions between all stakeholders (ground-ground and air-ground) via high-bandwidth, low latency fixed and mobile networks leveraging state of the art technologies (e.g. broadband connectivity, cloud services, IoT…) and the delivery of the digital backbone infrastructure (CNS and beyond) required by the digital European sky applications. R&I results shall enable the full implementation of concepts such as infrastructure as a service (IaaS) to facilitate the complete decoupling of service provision (infrastructure services, information services and all other ANS) from the physical location of the infrastructure as outlined in the target architecture defined in the European ATM Master Plan. It includes for example the following features:
   - Enabling the deployment of a performance-based communications, navigation and surveillance (CNS) service offer and transitioning to data services
   - Development of integrated , digital CNS solutions (e.g. L-DACS, Satellite based CNS)
   - Data communication as primary means of Air/Ground connectivity
   - Move from VHF voice to digital voice for controller-pilot communications
   - Development of Internet of things for aviation (Machine-to-machine communication for real-time and automatic decision-making )
   - Development of full IP-based communications and use of higher bandwidth mobile networks, including satellite-based solutions
   - The development of non-safety-of-life ATM applications using commercially available services (e.g. 5G, open SATCOM) required for hyper-connected ATM
   - Air-Ground and Ground-ground data communication solutions for RPAS (including remote-pilot to controller voice and CPDLC communications )
   - Operational use of datalink in the airport surface as per this element covers the ICAO TBO FF-ICE
   - Development of advanced applications of SWIM technical infrastructure

  *(R&I need: **Enabling the deployment of a performance-based communications, navigation and surveillance (CNS) service offer**)*



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- Advanced airborne systems supporting Single-Pilot Operations (SPO): In order to operate safely with a reduced crew, safety systems will be a key enabler to trigger the back-up modes in case of incapacitation, stress or exhaustion of crew members. This involves the development of systems such as Augmented & Virtual reality for smart/enhanced visual operations, Airborne digital assistants, Connected Flight Management system , Multi-sensors Navigation, Airborne Collision Avoidance, automated ATC communication and frequency management.

- Autonomous navigation in all phases of flight (landing, taxi and take-off, approach in all conditions with limited ground infrastructure)
- Advanced airborne systems supporting RPAS and HAO integration into ATM such as, data communication , airborne safety nets, Detect And Avoid (DAA) and Remain Well Clear (RWC) functionalities.

*(R&I need: **Single-pilot operations (SPO);** Enabling greater ground and airborne, integration and wider performance; Integration of drones in all classes of airspace (IFR and VFR); Super-high-altitude operating aerial vehicles)*

- **Air/Ground Integration enabling future operations :** This challenge refers to the development of operational solutions allowing for the safe integration of autonomous airborne operations (Single-pilot operations (SPO), RPAS and HAO) into the ATM system. It includes for example:

  - Operations for safe return to land in Single-Pilot Operations : conditions under which pilot incapacitation is declared and how it is handled by the various actors involved, definition of ground assistant role when the pilot is in command, the definition of incapacitation declaration and management procedures, between aircraft, the airline operation centre and ATM.

  - Operations for FOC-WOC/ATC connectivity in Single-Pilot Operations: addressing the expected role of FOC/WOC in the case of SPO abnormal situations requires their connection to ATC centres to support safe return to land even in a congested traffic environment.

  - Operations enabling the Integration of drones in all classes of airspace : This covers the integration with cooperative and non-cooperative traffic of small vehicles that are mainly operating at very low level (VLL) close to urban areas and airports, as well as large vehicles, such as remotely-piloted aircraft systems (RPAS), used both for civil and military applications .

  - Operations for Super-high-altitude operating aerial vehicles :this involves safe and efficient separation management, entry and exit procedures through segregated or non-segregated airspace.

  *(R&I need: **Single-pilot operations (SPO);** Enabling greater ground and airborne, integration and wider performance; Integration of drones in all classes of airspace (IFR and VFR); Super-high-altitude operating aerial vehicles)*

- **Integrated 4D trajectory automation in support of trajectory-based operations (TBO)** This challenge refers to the development of a common 4D trajectory, shared between every

*Scope:*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Applications for resilient ,cross-border, On-demand air traffic services and Dynamic airspace management:** This challenge refers to the development of applications leveraging state of the art technologies to deliver resilient, cross-border, on-demand air traffic services and dynamic airspace management. It includes for example, the following features:
  - Flexibly allocating resources to where they are required due to traffic demand, irrespective of the controller's physical location in Europe, while taking into account network optimisation needs.
  - Reconfiguration/Consolidation of cross-border dynamic and remote air traffic services (ATS). Development of operational plans for a flexible and dynamic sectorisation by taking into account basic complexity indicators based on specific shapes of demand, network flight efficiency needs plus existing ATC technology enabled capabilities and the application of the virtual centre concept, as well as the operation in real time of the concept.
  - Network Performance Management cockpit supporting the collaborative decision-making to improve the current monitoring process combining collected local performance indicators and the use of advance data science and prediction techniques allowing the identification of unattended business opportunities and the anticipation (and better management) of disruptive operational situations across the network.
  - Cross-border Flow centric operations. Full reconciliation of ATFCM measures with other measures/advisory and multiple constraint manager. Dynamic sector configurations that satisfy traffic flows and are adaptable and proportionate to variable traffic demand.
  - increased Flexibility in ATCO validations (IFAV) for a generic pan-European capacity-on-demand service.
  - Resilient ATM systems that would continue to provide services despite disruption, e.g. during capacity bottlenecks, adverse weather, national system breakdowns or disruptive social actions.

  *(R&I need: **On-demand air traffic services,** ATM continuity of service despite disruption)*

#### 7.6.2.2.8.4 Topic DES-IR1-WA3.4: Artificial Intelligence for Aviation

*Expected outcomes:*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: AI will enable the optimisation of aircraft trajectories, allowing a potential reduction in the aviation environmental footprint.
- **Capacity**: AI will play a fundamental role in aviation/ATM to address airspace capacity shortages, enabling dynamic configuration of the airspace and allowing dynamic spacing separation between aircrafts.
- **Cost-Efficiency**: AI will enrich aviation datasets with new types of datasets unlocking air/ground AI-based applications, fostering data-sharing and building up an inclusive AI aviation/ATM partnership. This will support decision-makers, pilots, air traffic controllers and other

- **AI powered Digital assistants :** In view of achieving automation level 4, this challenge refers to the development of Human-Machine joint cognitive systems where digital assistants propose the best possible options to the human (flows, sequences, safety net, etc.) and solves complex situations using machine-to-machine communication. It includes for example the following features:
  - Airborne digital assistant: Support pilots, and reducing the workload (e.g. automating non-critical tasks, adapting the human-machine interface during operations). This is a first step towards introducing the artificial co-pilot necessary for future operations like SPO.
  - Ground Digital assistant : Increasing ground operators (e.g. ATCOs) capabilities during complex scenarios and reducing workload in order to focus on highly added-value activities and strategical planning. For example alleviating controller workload, proposing the best possible options to the controller (flows, sequences, safety nets, etc.) while solving complex trajectory situations using machine-to-machine communication between airspace users. AI-based human operator support tools that ensure the safe integration of "new entrant" aircraft types into an increasingly busy, heterogeneous and complex traffic mix (i.e. UAVs, supersonic aircraft, hybrid and fully electric aircraft) should be developed.
  - Air/Ground synchronisation: development of Air/Ground applications to automatically negotiate trajectory changes and achieve the best possible air traffic patterns (environmental sustainability, safety…).

  *(R&I need: **Human – AI collaboration: digital assistants**)*

#### 7.6.2.2.8.5 **Topic DES-IR1-WA3.5: Civil-military Interoperability & Coordination**

*Expected outcomes:*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: The additional predictability resulting from the integration of military flight data into the network, will lead to more efficient use of available airspace capacity by civil traffic, which will lead to greater fuel efficiency.
- **Capacity**: The additional predictability resulting from the integration of military flight data into the network, will lead to more efficient use of available airspace capacity by civil traffic which will lead to fewer delays.
- **Operational efficiency**: Greater mission predictability will be of benefit to the operational efficiency of civil traffic in the European Network.
- **Security**: The confidentiality, integrity and availability of information and data is crucial in ensuring safe and secure military operations. The development of a secure virtual infrastructure would address the fragmentation issue, while digital technologies are viable options for enhancing the resilience of infrastructure to cyberattacks.
- **Civil-Military Coordination**: The coordination of sharable data relating to the mission trajectory with the Network Manager will ensure the optimal and timely integration of military flight data into the network, thus allowing solid and reliable traffic predictions.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

#### 7.6.2.2.9 Work Area 6 - IR Topics addressing key SESAR 2020 Solutions required to complete ATM MP Phase C (only in IR1 call) (SESAR-RIA)

***Note: The SESAR JU has translated the content of the SRIA into an initial list of Horizon Europe call topics and accompanying descriptions (See below). Please note that the list and description are not definitive and may be subject to updates during the course of finalising this MAWP.***

This work area comprises the industrial research activities required to complete TRL6 for the key R&D solutions that define the ATM Master Plan 2020 Phase C ambition, establishing a solid foundation for ATM Master Plan Phase D. The scope of this work area includes a number of elements that although addressed in SESAR 2020 Wave 1 and Wave 2 activities did not finally complete TRL6.

By the end of Phase C, the ATM system will have gradually integrated greater levels of automation and connectivity (Level 2 and 3), supporting higher productivity and full sharing of information among stakeholders. It will be using standardised and interoperable systems enabling TBO in a highly connected, service-oriented, network driven context. The collaborative planning and decision process will allow each flight to be managed and optimised as a whole rather than in relation to segmented portions of its trajectory. This phase will also see the full integration of airports into the ATM network, facilitating airspace user operations and thereby reducing the impact of ATM on user costs. This will be possible thanks to the involvement of airspace user / flight operations centres, dynamic demand - and capacity-balancing (DCB) management, and further integration of ATC and ATFCM. The data provided through ADSPs and a more flexible system with improved and new services, such as capacity on demand, will fully support the implementation of these operations. This integration will certainly be gradual; it may start at a regional level or for some alliances of ANSPs.

The new architecture will make it possible to decouple the system infrastructure from ATC operations. ANSPs, irrespective of national borders, will be able to plug in their services where they are needed, providing end-to-end services and sharing resources among ANSPs.

In this phase, drone operations (UAS and RPAS) could be managed as routine operations even if not yet fully integrated into ATM. Additional services, along with new ground and air capabilities, will make it possible to manage safely a large number of diverse drone operations in all environments, including urban areas, for which specific requirements will be set up.

##### 7.6.2.2.9.1 Topic DES-IR1-WA6.1: Master Plan Phase C Connected and Automated ATM

The key objective of this topic is to complete TRL6 maturity level for the levels of automation and connectivity expected in Phase C of the ATM Master Plan 2020 (level 2 and 3), supporting higher productivity and improved sharing of information among stakeholders, and deliver a solid foundation for Phase D ambition level. The scope is limited to those SESAR solutions identified as “Key” in the ATM Master Plan 2020.

<u>*Expected outcomes:*</u>

Project results are expected to contribute to the following expected outcomes:

- **Environment:** Improvements to the connectivity and automation of will enable ATM to facilitate trajectories that are closer to the optimum green profile.
- **Capacity**: The increased level of automation support to ATC (Level 2 and Level 3) will improve the use of the airspace. Improvements in ground operations predictability and integration of advanced tools for arrival and departure will help to optimise runway use. Better connectivity between stakeholders, the use of shared 4D trajectories, interoperability and higher predictability brought about by increased automation will increase capacity.

correlation with LVP (if there is any). In particular an alerting service timely forewarning airspace users of expected outages, prior to the outage actually happening, is necessary for a safe and efficient conduct of flights;

- Transitional aspects including downwards compatibility to GAST-D both ground stations and avionics, need to be addressed. Feasibility of transitional aspects on GAST-C need to be considered;
- GBAS approach service (GAST-F) for State aircraft operations: GBAS approach service (GAST-F) based on DFMC down to CAT II/III for State aircraft operations;
- Support standardization and accelerated certification activities:
  - Extension of current GBAS CAT-III standards (based on GPS L1 or GLONASS FDMA) to accommodate GALILEO signals and dual-frequency capability:
    - Creation of a new ICAO standard in line with the DFMC GBAS concept;
    - Extension of GAST D current standards to augment Galileo signals.
  - Provision of standards that allow the industrialization of GBAS equipment (ground station and airborne receiver), to ensure timely delivery and full compatibility of both sub-systems;
  - EUROCAE WG-28 activities (in coordination with RTCA SC-159) to produce MOPS for ground and airborne equipment.
- Development of implementation guidelines, in particular considering different airport layouts/complexity.

- **DFMC GNSS/SBAS/ABAS receivers**: complete TRL6 for DFMC GNSS/SBAS/ABAS receivers processing GPS and GALILEO signals in L1/E1 and L5/E5, architectural considerations and assessment of transitions, exploiting synergies and complementarities between different augmentations (DFMC ABAS (ARAIM) and DFMC SBAS) in nominal and degraded modes. This includes the consideration of requirements on backwards compatibility and joint airborne architecture for ABAS/SBAS/GBAS receivers (avoiding the need for multiple avionics) and a joint airborne architecture for GAST-F and SBAS. This also includes the development of DFMC GNSS receivers on State aircraft: undertakes standardisation work on the introduction of DFMC GNSS, based on the use of secure signals, for State aircraft operations in a General Air Traffic (GAT) environment ***(Note: this is a significant gap not addressed in Wave 2)***.
- **L-DACS digital voice capability:** complete TRL6 for the capability of the future terrestrial A/G datalink solution (L-DACS) to exchange digital voice services. Digital voice is foreseen to replace VHF radio completely in the long term in all continental operational environments: en-route (flight-centric or with geographic sectors, continental high and low density), Terminal Manoeuvring Area (TMA) and Tower (TWR), including ground and platform control. The technical solution should be configurable to support both party line and point-to-point ATC-Pilot communication ***(PJ.33-W2-02)***.
- **L-DACS NAV capability**: complete TRL6 for L-DACS capability as a potential target alternative Position, Navigation and Timing (A-PNT) solution (***PJ.14-W2-60***). The objective is to further study L-DACS as a complementary system for current navigation infrastructure, taking

capacity-constrained airports where complex separation rules are applied ***(PJ.02-W2-14.8)***. The objective is to complete TRL6.

- **Dynamic pairwise runway separations based on ground-computed arrival ROT (D-PWS-AROT):** Machine learning techniques are used to develop more accurate predictions of arrival runway occupancy time (AROT) and runway exit based on aircraft characteristics such as aircraft type, weight, equipage (Enhanced Braking System / non-EBS) and weather. In addition to an improvement of post-operations offline analysis, machine learning techniques lead to an improvement of the quality of AROT and runway exit predictions during operations. Overall, the pairwise runway separations based on ground-computed AROT bring benefit in terms of increased runway throughput capacity and resilience thanks to the optimised separation/spacing on the final approach with potential positive impact on safety thanks to an accurate prediction of the runway exit ***(PJ.02-W2-14.10)***. The objective is to complete TRL6.

- **Advanced automated support for separation management (Level 2 and 3).** Complete TRL6 for increased automation solutions (in planning and tactical separation management) including the use of the downlinked predicted speed at waypoints, the refinement of the wind model using Mode-S reports, and features specific to the tactical trajectory, that aim to bring further improvements to CD/R tools' performance. Complete level 2/3 of automation in CD/R tools, particularly in the resolution of conflicts, to assist the controller in the assimilation of diverse information that is needed to allows him/her to take optimal decisions taking into account flight efficiency and intent, adverse weather and ultimately, safety. This also considers the prediction of ATC intent (upstream clearances that have not yet been delivered to the aircraft, but that are likely to be delivered to the aircraft by the ground at a later stage) through Machine Learning and Big Data techniques, and to perform conflict detection using trajectories calculated using this predicted intent ***(PJ.18-W2-53A)***.

- **Collaborative control:** this element covers the completion of the collaborative control concepts, which will allow two or more controllers to separation responsibility between them in some cases thanks to advanced system support for coordination. It includes in particular the pull and push coordination concepts, tools and procedures. It supports improved descent profiles thanks to the improved coordination methods and the reduced need for aircraft to level off when crossing a sector boundary (because coordinating an aircraft to cross the sector boundary will now be easier) ***(PJ.10-W2-73 CC)***.

- **Virtual/Augmented Reality applications for tower:** complete TRL6 for solutions to support the Air Traffic Controllers by means of Virtual and Augmented Reality application in Tower Environment. The technology involves the use of Tracking Labels, Air Gestures and Attention Guidance ***(PJ.05-W2-97.1)***. Operational aspects shall be addressed before completing TRL6. These applications are enabled by devices like Head-Mounted See-Through display, that allow:

    - to visualise equivalent out-of-the-window view to good visibility even in LVC,
    - to augment the out of the window view by tracking labels,
    - to provide interaction with V/A-R interface by air gestures and
    - to guide controller's attention to critical ATC situations.

  The need to switch from head up to head down and vice versa is expected to decrease, with benefits on ATCO productivity and situation awareness.


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elements of ADS-C EPP and known constraints and the application of Machine Learning and Big Data techniques ***(PJ.18-W2-56)***.

- **Aircraft as an AIM/MET sensor and consumer:** Improved understanding and prediction of weather conditions contributes to enhanced flight safety and efficiency. In addition to information from onboard sensors, pilots receive updates in various formats via datalink including simple text messages, graphical products and satellite images. These inputs cover different timeframes, ranging from past observations to predictions for the next several hours. It falls to the pilot to organise and geo-reference this data, and temporarily build a mental picture as fast as possible. SESAR is examining novel and robust ways to support intelligent data pre-processing, smart filtering and integration, both on ground and on board the aircraft for the two-way exchange of meteorological data. Moving to SWIM based technology will enable standardised exchange of information. One aspect of this solution is the definition and design of purple profile SWIM services for meteorological data, which so far has no specification. EUROCONTROL has only published specifications for yellow profile to date. The research will contribute to EUROCAE WG-76 and RTCA SC-206 MET datalink standardisation, and ICAO is also developing standards for turbulence and space weather which could be downlinked or uplinked via a SWIM purple profile service. Downlink and uplink of weather parameters (pressure, temperature, wind speed and direction), turbulence, space weather, icing considerations and contrail related information (e.g. air humidity) should also be addressed. ***(PJ.14-W2-110)***. The objective is to complete TRL6.

- **IFR RPAS integration in controlled class A-C airspace**: complete TRL6 for the full IFR RPAS integration by developing technical capabilities and procedural means to allow IFR RPAS to comply with ATC instructions and the development of new procedures and tools to handle IFR RPAS in a cooperative environment in full integration with manned aviation ***(PJ.13-W2-117)***.

##### 7.6.2.2.9.3 Topic DES-IR1-WA6.3: Master Plan Phase C Capacity-on-Demand and Dynamic Airspace

*Expected outcomes:*

The key objective of this topic is to complete TRL6 maturity level for the ambition of Phase C of the ATM Master Plan 2020 on capacity on demand and dynamic airspace management aspects.

- **Capacity**: is increased through a dynamic airspace management responding with flexibility to the Airspace users' flight trajectory needs;

- **Safety**: Improved safety in better anticipating and managing potential overloads;

- **Efficiency** thanks to the monitoring of the DCB measures and network performance and the implementation of corrective actions;

- **Cost-efficiency**: allows improved ATM resource planning and better use of existing capacities leading to reduced ATC and Airport Capacity costs;

- **Predictability**: the provision of information regarding the planned network situation considering all known constraints and time deviation will be managed by anticipating demand/capacity imbalance detection and improving the implementation of DCB solutions;

- **Flexibility**: common awareness to all stakeholders and access to opportunities in case of late changes in capacity or demand.



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supporting pre-tactical and tactical decision-making ***(PJ.04-W2-28.2)***. The objective is to complete TRL6.

- **Environmental performance management:** Management of Airport operations often necessitates a trade-off between different performance criteria (flight delay, passenger satisfaction, resource availability etc.). The objective is to complete TRL6 for solutions focused on environmental performance management with the aim of integrating environmental considerations into the overall airport operations management process, bringing the question of environmental performance into the decision-making process ***(PJ.04-W2-29.3)***.

#### 7.6.2.2.9.4 Topic DES-IR1-WA6.4: Master Plan Phase C Civil-military Interoperability & Coordination

*Expected outcomes:*

The key objective of this topic is to complete TRL6 maturity level for civil-military objectives as expected for Phase C of the ATM Master Plan 2020, supporting higher levels of civil-military coordination and interoperability.

- **Environment:** further integration of military flight data into flight planning and network, will allow civil Airspace Users to make a better use of available airspace capacity thus leading to greater fuel efficiency.
- **Capacity**: improving the way military airspace demands are managed, will lead to an overall more efficient use of available airspace capacity by civil traffic.
- **Security**: the confidentiality, integrity and availability of information and data is crucial in ensuring safe and secure military operations.
- **Cost-efficiency**: the dual-use of a service-driven iCNS infrastructure will ensure a CNS cross-domains consistency in terms of robustness, spectrum use and interoperability for both military and civil users. Integrated Communications, Navigation and Surveillance services will ensure military needs in terms of security, appropriate levels of quality of service and access to RF spectrum resources, while reducing the cost.
- **Civil-Military Coordination**: The coordination of sharable data relating to the mission trajectory with the Network Manager will ensure the optimal and timely integration of military flight data into the network, thus allowing solid and reliable traffic predictions.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Dynamic airspace configurations (DAC) (Level 1 and 2):** dynamic airspace configurations (DAC) and airspace management improve the use of airspace capacity for both civil and military users by increasing the granularity and flexibility in airspace organisation and design. The objective is to complete TRL6 for a fully dynamic, agile and cross-border airspace management concept that will take into consideration all capacity/demand aspects and constraints in one seamless process, with a higher level of modularity and flexibility up to the execution phase all supported by automated tools ***(PJ.09-W2-44)***. It includes:

#### 7.6.2.2.10 Work Area 4 - FTIU topic addressing "U-space and urban air mobility" (SESAR-IA)

##### 7.6.2.2.10.1 Topic DES-IR1-WA4.1: Fast Track Innovation and Uptake U-space and Urban Air Mobility

*Expected outcomes:*

U-space provides an unparalleled opportunity to experiment, test and validate some of the key architectural principles and technology enablers of the future Digital European Sky before incorporating them into the broader ATM ecosystem. It will accelerate the digital transformation of the European ATM system while opening the way to the safe integration of new vehicles into the airspace.

- **Environment :** U-space shall not increase the environmental footprint of the air transportation system. Specific metrics will be defined, tailored to the U-space environment and the types of vehicles operating within it (most of them are expected to be zero emissions aircraft). Special consideration should be given to the noise impact of low-level operations enabled by U-space. The growing use of zero-emission UAVs enabled by U-space may also contribute to reducing the environmental footprint of the overall transportation system, for example by reducing road traffic levels.

- **Passenger experience:** In terms of passenger experience and overall socio-economic contribution, U-space will enable and accelerate the drone economy, opening the way to new services (delivery, inspection, security, UAM, etc.) that will increase the wellbeing of European citizens. U-space will foster the development of a new high-tech economic sector in Europe, leading to wealth and job creation. Particular attention must, however, be paid to safeguarding privacy and ensuring social acceptance.

- **Capacity:** U-space shall not negatively affect the capacity of the ATM system and will enable additional system capacity by enabling large volumes of unmanned aircraft to access the airspace. Specific capacity metrics shall be defined for U-space defined in terms of safety or other concerns such as noise.

- **Cost efficiency:** U-space shall not negatively affect the cost of providing ATM services. Specific cost-efficiency metrics shall be defined for U-space, focusing on the cost of delivering U-space services.

- **Operational efficiency:** U-space shall substantially reduce the costs of operating unmanned aircraft in the European airspace and will not negatively affect the operating costs of other airspace users. Specific operational efficiency metrics shall be defined for U-space, including fairness aspects.

- **Safety:** U-space shall not negatively affect the safety of the ATM system. Specific safety metrics shall be defined for U-space,

- **Security:** U-space shall not negatively affect the security of the ATM system. Cybersecurity will be a key area to consider in U-space, especially regarding the interaction (data exchange) between U-space services and ATM systems.

This thread is designed to accelerate the development of high risk / high gain projects with the perspective of shortening the time to market for disruptive and highly innovative solutions. These

- **Enable urban air mobility (UAM):** The requirements of UAM operations are expected to be the most challenging for the U-space ecosystem. One of the key research questions is how to integrate the airspace autonomous operations over populated areas safely into complex and congested airspace environments, with operations involving vehicles interacting with U-space and conventional ATM services. Research should investigate how U-space can support the transition from piloted to autonomous operations. The evolution of U-space together with its associated regulatory framework and standards will need to be synchronised and coordinated with the development of the UAM ConOps, future UAM services and the certification of UAM vehicles. Special consideration should be given to the operational limitations of these new vehicles and how U-space can contribute to operational safety by protecting their operation in contingency and non-nominal situations. (*R&I need: Enable urban air mobility (UAM))*

- **U-Space services for general aviation and rotorcraft** : General aviation and rotorcraft are expected fly jointly with drones in portions of airspace. In order to enable safe operations, U-Space services are required to be provided to airspace users such as general aviation and rotorcraft. These targeted services are based on enhanced information-sharing allowing for improved situational awareness at both strategic and tactical levels.
*(R&I need: ATM/U-space integration)*

- **Advanced Airborne capabilities for Air/Ground integration:** The required airborne technologies to enable safe operations, advanced situational awareness and autonomous decision-making. Interoperable, performance based communications, navigation and surveillance (CNS) services in U-space need to be developed and validated in operational environments. Activities should be focused on Air/Ground integration in a total system approach. This includes airborne sensor technology for situational awareness and safety, trajectory management, detect and avoid solutions for cooperative and non-cooperative traffic, high integrity data communication.
*(R&I need: CNS and separation minima)*

- **Environmental sustainability and Social acceptance:** Work is required to ensure that the new operations enabled by U-space and UAM are acceptable to the public. This includes the definition and development of measures reducing the environmental impact of U-space operations (noise , visual pollution and CO2 ), ensuring adequate levels of safety and security. This work should consider as a starting point the findings of the 2021 EASA study on the social acceptance of Urban Air Mobility in Europe[29]. *(R&I need: U-space social acceptance)*

[29] The 2021 EASA study on the social acceptance of Urban Air Mobility in Europe report is available in this link.

is the need for conflict resolutions, offering real-time options to airspace users so that they can select the least penalising trajectory.

- Enhanced network traffic prediction and shared complexity representation using data science techniques such as Artificial Intelligence and Machine learning (AI/ML) to improve the quality of the traffic forecast and increase the network stakeholders confidence on the planning information.
- Use of Machine learning to identify and exploit information patterns, and identify and design new elementary basic sector volumes) for complexity detection and resolution and balancing workload and optimising resources.

*(R&I need: On-demand air traffic services)*

- **ATM continuity of service despite disruption:** This challenge refers to the development of digital platforms and services leveraging state of the art technologies to enable ATM continuity of service despite disruption (e.g. during capacity bottlenecks, adverse weather, national system breakdowns or disruptive social actions). This includes for example the following features :
  - Smart digital solutions for predicting adverse situations (weather, capacity…) and distributed decision making between involved stakeholders minimising the risk and impact of the disruption. This includes facilitation of cross-border dynamic and remote air traffic services (ATS).
  - Improvements of airline operations based on the use of digital technologies (e.g. big data, machine learning algorithms, AI, IoT, behavioural economics, improved market modelling, complexity science, etc.) to support the airline decision making processes in disruption scenarios, the integration of airline operations into the network, the collaboration between FOCs, network management function and ATC and the better consideration of airspace users' preferences in the DCB and sequencing processes, etc.
  - Enriched DCB Information and Enhanced What-Ifs available to improve AUs decision process when planning or re-planning trajectories. Enriched DCB information encompasses DCB constraints/measures information like ATFCM regulations/CTOT/STAM, and additional DCB information such as hotspots and congestion level indicators.
  - Use of new data sources (big data), machine learning algorithms (including neural networks), AI based decision support tools, behavioural economics, improved market modelling, complexity science, etc. to support network operations e.g. models and methods for improving demand, flow and complexity forecasting and resolution.
  - Use of big data and machine learning to identify best practices regarding regulation strategies for particular traffic load patterns based on historical data and develop optimized strategies for the most frequent traffic load situations in the European ATFCM network.
  - Using modelling and operational data to understand typical resolutions to network planning and traffic management problems to develop optimisation capabilities which are less human centric.
  - Use of new data sources (big data), machine learning algorithms, AI based decision support tools, etc. to support airline decision making in disruption scenarios in order to improve the resilience of the system.

*(R&I need: ATM continuity of service despite disruption)*


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the data and specific applications (e.g. STCA, Correlation, etc.) required to provide ATM services.

  - Delivery of advanced cloud based services for applications such as flight correlation, trajectory prediction, conflict detection and conflict resolution and arrival management planning ,the provision of safety-net services (e.g. short-term conflict alerts - STCA, minimum safe altitude warning - MSAW, area proximity warning - APW) and decision-making support tools as a service

*(R&I need: Future data-sharing service delivery model)*

- **Infrastructure as a service:** This challenge refers to the development of digital platforms and services leveraging state of the art technologies to enable a service oriented approach to CNS Infrastructure with a wide implementation of IP based technologies. This includes for example the following features:
  - Digital solutions enabling location-independent transmission of CNS data and/or voice with stronger reliance on satellite based technologies. This includes integrated CNS applications using space-based sensors.
  - Digital solutions for dynamic allocation of IP connections reducing the need for VHF channels on the ground side and the need for the airborne side to switch frequencies several times during the flight.

  *(R&I need: Infrastructure as a service)*

- **Free flow of data among trusted users across borders :** This challenge refers to the development of digital platforms and services leveraging state of the art technologies to enable the sharing of data through interoperable platforms and, the exchange of open data between trusted partners, combined with open architecture policies.

  *(R&I need: Free flow of data among trusted users across borders)*

- **Cyber resilience:** This challenge refers to the development of digital platforms and services leveraging state of the art technologies to enable the protection of information and information systems, manage cyber-resilience risks, implement appropriate safeguards to ensure the delivery of services. In this context it is necessary to apply best practices and specific techniques already established in other domains such as banking (e.g. system design principles, cryptography, blockchain, software-defined networking). It includes for example, the following features:

  - Digital solutions for Cyber-resilience: Ability to prevent a cyber-attack from being successful, to prevent operational disruptions from successful cyber-attacks, to prepare for and adapt to changing conditions due to successful cyber-attacks and to respond and recover rapidly from successful cyber-attacks to ensure the continuity of operational services at an acceptable performance level.

  - Digital solutions increasing system robustness against cyber-attacks: The first and impact step towards strengthened cyber-resilience is to keep operating the event of a cyber-attack by preventing cyber-attacks from being successful. Elements that need to be addressed include the increase in foresight (prediction, anticipation, cyber-intelligence), introduction of patch management in safety-critical systems and the

- **Capacity**: Fully integrating the most congested airports into the ATM planning process, introducing tools that allow user-driven prioritisation based on real-time multimodal passenger constraint information, monitored and shared accurately at Network level, will help reduce departure delay, while improving IFR movement numbers at these airports and ultimately IFR network throughput.

- **Cost-efficiency**: The data-sharing-powered network performance cockpit will enable increased predictability of traffic flows coupled with increased network flexibility and resilience. This would in turn help reduce en-route congestion and air navigation service (ANS) costs. New data-sharing standards and systems will allow new 'as a service' businesses, creating more value for aviation, within an integrated transport-system.

- **Operational efficiency**: Improved, accurate, customer-focused planning, including user-driven prioritisation, allows operators to customise and optimise every flight, balancing their individual constraints against those of the Network, with a direct positive impact on additional gate-to-gate flight time, fuel burn per flight, and operational costs from congestion and disruption. There will be also a positive impact on resilience from data-sharing, increase knowledge and integrated network crisis management processes.

- **Safety**: Better integration of UAS, UAM and GA operations at airports and within TMAs will directly contribute to increased, seamless, and hassle-free mobility while enhancing operational safety. Similarly, punctual, predictable, integrated ground transport to/from the airport will reduce passenger stress and contribute to reducing stress-related accidents.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Access to /exit from the airport:** This challenge refers to the development of digital platforms and services leveraging state of the art technologies to enable a better door to door experience for the passengers. Considering ATM to be an integrated part of an intermodal transport system this about sharing data between modes and collaborating better to optimise the performance of both the overall transport system . It includes for example, the following features:
    - Real-time information exchange giving stakeholders (including mobility providers): an increased knowledge of the entire multimodal journey will enhance the reliability of multimodal journey planning ,identifying potential access issues that could affect the punctuality of operations, alleviating congestion, mitigating regulatory constraints, etc.

    - Extended integration of ATM network planning:  (multi-slot swapping, aircraft operator-driven prioritisation processes etc.) and cooperation on enhanced collaborative airport performance planning and monitoring, enabling passengers to have a full picture of their journey and optimise their Door to door time.

    - Extended CDM process:  Encompassing specific stakeholder information requirements relating to elements of the multimodal journey and fully included in the AOP and NOP collaborative processes.

enable the coordination – when managing a crisis – between different modes of transport and a multitude of actors, including local and national authorities' representatives. The research should also include proposals for counter measures based on the timely acquisition and sharing of information, as well as it should consider a broad set of threats affecting, directly or indirectly, aviation. A non-exhaustive list of threats is reported hereafter: volcanic ash dispersions, , armed conflict, hazardous chemicals events, spread of diseases/pandemic, earthquakes, flooding, major failure of a pan-European function, (massive) cyberattack, etc. *(R&I need: An integrated transport network crisis management process)*

#### 7.6.2.2.11.4 **Topic DES-IR1-WA5.4: Fast Track Innovation and Uptake Artificial Intelligence for Aviation**

*Expected outcomes:*

Project results are expected to contribute to the following expected outcomes:

- **Environment**: AI will enable the optimisation of aircraft trajectories, allowing a potential reduction in the aviation environmental footprint.

- **Capacity**: AI will play a fundamental role in aviation/ATM to address airspace capacity shortages, enabling dynamic configuration of the airspace and allowing dynamic spacing separation between aircrafts.

- **Cost-Efficiency**: AI will enrich aviation datasets with new types of datasets unlocking air/ground AI-based applications, fostering data-sharing and building up an inclusive AI aviation/ATM partnership. This will support decision-makers, pilots, air traffic controllers and other stakeholders, bringing benefits in cost efficiency by increasing ATCO productivity (reducing workload and increasing complexity capabilities).

- **Operational efficiency**: Increasing predictability will be a key role for AI, by enabling traffic predictions and forecasts that will boost punctuality.

- **Safety**: Safety science will also need to evolve to cope with the safety challenges posed by the introduction of machine learning. Actual safety levels will be at least maintained using this technology.

- **Security**: AI will offer the possibility to stay cyber resilient to new technologies and threats, the objective is to maintain a high level of security.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Trustworthy AI powered ATM environment:** This challenge refers to the development of advanced AI applications (e.g. supporting automation level 4) for ground or airborne use with a particular focus on the demonstration of new methodologies for the validation and certification of advanced AI applications that will ensure their transparency, robustness and stability under all conditions. It includes for example features like explainability , learning

### 7.6.3 Connecting Europe Facility (CEF) Call

#### 7.6.3.1 General conditions for the CEF call for proposals to be launched in 2022

**To be further described when the CEF General Conditions will be made available**

#### 7.6.3.2 Specific conditions for the DSD1 call for proposals (with reference CEF-SESAR-2022-DES-DSD-01)

##### 7.6.3.2.1 Call identifier

This call for proposals has the reference CEF-SESAR-2022-DES-DSD-01.

##### 7.6.3.2.2 Indicative call timetable

| | |
|---|---|
| Publication date | March 2022 |
| Opening date | March 2022 |
| Final date for submission | September 2022 |
| Information on the outcome of the evaluation | Maximum 5 months from the final date for submission |
| Signing of grant agreements | Not later than the end of May 2023 |

**Table 10: Indicative timetable for the DES DSD1 call for proposals with reference CEF-SESAR-2022-DES-DSD-01)**

##### 7.6.3.2.3 Indicative call budget

The indicative budget for this call is EUR 171.000.000.

| Budget | Commitment (first estimate) | Payment (first estimate) |
|---|---|---|
| | In 2022: EUR<br>In 2023: EUR | In 2023: EUR |

**Table 11: Indicative budget for the DES DSD1 call for proposals with reference CEF-SESAR-2022-DES-DSD-01)**

##### 7.6.3.2.4 Duration and key milestones

The awarded projects will start preparing and executing their research activities between Q2 2023 and Q1 2026, and shall deliver their full results no later than end of Q2 2026 (maximum project duration of 36 months).

- **Safety**: The automation of some procedures shall ultimately lead to improved safety and fewer errors, which tend to be human-triggered. Additionally, the increase in data sharing will also foster the early detection of potential safety issues and their mitigation.

The digital sky demonstrators will help to increase the buy-in from the ATM community on the next generation of SESAR technologies and services and will provide further evidence to support their business case. The digital sky demonstrator instrument will be closely connected to the standardisation and regulatory framework, and will provide a platform for a critical mass of "early movers" to accelerate market uptake, thus facilitating the industrialization process for SESAR solutions and promoting their deployment in Europe. All players including competent regulatory authorities can mutually learn and exchange practical expertise related to the introduction of the next generation of SESAR solutions.

*Scope*

The objective is to stablish a network of digital European sky demonstrators to accelerate the transition towards deployment of a number of SESAR solutions that are part of Measure 3 of the Airspace Architecture Study Transition Plan (AAS TP) in order to fully leverage breakthrough technologies that can contribute to prepare the defragmentation of European skies (e.g. dynamic airspace configurations, solutions boosting the level of automation support, multilink environment, etc.).

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Increased automation support:** improvement of conflict detection and resolution tools that are derived from the improvement of ground Trajectory Prediction (TP) with the use of advanced data from ATN B2 ADS-C reports messages as defined in the EUROCAE standards ED228A and ED75C and improved meteorological data. The improvements of ground TP may include: the use of ADS-C data e.g. gross mass, speed schedule, TOC and TOD altitudes, the predicted speeds at route points, etc.), improvements in the calculations of turning manoeuvres thanks to the use of turn radius and the turning strategy (overfly vs fly-by), the implementation of catch-up manoeuvres (not depending on EPP data), etc ***(PJ.18-W2-53B, AAS TP Milestone 6: Trajectory Based Operations (TBO))***.
- **New human machine interface (HMI) interaction modes and technologies** in order to minimise the load and mental strain on controllers in the ATC centre. This may include the use of in-air gestures, attention control, automatic speech recognition, user profile management systems, tracking labels, virtual and augmented reality, etc. ***(PJ.10-W2-96 AG, PJ.10-W2-96 ASR and PJ.10-W2-96 UPMS, AAS TP Milestone 4: Gradual transition towards higher levels of automation supported by SESAR Solutions)***.
- **Flight-centric demonstrator to improve ANS productivity**: this demonstrator covers the demonstration of flight-centric operations in environments where most benefits in terms of cost efficiency are expected, e.g., daytime high-altitude airspace and daytime or night-time low-density airspace ***(PJ.10-W2-73 FCA, AAS TP Milestone 5: Transformation to flight/flow centric operations)***.
- **Demonstration of near real-time traffic management in the TMA and nearby sectors to improve ANS productivity**, taking advantage of predicted demand information provided by local Arrival and Departure Management systems to identify over-demand or additional capacity. Departure flows are managed in an integrated manner enabling a more consistent and manageable delivery into the En-route phase of flight while ensuring an optimal usage of runway

A more flexible use of external data services, considering data properties and access rights, would allow the infrastructure to be rationalised, reducing the related costs. It will enable data- sharing, foster a more dynamic airspace management and ATM service provision, allowing air traffic service units (ATSU) to improve capacity in portions of airspace where traffic demand exceeds the available capacity. It furthermore offers options for the contingency of operations and the resilience of ATM service provision.

- **Cost efficiency**: Virtualization in support of delegation of the provision of Air Traffic Services amongst ATSUs will have an impact on the ANSP capability in terms of Resources Management at both staffing and facilities level (cost optimization).
- **Capacity/Resilience**: More manoeuvring margin on resources management by the ANSP will lead to a better use of the spare capacity (less demand measures required). A more dynamic airspace management will contribute to improve capacity while responding with flexibility to the Airspace users' flight trajectory needs.
- **Environment**: the delegation of the provision of Air Traffic Services amongst ATSUs, for both cross border and non-cross border cases, will impact the seamless air traffic service provision as the load balancing between ATSUs and avoidance of airspace or ATM services provision disruptions will allow AUs to fly more efficient trajectories

The objective is to achieve, for the topics under scope, a TRL 8 maturity level ("actual system completed and "mission qualified" through test and demonstration in an operational environment").

The digital sky demonstrators will help to increase the buy-in from the ATM community on the next generation of SESAR technologies and services and will provide further evidence to support their business case. The digital sky demonstrator instrument will be closely connected to the standardisation and regulatory framework, and will provide a platform for a critical mass of "early movers" to accelerate market uptake, thus facilitating the industrialization process for SESAR solutions and promoting their deployment in Europe. All players including competent regulatory authorities can mutually learn and exchange practical expertise related to the introduction of the next generation of SESAR solutions.

*Scope*

To successfully address the expected outcomes, all or some of the following sub-R&I needs should be addressed:

- **Demonstration of Delegation of ATS services based on Virtual Centre *(PJ.16-03, PJ.10-W2-93 and PJ.32-W2-01, AAS TP Milestone 3: Virtual centres and dynamic airspace management at large scale)*:** this includes:
  - Delegation of ATS services amongst ATSUs based on traffic / organisation needs (either static on fix-time transfer schedule (Day/Night) or dynamic e.g. when the traffic density is below/over certain level) or on contingency needs. Training and competency requirements for ATM personnel contributing to the cross border ATM/ANS service delivery as enablers of technical reconfiguration for remote ATS operations, include concepts to increase the flexibility of ATCO validations  New training and licencing needed for of ATCOs new cross-border dynamic sectors and remote ATS operations where sector families or traffic flows may be new to ATCOs. The list of potential use cases to be addressed in the demonstrations may include:
    - Delegation of ATM services provision cross-border;
    - Delegation of ATM services provision at night;

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parameters from a reference point as specified by AU (e.g. Aerodrome of Departure). The demonstrations scope includes the consideration of initial mission trajectory management capability at sub-regional/local level in the ATM planning phase to support the dynamic configuration of segregated airspace, thus contributing to the efficiency of both civil and military operations. The objective is to demonstrate improvements in the use of airspace capacity for both civil and military AUs within increased efficiency of airspace management and increased flexibility in the civil-military coordination. The demonstration scope includes the digital transformational technology impact on CDM, MTM and ASM e.g. ATCO support systems (ATCO screen to show active DMA in real time and support for revising trajectories of aircraft that are planned to go into the DMA) ***(PJ.07-W2-40 and PJ.09-W2-44, AAS TP Milestone 3: Virtual centres and dynamic airspace management at large scale)***.

###### 7.6.3.2.6.3 CEF-SESAR-2022-DES-DSD-01-03: Digital Sky Demonstrators on U-space and urban air mobility

The digital sky demonstrators on U-space, supported by the new regulatory framework and a set of new standards, will support the implementation of U1/U2 services across Europe ensuring safety and interoperability. U-space will have to integrate seamlessly with the ATM system to ensure safe and fair access to airspace for all airspace users.

*Expected outcomes*

U-space is expected to have a profound socio-economic impact, enabling the creation of a new marketplace for U-space service provision and accelerating the advent of the drone and urban air mobility economy. The objective of the digital sky demonstrators is to accelerate the transition towards deployment of a number of U-space services and capabilities:

- **Environment :** U-space shall not increase the environmental footprint of the air transportation system. Specific metrics will be defined, tailored to the U-space environment and the types of vehicles operating within it (most of them are expected to be zero emissions aircraft). Special consideration should be given to the noise impact of low-level operations enabled by U-space. The growing use of zero-emission UAVs enabled by U-space may also contribute to reducing the environmental footprint of the overall transportation system, for example by reducing road traffic levels.
- **Passenger experience:** In terms of passenger experience and overall socio-economic contribution, U-space will enable and accelerate the drone economy, opening the way to new services (delivery, inspection, security, UAM, etc.) that will increase the wellbeing of European citizens. U-space will foster the development of a new high-tech economic sector in Europe, leading to wealth and job creation. Particular attention must, however, be paid to safeguarding privacy and ensuring social acceptance.
- **Capacity:** U-space shall not negatively affect the capacity of the ATM system and will enable additional system capacity by enabling large volumes of unmanned aircraft to access the airspace. Specific capacity metrics shall be defined for U-space defined in terms of safety or other concerns such as noise.
- **Cost efficiency:** U-space shall not negatively affect the cost of providing ATM services. Specific cost-efficiency metrics shall be defined for U-space, focusing on the cost of delivering U-space services.

services in the same airspace. This could also cover the transfer of U-space operational concepts or technologies to ATM or the transfer or ATM concepts or technologies to U-space.

- **Demonstration on U-space for UAM:** Urban Air Mobility (UAM) refers to the provision of mobility services in an urban environment using air vehicles, which encompass everything from manned helicopters, as currently flown, through small inspection and delivery drones to ‘flying taxis’, with or without a pilot. The demonstrations shall aim at showcasing solutions that contribute to safely integrate UAM with manned aviation and air traffic control, defining new operational concepts (underpinned by existing and new technologies) while contributing to the definition of the required standards and regulations (e.g. recommendations for associated means of compliance). The demonstrations shall perform a significant number of flights, in coordination with relevant stakeholders, and using one or more eVTOL platforms, including vehicles with full autonomous capabilities. The demonstration projects shall build on the work done in SESAR 2020 on this field. Close coordination with EASA is required to ensure complementarity and consistency with EASA activities.

###### 7.6.3.2.6.4 **CEF-SESAR-2022-DES-DSD-01-04: Digital Sky Demonstrators on Aviation Green Deal**

*Expected outcomes*

The objective of the demonstrations under this topic is to contribute to achieve the objective of net-zero greenhouse gas emissions by 2050 set by the European Green Deal, in line with the EU’s commitment to global climate action under the Paris Agreement. This implies the need for aviation to intensify its efforts to reduce emissions, in line with the targets set in Flightpath 2050.

To this end, a set of operational measures to improve the fuel efficiency of flights will have to be put in place. At the same time, to ensure sustainable air traffic growth, it is necessary to speed up the modernisation of the air infrastructure to offer more capability and capacity, making it more resilient to future traffic demand and adaptable through more flexible air traffic management procedures. Furthermore, reducing aircraft noise impacts and improving air quality will remain a priority around airports

- **Environment**: proposed operational measures shall enable gate-to-gate optimal flight trajectories and demonstrate improvements on fuel efficiency of flights, and thus $CO_2$ (and non-$CO_2$) reductions.
- **Capacity and operational efficiency**: the higher level of automation supporting the solutions under demonstration will make it possible to go beyond the current limits of sector capacity due to controller workload, which will allow optimal and environmentally- friendly flight trajectories.
- **Cost-efficiency**: saving fuel for airspace users will reduce $CO_2$ emissions and related costs (ETS).
- **Safety**: Safety levels are maintained or improved in case of a higher level of automation.

The objective is to achieve, for the scope under this topic, a TRL 8 maturity level (“actual system completed and “mission qualified” through test and demonstration in an operational environment”).

The Digital Sky Demonstrator instrument will be closely connected to the standardisation and regulatory framework, and will provide a platform for a critical mass of “early movers” representing at least 20% of the targeted operating environment to accelerate market uptake.


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including: GBAS - GAST D (Cat II/III) GPS and Galileo, SBAS / GBAS Complementarity, reversion from GNSS to ILS and from GNSS area navigation to multi DME (A-PNT) ***(Solution PJ.14-W2-79a)***.

- **Green approaches through improved speed and aircraft configuration management on arrival**: this demonstration aims at investigating the impact of the throttle and high-lift-device management on the environment. It will aim at identifying quick-win airborne and ground procedures that reduce the impact on the environment without the need for an update to the avionics or ground systems *(R&I need: Advanced RnP green approaches)*.

- **Green climb-via and descend-via procedures including descent-via with re-cruise options:** this demonstration builds on the SESAR SES-award winning Optimized Descent Profiles demonstration. It will support the implementation of the CDO/CCO Action Plan recommendation to implement the ICAO descend-via procedures, in combination with the re-cruise FMS function developed within SESAR 2020 solution PJ.01-03b, which will be brought to maturity in this demonstration. The focus of the demonstration will be on addressing the ground and airborne challenges in order to allow the widespread adoption of the descend via procedures in Europe and the adoption of the re-cruise concept in order to mitigate the negative impact on the environment of early descent clearances *(R&I need: Environmentally optimised climb and descent operations (OCO and ODO)* ***(Solutions PJ.01-03b & PJ.01-W2-08B, AAS TP Milestone 4: Gradual transition towards higher levels of automation supported by SESAR Solutions)***.

- **Initial ATN B2 datalink green trajectory revision concepts:** this activity will demonstrate of the uplink via ATN B2 CPDLC of an ATC clearance containing a revision of the 2D route or a vertical clearance with a vertical constraint. The activity should consider both ATN B2 and ATN B2 Revision A standards (with DRNP). These clearances will be auto-loaded in the FMS. The demonstration will make an assessment of the environmental benefits and of the impact on the flight-crew workload and crew resource management *(R&I need: Optimum Green Trajectories)* ***(Solution PJ.18-W2-56, AAS TP Milestone 4: Gradual transition towards higher levels of automation supported by SESAR Solutions)***.

- **TBO for green trajectories in the planning phase (FF-ICE 1):** this activity will demonstrate the environmental benefits of the enhancements to the planning phase brought by the FF-ICE 1 concepts, in particular the extended flight plan. The demonstration should investigate a concept to allow AU to load less fuel thanks to the reduced uncertainty for the AU, potentially incorporating information like planned departure and arrival runways, foreseen SID and STAR, intelligent prediction of ASMA time (prediction derived from demand data using machine learning), etc. *(R&I need: Optimum Green Trajectories)* ***(Solution PJ.18-02c, AAS TP Milestone 4: Gradual transition towards higher levels of automation supported by SESAR Solutions)***.

- **Green taxiing:** this element aims at implementing reduced emissions or emissions free taxi operations at medium and large European airports, applying any of the available technologies (engine-off taxi out and taxi-in, taxibots, auxiliary engines in the undercarriage), or a combination thereof. The demonstrators focus will be on addressing the ATM aspects as required to make it possible to scale up the operations to all AU at the airport. Attention will be paid to consider both nominal and adverse conditions, in particular with de-icing process where relevant. These demonstrators will pave the way for the large-scale implementation across Europe *(R&I need: Accelerating decarbonisation through operational and business incentivisation).*

- **Integrated ATM/apron management for green surface management:** this element is based on the use of cameras and machine learning/artificial intelligence to optimise turn around

# Annexes

[1] This is the first reference

[2] And this the second

# A. ATM Master Plan 2020

## A.1 The SESAR Vision

By 2040, an increasing number and variety of air vehicles will be taking to Europe's skies. The SESAR vision aims to deliver a resilient and fully scalable ATM system capable of handling growing air traffic made up of a diverse range of manned and unmanned air vehicles in all classes of airspace, in a safe, secure, sustainable manner

The vision builds on the SESAR target concept and primarily on the notion of trajectory-based operations (TBO), which enable airspace users to fly their preferred flight trajectories, delivering passengers and goods on time to their destinations as cost- efficiently as possible. This will be enabled by a new architecture referred to as the 'digital European sky', in which resources

(on the ground and in the air) are connected and optimised across the network and irrespective of altitude (up to and including super-high-altitude operations), class of airspace or aircraft performance (manned or unmanned), leveraging modern technology through a data-rich and cyber- secure connected digital ecosystem. In this environment, service providers will be able to collaborate and operate as if they were one organisation with both airspace and service provision optimised according to traffic patterns. This architecture is also more compatible with the overall global vision for a more profound evolution of core ATM capabilities driven by new forms of traffic (drones and super-high-altitude operations)

## A.2 OFFERING IMPROVEMENTS ACROSS ATM

It is widely recognised that, to increase performance, ATM modernisation should look at the flight as a whole and not in segmented portions, and take account of parallel industrial evolutions. With this in mind, the SESAR vision embraces the entire ATM system, offering improvements at every stage of the flight.

### A.2.1 Enabling high network capacity and resilience

The future airspace will be fully optimised according to network flows, making maximum use of cross-FIR cooperation. Supported by progressively higher levels of automation and common ATM data services, the system will be able to use resources more efficiently, responding to disruptions and changing demand with greater flexibility and resilience. The introduction of service-oriented architectures — relying on vertical and geographical decoupling of services along with new technologies, such as virtual centres associated with a sector-independent air traffic services (ATS) framework — will enable dynamic and shared management of airspace and remote provision of ATS, meaning that sectors can be dynamically modified based on demand and airspace available and managed by the most appropriate area control centre. Moreover, flight-centric operations may mean that ATS methods gradually evolve from the management of pieces of airspace (sectors) to the management of the trajectory of flights across a larger portion of airspace, thus enabling increased flexibility. Air traffic flow and capacity management (ATFCM) will evolve to enable the management of two crew members in the cockpit to a single crew member in the cockpit, that is, single-pilot operations (SPO), paving the way for fully autonomous flights. Flights above FL660 (66 000 ft) will also be integrated, with entry and exit procedures through segregated or non-segregated airspace. These innovative airborne research concepts, when confirmed, will feed into and steer ATM research, first exploratory and then industrial. All these different environments will converge towards an integrated ATM in which manned and unmanned aerial vehicles will operate in a seamless and safe environment using common infrastructure and services. All of this will enable the growth of the sector, particularly with regard to the use of large certified unmanned aircraft systems (UAS) for cargo and other civil operations, air taxis and smaller drones for a host of services (parcel delivery, medical emergencies, etc.).

### A.2.5 Improved air navigation services productivity

Air navigation services (ANS) productivity will improve thanks to the introduction of increased levels of automation support in air traffic control (ATC), the move from voice to data communications, and better connectivity and information sharing between ground systems. This means that controllers will perform fewer manual and repetitive tasks, since these will be automated and delegated to the system, allowing controllers to concentrate on more complex work. At the same time, new capabilities will be introduced to enhance the interface between air and ground and enable data exchange, as well as separation management. These enhancements will mean that the system will be more scalable to meet growing demand. ANS productivity will also increase thanks to the shift to a new ATM service delivery landscape. ATM data service providers (ADSPs) will provide the data and applications required to provide ATS. This will enable capacity on demand — more dynamic delegation of the provision of ATS to an alternative centre with spare capacity — and will result in a substantial improvement in ANS operations and productivity.

### A.2.6 Optimal use of air navigation services infrastructure and use of scarce resources

The move from physical assets to services, as well as standardisation between systems, will result in a rationalised aviation infrastructure. This is especially the case for CNS, which will rely on more integrated solutions, increased civil- military synergies, and combined ground- based and satellite-based services. This rationalisation and integrated approach to CNS will result in a more efficient use and long-term availability of spectrum. Similarly, the virtualisation of ANS and sharing of data services will enable the delivery of ATC services irrespective of the location of the infrastructure. Virtual control centres and use of remote towers will allow a more efficient and flexible use of resources, substantially improving the cost efficiency of service provision.

As a result, ANSPs will have leaner, more modular and scalable systems that are easier to upgrade and more interoperable. Because of this, the system will become more resilient to unexpected traffic downturns or rapid returns to growth.

### A.2.7 Increased global interoperability and enhanced collaboration

The exchange of trajectory, weather and aeronautical information made possible through information management, supported by SWIM, will enhance collaborative decision-making at network and global levels. Global interoperability will be improved through standardised interfaces for ATM information exchanges, allowing seamless ATM operations for all operational stakeholders.

Sophisticated algorithms and forecast models capable of mining historical data for trends and providing real-time information (big data management) will support further efficient and effective collaborative decision-making involving all relevant parties. These capabilities will be especially important in view of the forecast increase in extreme weather phenomena, which may cause severe local and network-wide disruptions. AI capabilities that combine weather, flight, airport and other strategy (22). The future European society and economy will build strongly on increased digitalisation. The ATM industry cannot fall behind and must consolidate its position at the forefront of innovation with a global perspective given the significant potential value for the European economy and citizens.

Digitalisation is a transversal topic affecting the full width of ATM, from concept of operations to service provision, from safety-critical systems to passenger travel experience. Therefore, progress in this field must be visible.

The digital single market strategy defines the Digital Economy and Society Index (DESI). It is a composite index that summarises relevant indicators on Europe's digital performance and tracks trends in EU Member States' digital competitiveness. The DESI indicator is a broad societal index that, so far, does not provide details on specific branches of industry. Consequently, to demonstrate alignment between the SESAR project and the digital single market goals, this Master Plan includes a proposal for an ATM digitalisation index that, by analogy with the DESI, could be used in the years to come to illustrate the uptake of digitalisation by the European ATM industry. The expectation is that higher scores on this index will indicate an improvement in ATM performance and an increase in the economic potential generated by the European ATM industry.

Figure 14 introduces an automation model for ATC based on the classic levels of automation taxonomy model used by human performance and safety experts in the SESAR Programme. It mirrors the five-level model from the Society of Automotive Engineers (ranging from Level 0, 'low automation', to Level 5, 'full automation'). It presents a simplified view of the overall level of automation in each of the ATM Master Plan phases (A to D) in two different areas: ATC and U-space services. It highlights the steps envisaged towards the profound digital transformation outlined in the Master Plan.

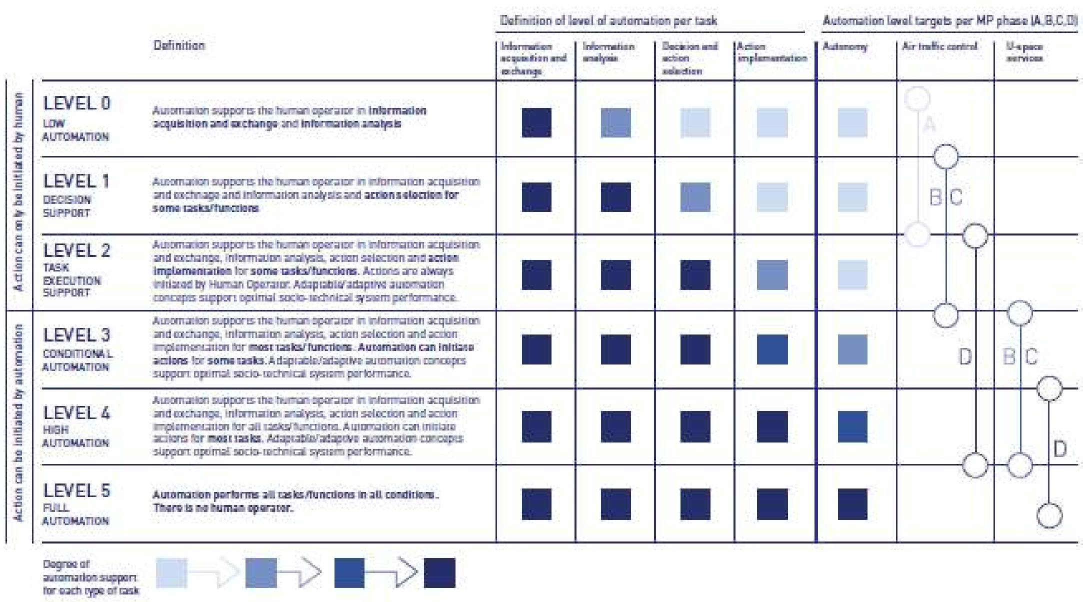


**Figure 14:Levels of Automation**

The progress made in the fields of machine learning and AI will open the door to a multitude of innovative applications in ATM. Tasks will be performed collaboratively by hybrid human-machine teams, in which advanced adaptable and adaptive automation principles could dynamically guide the allocation of tasks. The goal is not automation per se but optimising the overall performance of the socio-technical ATM system and maximising human performance and engagement at all times. The

Airports and other operational sites (e.g. for rotorcraft and drones) will be fully integrated into ATM at network level, which will facilitate and optimise airspace user operations.

The achievement of the digital European sky and maximising performance gains will require a change in the approach to how SESAR Solutions are developed and deployed and how services are provided. Through four transitional phases, the system architecture will gradually move away from a country-specific architecture to a more interoperable, global and flexible service provision infrastructure. It should be noted that these transitional phases will overlap and that the first three phases are already being deployed or in the pipeline towards deployment.

**PHASE A : Address known critical network performance deficiencies**

Although most ANSPs are vertically integrated into country-based infrastructures, this phase sees the initial adoption of a service-oriented architecture as an enabler for TBO. The sharing of data and information is enabled by SWIM implementation and the introduction of open architectures and standards, as well as common data layers. Specific measures related to the protection of ATM systems and infrastructures against cyberattacks are jointly implemented to ensure the continuity and the integrity of the operations.

This approach allows increased information sharing across national borders and exchange between ATM stakeholders, including the Network Manager, airlines, airports and the military. In this way, it targets both ground-ground and air-ground communications with the implementation of the SWIM blue profile (flight object interoperability), the automatic dependent surveillance contract/extended projected profile (ADS-C/EPP) and controller-pilot datalink communications.

This phase has already started, with the deployment of solutions delivered by SESAR and mainly, but not exclusively, deployed through the PCP.

**PHASE B : Efficient services and infrastructure delivery**

The development of open standards for ATM systems also means that stakeholders will find commonalities in terms of their operations and service needs, allowing for the development and introduction of a common service layer achievable through a set of ADSPs. This will make possible the optimisation and rationalisation of ATM support services, enabling a move from physical infrastructures to virtual infrastructures that are characterised by automation and increased sharing of data and information to enhance predictability and enable the remote provision of ATS.

This phase is reliant on the delivery of a continuous flow of solutions from the SESAR 2020 R&D activities and demonstrable evidence of the related performance gains expected from Europe- wide and/or local deployment, where appropriate. In tandem with the more efficient organisation of infrastructure and services, this phase will see the business cycles of the traditional ATM stakeholders gradually start to shorten and move towards the accelerated cycles already seen with the integration of new entrants (e.g. drone operators, very high- altitude operators, mobility providers, U-space service providers) into the aviation environment.


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**PHASE C : Defragmentation of European skies through virtualisation**

By this phase, the ATM system will have gradually integrated greater levels of automation and connectivity, supporting higher productivity and full sharing of information among stakeholders. It will be using standardised and interoperable systems enabling TBO in a highly connected, service-oriented, network-driven context. The collaborative planning and decision process will allow each flight to be managed and optimised as a whole rather than in relation to segmented portions of its trajectory. This phase will also see the full integration of airports into the ATM network, facilitating airspace user operations and thereby reducing the impact of ATM on user costs. This will be possible thanks to the involvement of airspace user / flight operations centres, dynamic demand - and capacity-balancing (DCB) management, and further integration of ATC and ATFCM. The data provided through ADSPs and a more flexible system with improved and new services, such as capacity on demand, will fully support the implementation of these operations. This integration will certainly be gradual; it may start at a regional level or for some alliances of ANSPs.

The new architecture will make it possible to decouple the system infrastructure from ATC operations. ANSPs, irrespective of national borders, will be able to plug in their services where they are needed, providing end-to-end services and sharing resources among ANSPs.

In this phase, drone operations (UAS and RPAS) could be managed as routine operations even if not yet fully integrated into ATM. Additional services, along with new ground and air capabilities, will make it possible to manage safely a large number of diverse drone operations in all environments, including urban areas, for which specific requirements will be set up.

This phase is also reliant on the delivery of solutions arising from the SESAR 2020 R&D activities and demonstrable evidence of the performance gains expected from Europe-wide, regional and/or local deployment, where appropriate.

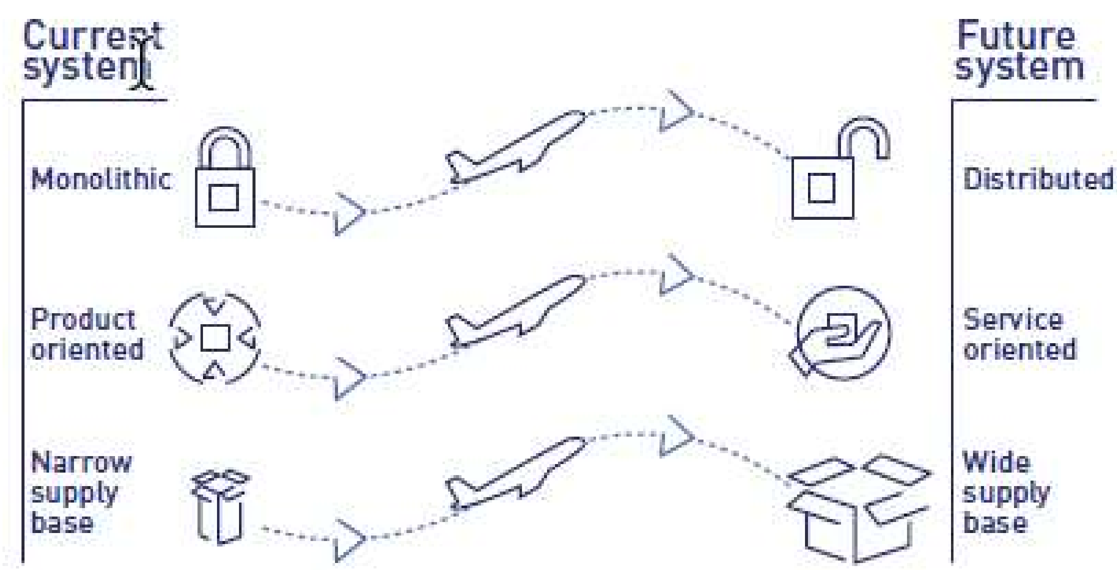


Figure X Towards a Digital Ecosystem


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Delivery of the digital European sky by 2040 is ambitious and will require, from 2020 onwards, a new way of working within SESAR, combined with changes to the regulatory framework to further shorten innovation cycles and time to market. It is only by introducing these bold changes in a timely manner that the aviation infrastructure will be able to effectively and sustainably cope with the entry into service of new types of vehicles expected to shape the future of aviation

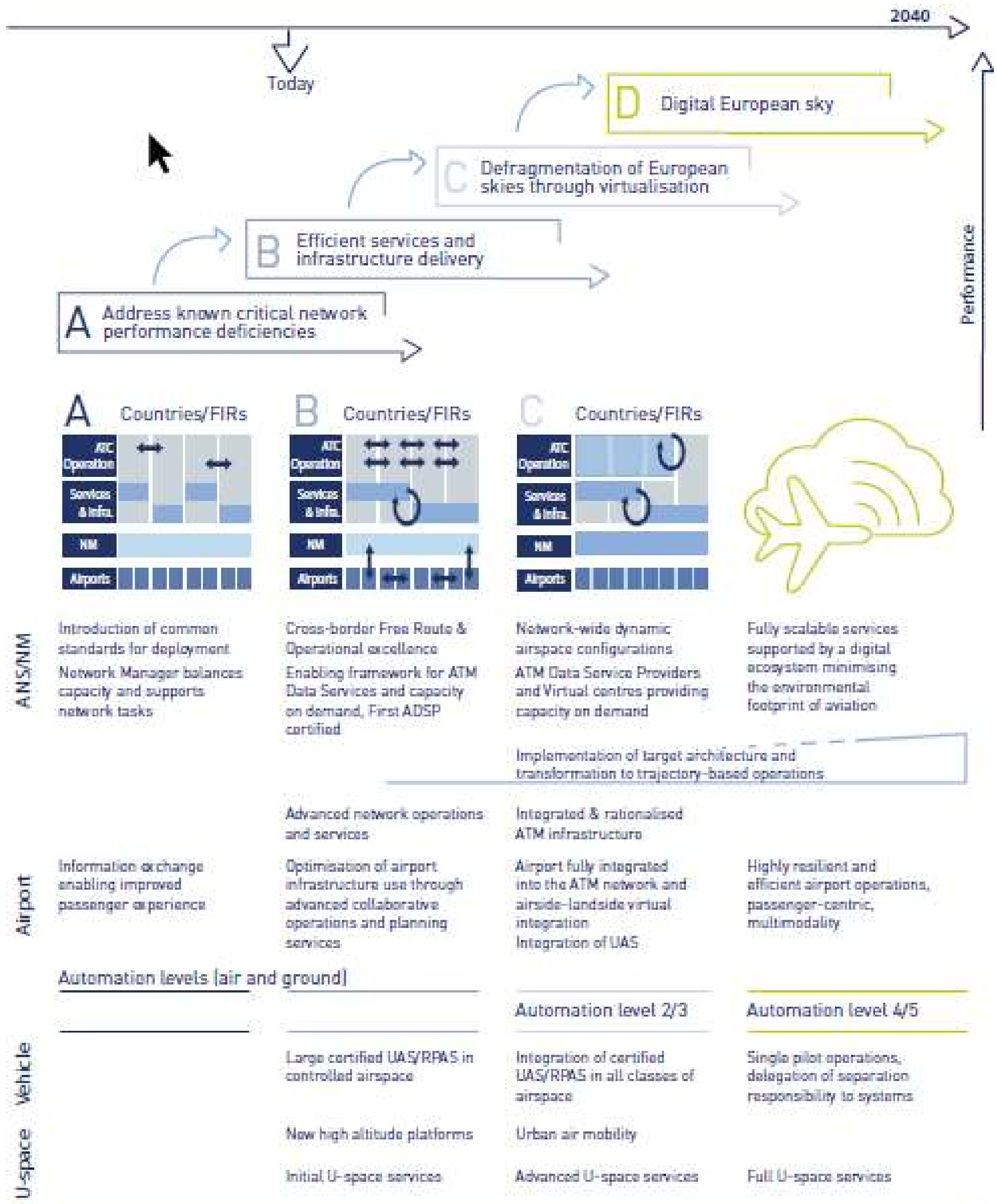



Figure X Four-phase approach for improvements

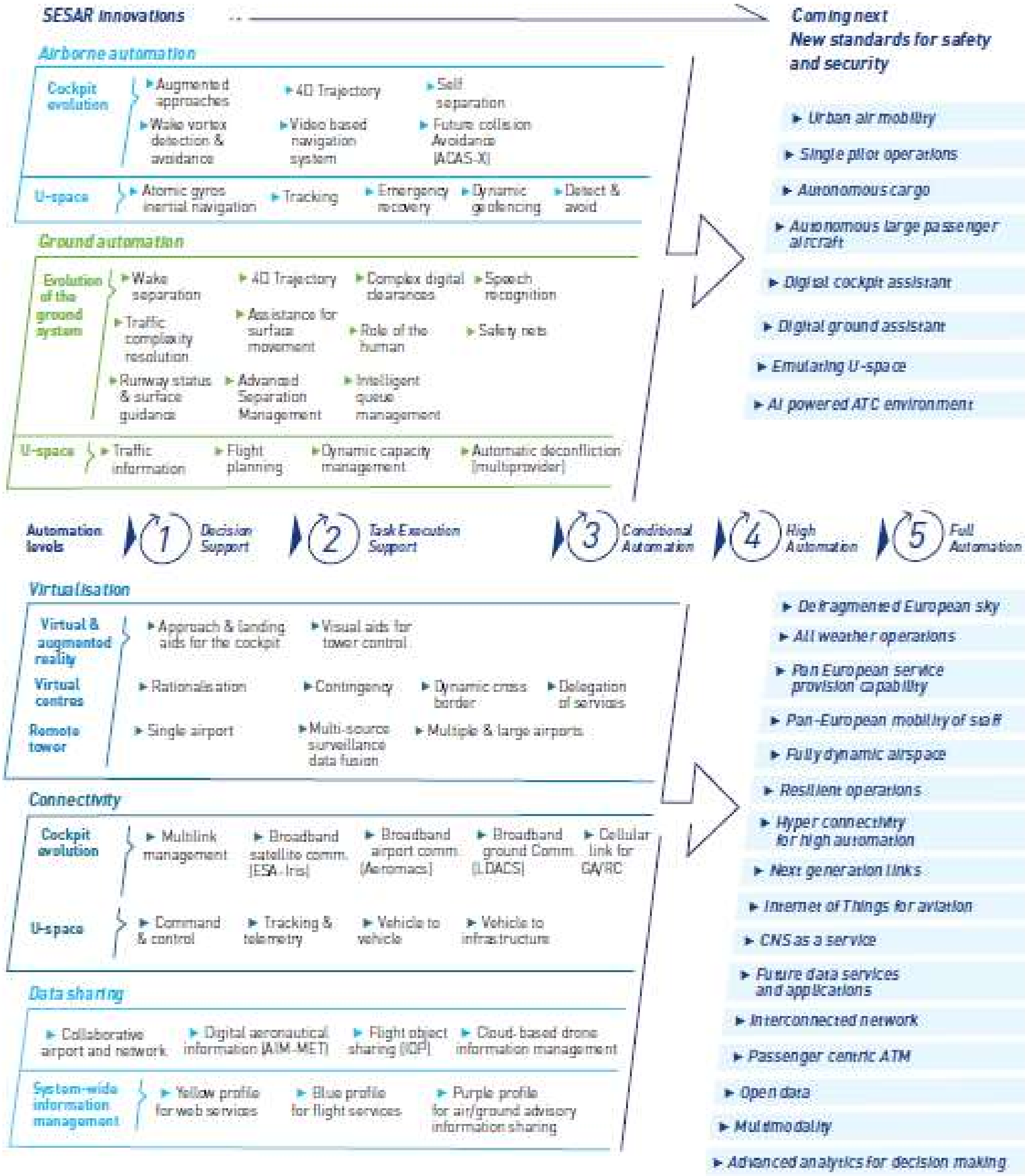
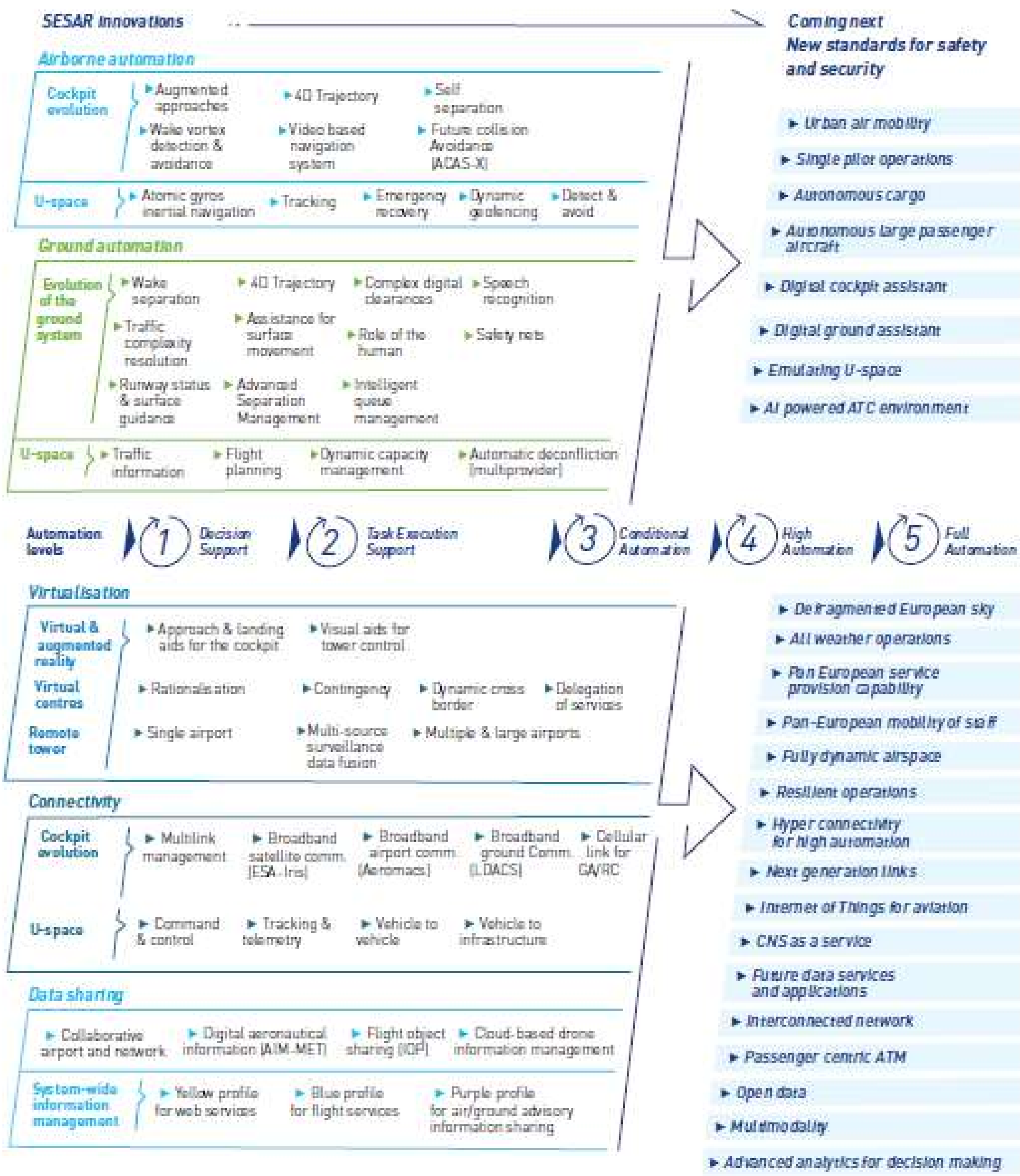



Figure x What is coming next

- **Virtualisation serving scalability and resilience**

Increased automation and virtualisation hold the greatest promise for effectively balancing supply (of ATC) and demand (for flights) while ensuring higher levels of resilience. With services delivered irrespective of physical infrastructure or geographical location, the defragmentation of European skies can be realised through virtualisation. Airspace capacity can be offered on demand through horizontal where threats are continuously evolving. An integrated operational and technical architectural approach will be required. Cybersecurity and safety considerations for systems powered by advanced digital technologies (e.g. AI, speech recognition) will have to be taken into account. Designing safety and cybersecurity provisions for highly automated systems will be a major challenge and will open up new avenues of research.

Themes: provisions for highly automated and autonomous air-ground systems, integrated safety and cybersecurity, the trust framework in hyper-connected and virtual networks, system and human performance.



sociological factors and the needs of all actors involved, including those who will influence and enable organisational change, are taken into account.

### A.6.2 Changes to address

The following developments are anticipated within the work system:

- the gradual digitalisation of the ATM ;
- in this context, the changing human role and the changing nature of work carriedout by human,, which will emerge from the implementation of the ATM target concept;
- new work relationships and dependencies, as the integrated nature of work evolves.

It is not yet possible to describe the full scope and scale of the changes in detail owing to changes in the human role as the work system itself evolves.

From the analyses performed on changes within the scope of SESAR, the following most critical challenges and assumptions with regard to the human role in ATM have been identified.

- Potential exists for redistribution of tasks and functions between existing system actors (between humans in the system, and between the human and the machine) and new, emerging roles.
- The traditional belief that the human will manage unexpected events unaided or unsupported is no longer viable.
- A new human-machine integrated approach will be utilised to deliver targeted performance in nominal and non-nominal conditions.
- In some cases, responsibilities traditionally attributed to human roles (pilots, ATCOs, ATSEP), including for system maintenance and supervision, will change. This may result in machine actors taking over a number of tasks, for instance where it is not possible for the human to perform any meaningful function.
- Assistance will be provided by new tools to enable human operators to address new challenges such as cybersecurity, new degraded modes or cascade failure effects due to the interdependence and tightly coupled relationship of interoperable ATM/ANS systems.
- The legal implications of human and machine actors sharing tasks, in terms of responsibilities and accountabilities, will be determined at every step-change towards the ATM target concept.
- The joint nature of a collaborative work system introduces new factors and behaviours that serve to add complexity and system variability, as each new function may involve differing combinations of human and system elements working together and interacting functionally.
- In particular, for cybersecurity, new tools will be needed to enable actors to distinguish, for all systems, between system failures and cyberattacks.
- Change management will remain an essential element of the critical path for successful implementation of the target concept. In keeping with the systems approach, the scale of collaborative activities will include a broad range of roles, actors and organisations at all levels.
- The skills and knowledge required of human actors — system wide — will be different, generally more managerial and complex, in future. Ongoing competence and capability will be achieved only through integrated continuation training.



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A change management strategy across the extended ATM system is an essential prerequisite to fulfilling the ambitions of the Master Plan. A clear change management strategy and associated planning to initiate, implement, manage and steer effective and sustainable change and transition within all organisations should be established before SESAR deployment.

This will be supported by appropriate governance and management to ensure that personnel have reached the capability required for each role or function to be undertaken. Where new roles and capabilities are introduced, competence to undertake such roles with confidence will need to be proven and attained.

A strategic change plan — to include a clear statement of the objectives of change, timescales, resources, communication plans, a description of the contribution of staff (in deployment activities, with regard to the establishment of a social forum at European, national and company levels, etc.) and risks associated with the execution of the plan — is needed.

Building the momentum for change will involve taking into account the need for humans to develop effective working relationships with new actors and to develop new working methods. Change management will support and enable the transition through the step-changes of the numerous iterations of the delivery of the ATM target concept. This will include, but not be limited to, implementing a pattern of changes that will lead humans to feel that they are in control and able to navigate the changes in ways that do not compromise their safety or competence.

### A.6.4 Gender equality in ATM

ATM in Europe used to be a rather male- dominated business, and it lags behind many other businesses when it comes to balancing gender participation at all organisational levels.

Not only is the share of women in most ATM organisations lower than that of men, women are in particular often underrepresented at higher management levels.

Most organisations today recognise the added value that gender equality and also ethnic and cultural diversity bring to organisations. While transforming the European ATM system over the years to come, as described in the Master Plan, all ATM organisations are strongly encouraged to achieve balanced gender participation at all levels of their organisations in line with the European initiative ‘Women in Transport — EU Platform for Change’ (50).

## A.7 CYBERSECURITY IN A SAFETY-ORIENTED INDUSTRY

The main objective of SESAR is to deliver a fully scalable system, fulfilling successfully the growing capacity needs while remaining even safer than today’s system, striving to achieve the ambition of ‘no ATM-related accident’ (see Chapter 3). From a safety perspective, this means that all SESAR Solutions will be validated to deliver safety performances that, taken collectively, will make it possible to maintain or improve on the current high safety levels despite the increase in traffic.

The aviation system will evolve significantly in the future, with the application of new operational concepts, an increased use of commercial off-the- shelf products developed using open standards, increased sharing of data and networking of systems, and the

introduction of new vehicles into controlled airspace. The next generation of systems resulting from the digitalisation of aviation will apply emerging technologies (e.g. AI (51), data analytics, new security technologies, etc.), and may introduce new threat vectors, particularly in the area of cybersecurity, the

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carried out under ATC supervision without impacting separation and sector team management. The efficient strategy and resolution of simultaneous constraints (brokerage function) related to multiple extended AMAN advisories also requires further research. Furthermore, research should consider how larger unmanned aircraft, such as cargo drones, could fit into airport arrival queues, and whether arrival management automation could be extended to possible queues of air taxis approaching a congested air taxi hub. Research into departure queue management automation will also contribute to improvements in uninterrupted aircraft climb profiles from airport to free route airspace. As with arrivals, departure queue management automation is dependent on the ex- change of highly accurate trajectory information between all actors (i.e. airport, ANSP, aircraft operator); such techniques are likely to also apply to drones, air taxis and larger unmanned aircraft.

- **Runway use optimisation through integrated use of arrival and departure time-based separation (TBS) tools**: The most modern time-based separation tools are already good examples of the value of automation in ATM. Research is required to further improve the whole runway usage process, combining arrival and departure capabilities. Data-sharing between airport collaborative decision-making parties, arrival and departure managers and time-based separation tools will allow the dynamic optimisation of the runway(s) based on prevailing operational needs. Such solutions will, for example, choose the most appropriate departing aircraft to make use of an arrival gap, sharing data with the airport systems to en- sure the departing aircraft is loaded and taxies to be in the right place at the right time.
- **Airport automation including runway and surface movement assistance for more predictable ground operations**: Airport ATC will also benefit from further automation support to manage increasing complexity. Further research is required into the automation of stand planning, taxi routing and ground de-confliction, and runway use optimisation, based upon improved and increasingly accurate data-sharing between applications. A holistic view, beyond the integration of airport operations plan (AOP) and network operations plan (NOP), integrating different technologies and data sources combined with artificial intelligence/machine learning will bring improvements to ground operations and enable more collaborative decision-making between stakeholders, thus improving predictability and the network performance as a whole.
- **Integration of safety nets (ground and airborne) with the separation management function**: The separation assurance of the future aviation ecosystem will require close conformance monitoring of the negotiated and authorised flight trajectories throughout the execution phase, to be coupled with the advanced defences provided by independent ground-based and airborne safety nets. The use of those trajectories in the progressively more automated detection, classification, resolution and monitoring of conflicting profiles in the planning and tactical phases of ATM will minimise the opportunity for separation to be eroded. However, consideration as to the level of independence of the safety nets from the other aspects of control will be critical as the levels of autonomy of those other systems increase.
- **Role of the human**: The goal of automation is not to replace the human but to optimise the overall performance of the socio-technical ATM system and maximise human performance2. This will require the development of the role of the human in parallel with ATM concepts and technological developments. New tools are needed to support continuous, system-wide monitoring of all critical processing, including during degraded modes of operation or, for example, cyberattacks. New tools must also enable humans to make effective decisions, including where collaborative, co-adaptive and joint intelligence modes of decision-making are used. A move from executive control to supervisory control will require a thorough understanding of the implications for the humans and their interaction with the systems. The


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appropriate definition of new SWIM services to further speed up their deployment based on clear use-cases in line with the ADSP requirements. Ad- ditionally, future seamless integration of ATM and U-space domains via SWIM (e.g. through the yel- low profile) requires R&I actions in support of the provision of different services like registration and identification, dynamic airspace information and geo-fencing, flight planning and surveillance data.

## B.2 Air-ground integration and autonomy

The future ATM needs to evolve, exploiting existing technologies as much as possible, and developing new ones in order to increase global ATM performance in terms of capacity, operational efficiency and accommodation of new and/or more autonomous air vehicles, i.e. supporting the evolving demand in terms of diversity, complexity from very low-level airspace to high level operations. This progressive move towards autonomous flying, enabled by self-piloting technologies, requires closer integration and advanced means of communication between vehicle and infrastructure capabilities so that the infrastructure can act as a digital twin of the aircraft. Ultimately, manned and unmanned aerial vehicles should operate in a seamless and safe environment using common infrastructure and services supporting a common concept of trajectory-based operations. Future operations should therefore rely on direct interactions between air and ground automation, with the human role focused on strategic decision-making while monitoring automation.

Seven R & I needs have been identified in relation with this flagship:

- **Enabling greater ground and airborne integration and wider performance**: Greater air-ground integration will require solid, safe and secure means of communication and networking to transform, in a stepped approach, the current way to communicate. From gate to gate, air to ground automation (A/G) will ensure the use of automatic selection of the link and frequency for communications by the pilot and ATC. This will support single-pilot and cross-border operations. Air to air communication (A/A) will enable new operations (formation flights, etc.) and will support advanced separation management and safety nets in the context of the safe cohabitation of different types of air vehicles (High altitude, drones, airplanes, helicopters, etc.). Satellite-based technologies can speed-up global deployment for other technologies through virtualisation of infrastructures and synchronised deployments for all stakeholders. Research is required to integrate these technologies into a multilink environment that supports the interoperability and hyper-connectivity of air- ground communication as well as the transition to IP-based communications.
- **Integrated 4D trajectory automation in support of trajectory-based operations (tBO)**: A common 4D trajectory, shared between every application that needs to process each flight, and updated by every application acting upon that flight, underpins ground-provided ATM. The accuracy of the trajectory is likely to improve at every stage of flight planning and execution. This requires earlier access to/sharing of detailed flight planning information, and all subsequent updates, publication of planning adjustments to the trajectory, and subsequently ATM trajectory adjustments, correlated with the aircraft's actual trajectory. These principles also apply to new airspace users, including drones, air taxis and high- altitude vehicles. The integration/revisions of 4D trajectories will be based on the extended flight plan (eFPL) exchanges and require different flight and flow – information for a collaborative environment (FF-ICE) services in pre-departure and post-departure phase of flight, including the exchanges of planned 4D trajectory. The eFPL revisions during the planning and execution phase requires further research. Implementation of the TBO concept and FF-ICE needs to consider all the different parts that in a synchronised way have to be developed and, as soon as integrated, can

operating at very low level (VLL) close to urban areas and airports, up to large vehicles, such as remotely-piloted aircraft systems (RPAS), used both for civil and military applications, which will routinely operate safely using ATM services: manned and unmanned should be able to use the same airport infrastructure; they will both communicate with ATC using datalink; rules and procedures will be applied to both, with some adaptations for drones as the pilot is on the ground. The research will look at:

- How to enable drones to operate in controlled/ uncontrolled airspace, both under IFR or VFR, and safely integrate with cooperative and non-cooperative traffic
- How to ensure that airborne safety nets will re- main effective and independent from separation provision while possibly adapting ground-based safety nets to these new modes of separation.

- **Super-high-altitude operating aerial vehicles:** These vehicles, which can be viewed as drones, will also need to be integrated, with entry and exit procedures through segregated or non-segregated airspace. As a result, new airspace users include highly autonomous vehicles. Safe separation management of this traffic and efficient integration into the traditional ATM operation is both a technical and operational challenge. Moreover, airborne surveillance and the safety nets (terrain, weather, traffic) and evasive manoeuvres will certainly be impacted by the introduction of new vehicles, such as drones (evolving in lower airspace below 500 ft.).

## B.3 Capacity-on-demand and dynamic airspace

For the last decades, capacity has not been available when and where needed and it has often been available when and where not needed. New airspace users including RPAS/HAO traffic will increase by 2030 and will require an increased level of capacity and its variability. Integrated Air Traffic Management requires agility and flexibility in providing capacity where and when it is needed, particularly for maximising the use and performance of limited resources, i.e. airspace and ATCOs. It will require the dynamic reconfiguration of resources and new capacity-on-demand services to maintain safe, resilient, smooth and efficient air transport operations while allowing for the optimisation of trajectories even at busy periods.

Three R & I needs have been identified in relation with this flagship:

- **On-demand air traffic services**: In the future, the increasing number of flights and emerging new technologies will lead to a structural transformation of the way air traffic services are provided. Delivering the capacity needed across the network, improving cost and flight efficiency while maintaining safety and resilience requires the supply to be optimised on demand in a dynamic, agile and resilient manner. The challenges of providing capacity on demand are:
  - 3 Ensuring that automation using artificial in- telligence supports ATCOs and is under their supervision.
  - 3 Adapting training programmes for ATCOs and other ATM personnel in order to manage an in- creased level of automation. The management style should ensure the transparency of auto- mated processes to humans and the capability of human interventions only when necessary.
  - 3 Addressing legislation, certification and social dialogue issues.

enhanced by the optimisation of multiple ATFCM demand measures while reducing the adverse impact of multiple regulations affect- ing the same flight or flows. Indeed, for the provision of common network situation aware- ness and enhanced demand and capacity bal- ancing, network management will gradually evolve towards flow-centric operations. This will enable a collaborative approach in the con- text of flow and network management for in- creased dynamic capabilities and predictability, leading to the capacity-on-demand concept.

- 3 Digital integrated network management and ATC planning (INAP): In order to cover the plan- ning gap between ATFCM and ATC processes and facilitate layered ATM planning in the exe- cution phase, integrated network management and ATC Planning (INAP) will be gradually implemented to optimise the flow management process. Digital platforms would aim to expand the what-else concept e.g. the system suggests alternatives or refinements based on the initial solution proposal by the operator. AI and auto- mation is still to be researched while the INAP CONOPS is already clear now. Within INAP there is also the need to research spot man- agement, which uses traffic monitoring values (TMV), standing for different objectives (safety, rate optimisation, critical and crisis situations, etc.) to define and address different types of spots (regions of interest). For instance, local spots need to be integrated (in terms of infor- mation-sharing and operational procedures) with the Network Manager's NetSpot.
- 3 The network integration of higher airspace operations (HAO) (FL500 and above): There is a need to ensure the integration of these op- erations as they transit through the classic European ATM Network. Indeed the current Network and higher airspace should be seen as a continuum requiring research and even- tually demonstrations to confirm the services required by new airspace users, notably high altitude long endurance (HALEs) platforms, sub-orbital and commercial space operations, supersonic and eventually hypersonic pas- senger transport. Challenges exist in how to integrate new entrants with their diverse per- formance transiting through the classical ATM network as well as determining services re- quired in HAO. Moreover, these HAO challenges and services' definition require extra-European coordination. Some examples:
- 3 To transform some European airports into spaceports (designated and authorised site for launch/take-off and/or re-entry/landing of sub-orbital vehicles).
- 3 The use of non-cooperative tracking of a high-altitude vehicle: it could be continuous- ly carried out in real time in order to moni- tor the vehicle's status, the flight path and to enable the prediction of the vehicle's position or debris excursion in case of a mishap.
- 3 RPAS demonstration for RPAS accommoda- tion in controlled airspace (Airspace Class A to C): This key R&I activity is aimed at accommo- dating IFR RPAS in non-segregated airspace in accordance with the drone roadmap in the European ATM Master Plan. The objective is to enable IFR RPAS operating from dedicated air- fields to routinely operate in airspace classes A-C as general air traffic (GAT) without a chase plane escort. The scope includes development of adaptations to the flight planning processes, DCB developments, contingency, etc.

- **ATM continuity of service despite disruption**: In case of disruption, the new airspace architecture should enable solutions allowing for continuity of service. For example, it should enable resources (including data) to be shared across the network supporting flexible and seamless civil/military coordination allowing for more scalable and resilient service delivery to all airspace users. Resilient ATM systems would continue to provide services despite disruption, e.g. during capacity bottlenecks, adverse weather, national system breakdowns or disruptive social actions.


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## B.4 U-space and urban air mobility

Over the next 10 years, the implementation of this SRIA aims to unlock the potential of the drone economy and enable urban air mobility (UAM) on a wide scale. To that end, a new air traffic management concept for low-altitude operations needs to be put in place to cater safely for the unprecedented complexity and high volume of the operations that are expected. This concept, referred to as U-space, will include new digital services and operational procedures and its development has already started within the SESAR 2020 Programme. U-space is expected to provide the means to manage safely and efficiently high-density traffic at low altitudes involving heterogeneous vehicles (small unmanned aerial vehicles, electric vertical take-off and landing –eVTOLs - and conventional manned aircraft), including operations over populated areas and within controlled airspace. U-space will have to integrate seamlessly with the ATM system to ensure safe and fair access to airspace for all airspace users, including UAM flights departing from airports.

- Safety assurance,
- Applications above VLL airspace;

The development of U-space will have to over- come extraordinary challenges. A new regulatory framework, supported by a comprehensive set of standards, has to be established to provide a solid framework for safety and interoperability without hindering innovation. U-space will have to integrate seamlessly with the ATM system to ensure safe and fair access to airspace for all airspace users. This integration will not be straightforward since the re- quirements on U-space services may not be com-patible with those imposed on ATM. To cater for the anticipated volume of operations, U-space will need to rely heavily on automation and to take advan- tage effectively of emerging on-board capabilities and advanced digital technologies on the ground. In addition, U-space is expected to have a profound socio-economic impact, enabling the creation of a new marketplace for U-space service provision and accelerating the advent of the drone and urban air mobility economy. Ultimately, the development and deployment of U-space will help position Europe as the global leader in UAM and drone-based services, accelerating the development and adoption of new technologies (AI, cloud, digital services, big data) and fostering the creation of high quality jobs.

U-space provides an unparalleled opportunity to experiment, test and validate some of the key ar-chitectural principles and technology enablers of the future Digital European Sky before incorporat-ing them into the broader ATM ecosystem. It can potentially help de-risk and accelerate the digital transformation of the European ATM system while opening the way to the safe integration of new ve-hicles into the airspace. UAM is expected to be the most challenging type of operations supported by U-space. UAM will enable on demand highly auto- mated operations of drones and larger eVTOL vehi-cles over urban areas, providing cargo, emergency and passenger transportation. Plans are afoot to deploy UAM in many European cities, with small- scale cargo operations already taking place and ini-tial passenger services expected to launch by 2025. UAM will involve new types of vehicles with hetero-geneous performances and high levels of autonomy, which will have to coexist with conventional manned traffic and will need to be accommodated by the U-space and ATM ecosystems.

Considering the above, the main research and innovation challenges required to deploy U-space will include the following:

airspace (includ- ing airborne detect and avoid (DAA) as well as ground-based and hybrid solutions) should also be considered.

**Enable urban air mobility (UAM):** The require- ments of UAM operations are expected to be the most challenging for the U-space ecosystem. One of the key research questions is how to inte- grate the airspace autonomous operations over populated areas safely into complex and con- gested airspace environments, with operations involving vehicles interacting with U-space and conventional ATM services. Research should in- vestigate how U-space can support the transition from piloted to autonomous operations (linked to EASA AI Regulatory Roadmap[17]). The evolution of U-space together with its associated regula- tory framework and standards will need to be synchronised and coordinated with the develop- ment of the future UAM ConOps, its associated UAM services and the certification of UAM vehi- cles. Special consideration should be given to the operational limitations of these new vehicles and how U-space can contribute to operational safe- ty by protecting their operation in contingency and non-nominal situations. In addition, mech- anisms and protocols to enable Collaborative Decision Making in the context of UAM, involving ATM, U-space and city stakeholders, will need to be explored.

**ATM/U-space integration:** U-space services shall enable safe and efficient operations of un- manned aircraft without negatively impacting the operations of other airspace users. The seam- less integration of U-space and ATM services  is expected to contribute to the fairness, safety, efficiency and environmental impact of the over- all air traffic system. The capacity benefits and flexibility of an airspace without segregation re- quires the full integration of U-space and ATM. For U-space and ATM environments to be inte- grated, it does not necessarily mean they oper- ate in the same way. They could be very different indeed, but with suitable interfaces to allow safe and effective coexistence. Standard operating procedures will need to be defined (for example rules of the air and airspace management) to allow manned and unmanned aircraft to share the same airspace safely, as well as the simul- taneous provision of U-space and ATM servic- es). The safety, security, certification and regu- latory challenges arising from the provision of U-space services to manned aircraft should be studied. Information exchange will be critical to enable a safe convergence of U-space and ATM. Challenges include cybersecurity, data compati- bility and the reconciliation of different standards and certification requirements. Another critical aspect of the integration will be the role of the human, particularly regarding the high level of automation that will be delivered by U-space ser- vices and the automation disparity between ATM and U-space.

In addition to the key challenges described above, the following transversal research areas will be crit- ical to the successful development and deployment of U-space.

**Financial and legal aspects**: Research needs to be conducted on potential U-space and drone op- erator business models, focusing on the mecha- nisms required to create a fair and competitive U- space market across Europe. The available alternatives for the financing of a sustainable U-space ecosystem should be analysed, includ- ing how to optimise public and private invest- ments and the implications for the financial model of European ANSPs. The insurance mod- els required for U-space should also be analysed.

**Social acceptance:** Work is required to ensure that the new operations enabled by U-space are acceptable to the public. Specific areas of con- cern will be UAM noise, visual pollution, privacy, etc. In addition, a consensus must be reached on the acceptable target level of safety of the differ- ent types of operations under U-space. The im- pact on general and leisure aviation should also be considered.

**CNS and separation minima**: Definition and vali- dation of performance-driven CNS requirements for operations under U-space, together with the applicable separation minima. The separation minima

- Scalability and resilience,
- Free flow of data among trusted users across borders,
- Regulations and standards,
- Cyber resilience;

future data-sharing service delivery model

Data-sharing supports the progressive shift to a new service delivery model for ATM data, through the establishment of dedicated ADSPs. A common EU-wide ATM data service layer, will enable all ATM service providers to benefit from the cross- border sharing of data. The ADSP would provide the data and specific applications (e.g. STCA, Correlation, etc.) required to provide ATM services. On the data side, the ADSP will convey CNS (e.g. radar data, flight data processing information), ATM, voice data, AIM data (static, semi-static and dynamic data) and also meteorology (MET) data. The data can be delivered in raw format or be processed to allow the delivery of services such as flight correlation, trajectory prediction, conflict detection and conflict resolution and arrival management planning and will extend to the provision of safety-net services (e.g. short-term conflict alerts - STCA, minimum safe altitude warning - MSAW, area proximity warning - APW) and on decision-making support tools as a service (providing the what-if and the what-else functions, attention guidance, etc.). At a detailed operational and technical level, the question of drawing a clear boundary between ATM services and ADS is open and will be tested through simulations and impact assessments as the concepts mature.

Infrastructure as a service

Through a service-oriented architecture (SOA), the infrastructure services (e.g. communication, navigation and surveillance) will be specified through contractual relationships between cus- tomers and providers with clearly defined Euro- pean-wide harmonised service-level agreements. This approach will create business opportunities for affordable services with a strong incentive for service providers to rationalise and harmonise their own infrastructure in support of nominal and contingency operations and more generally the provision of safe, efficient, cost-efficient, interop- erable and standardised ATM and CNS services. A large part of the CNS services will be provided through applications using space-based sensors. With regard to communications, the transition to- wards an IP-based environment will enable the location-independent transmission of data and/or voice. Possibly, a dynamic allocation of IP connec- tions will reduce the need for VHF channels on the ground side and the need for the airborne side to switch frequencies several times during the flight. R&I needs to deliver solutions utilising infrastruc- ture (CNS, IT, U-space, etc.) as a service, enabling new combined services.

Scalability and resilience

Open architecture guarantees the long-term upgradability and scalability of ATM service provision and the agility required to enhance services. With the delivery of ATM services irrespective of physical infrastructure or geographical location, the defragmentation of European skies can be realised through virtualisation: i.e. decoupling the provision of ATM data services from ATS, allowing them to be provided from geographically decoupled locations. Airspace capacity can be offered on demand through horizontal collaboration between the Network Manager and the ATSU. The Digital European Sky will allow for more efficient and flexible use of resources, substantially improving the cost-efficiency of service provision and delivering the capacity needed. Ultimately, the virtualisation of Air Traffic Management services will allow the creation of new business models and the emergence of new ATM players, which will foster competition in the sector. Importantly, this will enable ANSPs to

## B.6 Multimodality and passenger experience

A significant portion of the planned door to door (D2D) journey time is taken up by the buffers needed to absorb uncertainties associated with the performance of the various modes contributing to a journey (including within the airports). Mobility providers need access to reliable planning and real-time information on schedules to give more accurate forecasts of arrival and transfer times. Optimising D2D mobility for people and goods is essential in meeting citizens’ expectations for increasingly seamless mobility, where they can rely on the predictability of every planned door-to-door journey and can choose how to optimise it (shortest travel time, least cost, minimal environmental impact, etc.). Considering ATM to be an integrated part of an intermodal transport system will make it possible to share data between modes and to collaborate better to optimise the performance of both the overall transport system and the D2D journey. Four R & I needs have been identified in relation with this flagship:

- Access to /exit from the airport: Airports are obvious multimodal nodes for aviation,
- Passenger experience at the airport,
- An integrated transport network performance cockpit,
- An integrated transport network crisis management process;

Access to /exit from the airport: Airports are obvious multimodal nodes for aviation

Real-time information exchange giving stakehold- ers (including mobility providers) an increased knowledge of the entire multimodal journey will en- hance the reliability of multimodal journey planning, identifying potential access issues that could affect the punctuality of operations, alleviating congestion, mitigating regulatory constraints, etc. This, with the extended integration of ATM network planning (mul- ti-slot swapping, aircraft operator-driven prioritisa- tion processes etc.) and cooperation on enhanced collaborative airport performance planning and monitoring, will enable passengers to have a full picture of their journey and optimise their D2D time.

The concept of airport collaborative decision mak- ing (A-CDM) has proven the benefits of sharing in- formation and procedures between airport stake- holders and the wider ATM network. The A-CDM concept will be extended to encompass specific stakeholder information requirements relating to elements of the multimodal journey and fully in- cluded in the AOP and NOP collaborative processes.

Understanding passenger origin-destinations will ensure easy access/egress for all passengers (not only those from the nearby city) and optimal land- side and airside design. Use of AI will help optimise pre-screening of passengers and departure / arriv- al queues /sequences in order to accommodate as much door-to-door journeys as possible. Single ticketing and remote check-in/bag-drop will enable smooth transit and easier planning of the passenger journey. Mobility as a service (MaaS) will help with this planning and provide alternative routings in case of disruption. This will require seamless integration between ATM, UAM (see section 3.4), and surface transport. The integration of vertiports into airport operations and city surface transport networks will allow the rapid transfer of some passengers’ right to the heart of an airport using UAS/UAM and facilitate the introduction of point-to-point inter-urban UAS/ UAM flights. This SRIA targets demonstrating such integration through at least one operational imple- mentation in a European city before 2027.

Passenger experience at the airport


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## B.7 Aviation Green Deal

The objective of net-zero greenhouse gas emissions by 2050 set by the European Green Deal, in line with the EU's commitment to global climate action under the Paris Agreement, requires accelerating the shift to smarter and more sustainable mobility. This implies the need for aviation to intensify its efforts to reduce emissions. To this end, a set of operational measures to improve the fuel efficiency of flights will have to be put in place with the aim of enabling aircraft to fly their optimum fuel efficient 4D trajectory. At the same time, to ensure sustainable air traffic growth, it is necessary to speed up the modernisation of the air infrastructure to offer more capability and capacity, making it more resilient to future traffic demand and adaptable through more flexible air traffic management procedures. Furthermore, reducing aircraft noise impacts and improving air quality will remain a priority around airports. Eight R & I needs have been identified in relation with this flagship:

- Optimum green trajectories,
- New ways of flying,
- Formation Flight,
- Advanced RNP green approaches,
- Environmentally optimised climb and descent operations (OCO and ODO),
- Non-CO2 impacts of aviation,
- Impact of new entrants,
- Accelerating decarbonisation through operational and business incentivisation;

Optimum green trajectories

The objective is to enable aircraft to fly their optimum fuel-efficient 4D trajectory (cross- border, where applicable). ATC actions should preserve as much as possible this optimum green trajectory from any potential degradation and from the associated additional emissions. Thanks to data sharing between all the actors (e.g. airlines, airports at departure and arrival, Network Manager and often multiple national air navigation and data service providers) involved in the execution of a given flight, monitoring tools and appropriate measures have to be defined to remove or reduce any gap between the optimal 4D trajectory and the planned or in execution trajectory. In terminal areas, it will be necessary to find the best possible compromise between maintaining the optimum fuel-efficient 4D and minimising the noise impact. Optimal green trajectories should also include and anticipate the challenges and performance characteristics of new aircraft types and propulsion that the European Partnership for Clean Aviation will deliver.

new ways of flying

This includes the exploration of innovative flight operations based either on existing or future avionics

that reduce the environmental impact of aviation (both emissions and noise) without compromising safety, for example more efficient ATFCM services or the application of short-term ATFCM measures (STAM) to flight paths, limiting the need to apply horizontal and vertical re-routings.



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Impact of new entrants

The introduction of new types of air vehicles, such as hybrid-electric/ hydrogen/electric aircraft, drones/ UAVs or super/hyper-sonic aircraft will offer new opportunities for the development of the air transport of freight and passengers, adding to the flexibility of the system, reducing door-to-door journeys and, with the use of non-fossil fuels, reducing or eliminating associated emissions. At the same time, however, they could create new annoyances and fears among the population overflown (noise; visual pollution, particularly at night; intrusion into privacy; risks to third parties, etc.) and even risk to wildlife (e.g. migrating birds, nesting areas), notably in locations where no nuisance from aviation existed before. These impacts need to be studied further, and the operations of these new entrants adjusted to minimise them.

Accelerating decarbonisation through operational and business incentivisation

Optimisation of flight operations (including taxiing at the airport) from an environmental perspective in the context of a full door-to-door green mobility.

3 Environmental impact assessment toolset: There is a need to develop further the set of European environmental impact assessment tools, in order to analyse, inter alia, the inte- gration of new entrants into the future ATM system and the overall environmental benefits and impacts they will have. Due to the com- plexity and diversity of environmental impacts, particular attention needs to be paid to the analysis of trade-offs, between environmental impacts, but also possibly with other perfor- mance areas.

3 Environmental impact assessment method- ology and new metrics: It is necessary to de- velop further the methodology used in SESAR 2020 not only to cover the research phase, but also the deployment and implementation phas- es. As part of this methodology, the use of big data analysis and machine-learning should be extended to the development of new environ- mental metrics that will be used to monitor environmental impacts and incentivise actors to promote compliance with environmental tar- gets and regulations. These metrics will also be integrated into the Environmental Dashboard, and into the Environment Impact Assessments toolset.

3 Climate resilience and adaptation: All future ATM solutions must demonstrate their resil- ience to projected future meteorological and atmospheric conditions, which could become increasingly extreme.

## B.8 Artificial intelligence (AI) for aviation

AI is one of the main enablers to overcome the current limitations in the ATM system. A new field of opportunities arises from the general introduction of AI, enabling higher levels of automation and impacting the ATM system in different ways. AI can identify patterns in complex real-world data that human and conventional computer-assisted analyses struggle to identify, can identify events and can provide support in decision-making, even optimisation. Over recent years, developments and applications of AI have shown that it is a key ally in overcoming these present-day limitations, as in other domains. Tomorrow's aviation infrastructure will be more data-intensive and thanks to the application of Machine Learning (ML), deep learning and big data analytics aviation practitioners will


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volcanic ash clouds or COVID-19), new methodologies will be re- searched to cope with the AI gap. This includes not just the tactical phase but also the strategic phase, when the operators of the system may be interest- ed in exploring what should be done to achieve a certain multi-objective system performance (for instance, by balancing capacity, cost efficiency and environmental impact), and a prescriptive system would be able to identify strategies.

Human – AI collaboration: digital assistants

The interaction between humans and machines powered by AI, or other sub-branches such as re-inforcement learning (RL), explainable AI (XAI) or natural language processing (NLP), will positively impact the way humans and AI interact. These ad- vances aim to increase human capabilities during complex scenarios or reduce human workload in their tasks, not to define the role of the human or to replace the human, but to support him4.

Aviation will need to ensure a human-centric ap- proach as described in the EASA Artificial Intelli- gence Roadmap [17]. Humans should understand what the systems are doing and also maintain the right level of situational awareness, i.e. to have con- science of the situation to enable human-machine to cooperate. The different levels of ATM Automa- tion (0 to 5) described in the European ATM Master Plan[1] and Airspace Architecture Study [11], and also linked to Master Plan phases, present an evo-lution in the way that the human and the system in- teract, with different transparency and explainabil-ity needs. This SRIA aims at laying the foundations for an automation level of up to 4.

AI-based human operator support tools that ensure the safe integration of "new entrant" aircraft types into an increasingly busy, heterogeneous and com- plex traffic mix (i.e. UAVs, supersonic aircraft, hy-brid and fully electric aircraft) should be developed. In addition, AI-powered systems are expected to be integrated into ground/cockpit systems, enhanc- ing communication for trajectory management

and much more. Digital assistants will request to be connected to the avionics world in order to ease data exchanges: in this context, cybersecurity will be a key enabler of these exchanges. Moreover, digital assistants will support pilots, thus reducing the workload (e.g. automating non-critical tasks, adapting the human-machine interface during op- erations). This is a first step towards introducing the artificial co-pilot necessary for future operations like SPO.

There will be a need to develop new HMI interfaces for ATCOs (e.g. augmented reality) and the capability to monitor ATCO workload in real time based on AI, as well as new skills and new training methods to support these new joint human machine systems.

AI Improved datasets for better airborne operations.

Datasets are essential to AI-based application de- velopment. R&I should be conducted to generate and in particular to enable the automation of such aviation-specific data sets from a large variety of on-board and ground communication across the network, which could then a enable broad range of AI-based applications for aviation (e.g. voice communications between ATC and pilots). New sensors will be loaded on board (drones/UAV and aircraft) such as camera, millimetre wave (MMW) radar, detect and avoid (DAA), light detection and ranging (LIDAR) in order to be able to execute new types of operations (automatic take-off or land- ing, etc.). These new operations will require new functions, such as intelligent augmentation tools, vision-based navigation or trajectory optimisa- tion. This will enable the use of AI as a response to the European Green Deal [3], applying opera- tional strategy based on environmental criteria and developing AI-based solutions to operational mitigations of aviation's environmental impact, such as near-real-time network optimisation (air- space/route

Action Area 4.9 of ACARE SRIA 2017 update Vol.1 [15], military authorities must have full access to all available information without additional cost. Increased civil-military data-sharing requires solutions ensuring the appropriate levels of quali- ty of service and security for military systems.

connectivity and access to cnS infrastructure

Future technical solutions making use of emerg- ing SATCOM and terrestrial datalink technologies and multilink, as well as advanced navigation and surveillance should enable a joint civil and mili- tary utilisation, reducing technical constraints and costs while maintaining appropriate levels of safety, security and environmental sustainability. The con- nectivity and access to CNS infrastructure also re- quires solutions ensuring security and appropriate levels of quality of service. At same time, the inte- gration of CNS and spectrum consistency in terms of robustness, spectrum use and interoperability is essential to define the future integrated CNS ar- chitecture and spectrum strategy. A service-driven approach, accommodating civil and military alike is needed to describe how the CNS services are delivered for navigation, communication, surveil- lance and traffic or flight information, including cross-domain services (e.g. contingencies). Fur- ther military and civil interoperability is expected in terms of the common use of CNS, rationalising civil infrastructure and costs, taking into account the capacity of military legacy systems to evolve. Research initiatives are needed to enable the use of multi-mode avionics relying on software-defined radios and reliance on enhanced visual systems and airborne surveillance to mitigate airborne col- lision functions. The success of military missions depends on adequate access to RF spectrum re sources, in particular to ensure the mobility and interoperability of forces. The digitalisation of ATC systems enables virtualisation approaches where remote operations become an important contrib- utor for resource pooling and sharing and ration- alisation. Virtual control centres allow for a more efficient and flexible use of resources, with civil/ military synergies.

cybersecurity

In a highly information-oriented operational sys- tem, data becomes a core asset to be protected. Civil-military data-sharing requires solutions en- suring the appropriate levels of quality of service and security for military systems. A necessary precon- dition to support the digitalisation of processes is a sufficient level of cybersecurity and data-protection,

which should be considered holistically in an end- to-end information management process. Further aspects to consider are personnel education, train- ing and capacity building, technical infrastructure and increased cooperation and information-sharing among civil and military authorities.

Performance orientation

Environmental sustainability, cost efficiency or de- lays imposed by inefficient use of available capac- ity represent a concern against which all aviation stakeholders have to assume responsibility. The complex interdependencies between civil and mili- tary stakeholders need to be examined to enable ap- propriate performance measurements in a spirit of balanced consideration between commercial needs and security and defence requirements.


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called machine learning methods, based on exploitation of data-derived information instead of formalised human knowledge. While at first the success was limited due to insufficient data, the availability of many training exemplars (e.g. Big data resources) made possible the application of statistical-based deep-learning methods. While this has resulted in significantly increased performance in AI, it has come at a cost of reduced transparency and explainability, leading to understandable concerns about system validation and robustness. Table 1 summarises the main features of these first two waves of AI.

While other industries like the automotive industry have developed roadmaps, research in ATM automation currently lacks a long-term vision on automation. Although it is generally agreed that the future of the ATM system will evolve towards higher levels of automation, a shared vision is needed in order to develop a research roadmap with a breakdown of specific research actions.

| | First Wave | Second Wave | Second Wave ext. |
|---|---|---|---|
| Years | 1960-1980 | 1980-2010 | 2010- |
| Technology | Expert-systems* | Machine learning | Deep learning |
| Algorithms | Logical rules | Statistical methods | Statistical methods |
| Expert knowledge | Expert knowledge<br>↓<br>Rules | Expert knowledge<br>↓<br>Model, Features | Expert knowledge<br>↓<br>Model |
| Learning | | Parameters<br>↑<br>Data | Parameters<br>↑<br>Data |
| Algorithm application | Rules<br><br>Data | Model<br>↓<br>Data | Model<br>↓<br>Data |
| Uncertainty handle | No | Yes | Yes |
| Abstraction | No | No | Yes |
| Interpretable | Yes | No | No |

* It should be noted neural networks (and other forms of machine learning) started to be studied and used in the late 1950s, in parallel to expert systems development, although the later were prevalent in early successful AI applications.

Figure x Waves of Artificial Intelligence

**Levels of automation in the SESAR research and innovation programme**

The SESAR research and innovation programme (SESAR 1 and SESAR 2020) has featured many projects in the field of automation, resulting in a lot of ground-breaking and useful outcomes. An especially interesting paper [31] summarises the levels of automation taxonomy (LOAT) which were developed in SESAR, drawing upon aviation-related automation experiences. This LOAT was inspired by the renowned work from Parasuraman, Sheridan and Wickens [32].

[31] Save, L. and Feuerberg, B., 'Designing Human-Automation Interaction: a new level of automation taxonomy', in de Waard, D., Brookhuis, K., Dehais, F., Weikert, C., Röttger, S., Manzey, D., Biede, S., Reuzeau, F. and Terrier, P. (eds), Human Factors: A view from an integrative perspective – Proceedings HFES Europe Chapter Conference Toulouse 2012, 2012 (https://www.hfes-europe.org/largefiles/ proceedingshfeseurope2012.pdf)

[32] Parasuraman, R., Sheridan, T. B. and Wickens, C. D. 'A Model for Types and Levels of Human Interaction with Automation', IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and humans, Vol. 30, No 3, 2000, pp. 286–297 (https://ieeexplore.ieee.org/ document/844354)

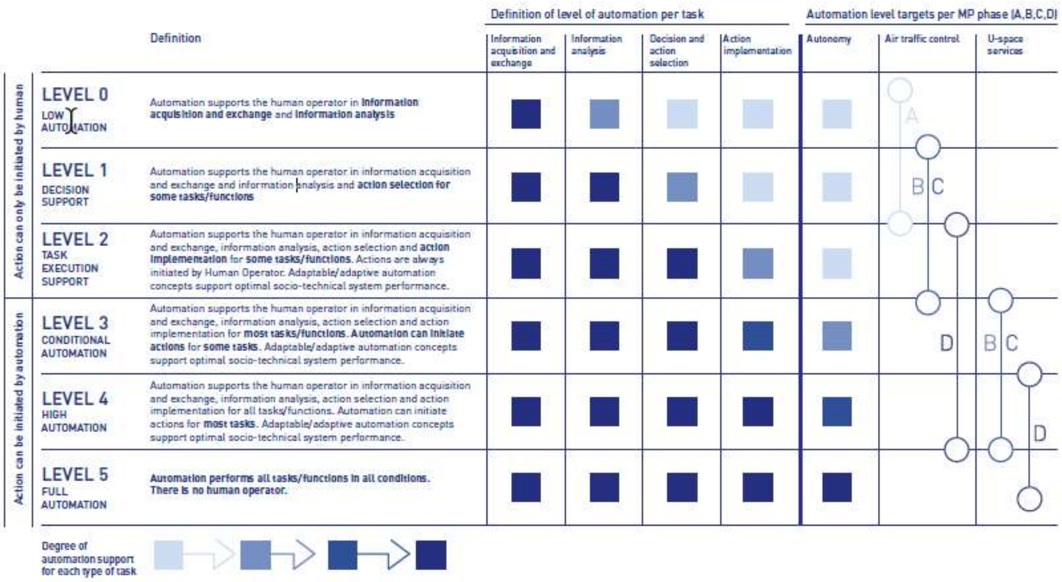


Figure x Levels of Automation from SESAR ATM Master Plan 2020

## Long-term automation scenarios

The implementation of higher levels of auto- mation imposes very demanding requirements not only on the technology itself, but it will also impact significantly the users and organisations, even at a societal level. Engagement with stakeholders and society, as well as those designing the system is needed in order to define a realistically acceptable proposal for the future of ATM automation. Table 2 shows a summary of the different challenges at each level. The three automation scenarios described in the table are suggested as potential candidates for a long-term vision of automation in ATM.

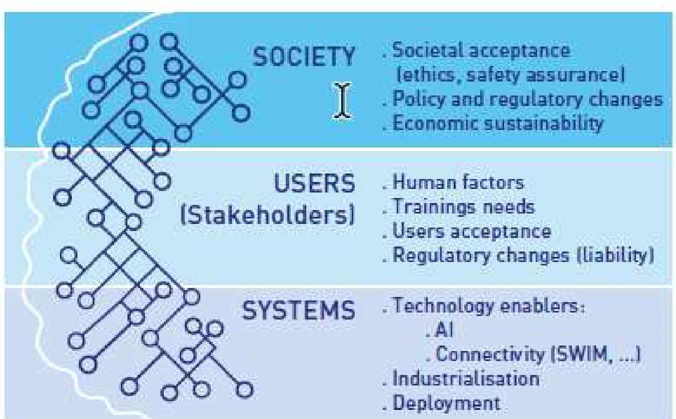


Figure x Summary of common automation challenges

| | S1 | S2 | S3 |
|---|---|---|---|
| Increased adaptability to context (improved generalisation) | M | H | VH |
| Capability to handle more complex tasks (involving multidimensional data) | VH | VH | H* |
| Reduce human stress, workload in nominal conditions (and as a result, increased capacity/reduced staffing costs) | M | M | VH |
| Reduce human stress, workload in non-nominal conditions (and consequently, increased safety) | M | H | VH** |

* Not so clear, as we are losing human inherent resilience while being able to handle more computationally complex problems.

** Surely true in normal conditions but not necessarily under unexpected or safety-critical events. This is in fact a critical discussion point, as current ML and AI capabilities are unable to compete with human capability in handling non-nominal conditions being the human critical to maintain overall system resilience.

Figure x Expected benefits of future automation scenarios

Additionally, these three scenarios were presented and evaluated during a workshop, which involved more than 40 participants representing each level (i.e. society, users, systems - see Figure 3) to get a holistic view on automation. The following conclusions can be drawn from the feedback received during the workshop.

| | S1 | S2 | S3 |
|---|---|---|---|
| Stability concerns (brittle system with erratic generalisation) | L | H | VH |
| Transparency concerns (reducing human situation awareness) | L | H | VL |
| Auditability concerns (complicating failure assessment) | L | H | VH |
| Lack of "creativity" when handling completely new circumstances | VL | L | VH |
| Reduction of human skills, which could be critical in failure situations (due to lack of training, experience, etc.) | L | H | VH |
| Lack of clearly established evaluation/validation procedures | H | VH | VH |
| User acceptance issues (trust, ethical issues, ...) | M | VH | VH |
| Legal issues (lack of clarity in liability) | H | VH | VH |
| Society acceptance issues | VL | M | VH |
| Risks related to unintended system manipulation (cyberattacks, ...) | L | H | VH |

Figure x Potential risks of future automation scenarios



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industrial and exploratory research strands. U-space research should continue in parallel, in particular on applications of AI/ML according to the U-space research roadmap outlined in the U-space Blueprint [15].

In the medium term (2023-2025), ATM automation research should start to investigate and mature the first applications of the "holistic cognitive support" scenario (S2). Additionally, U-space results should be analysed to assess the feasibility to transfer solutions for the holistic scenario to ATM. The transfer of U-space solutions offering full automation could be also investigated for some functions of the ATM system.

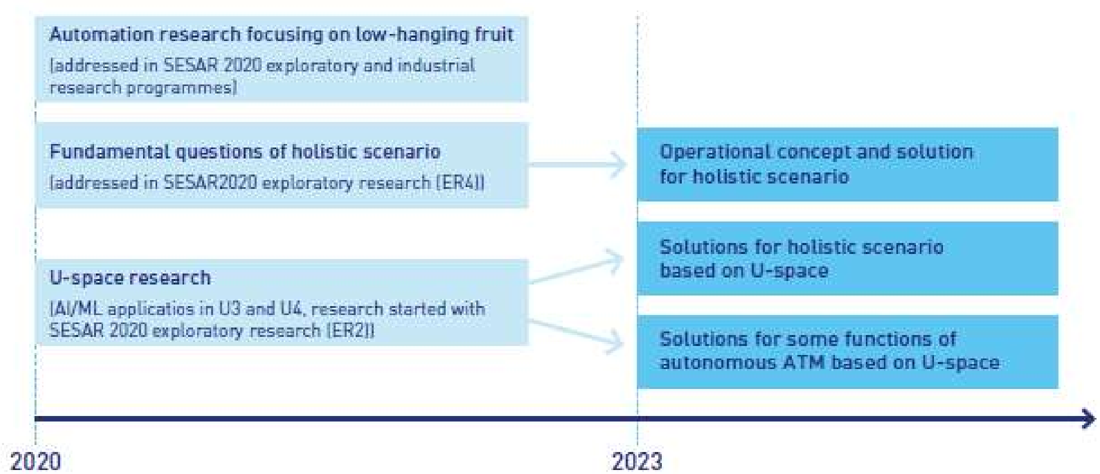


Figure x Initial automation research roadmap

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providers). This led to a high number of possible service combinations, the analysis of which provides a picture of the coverage of the services researched by the projects.

### D.2.2 Foundation services (U1)

An analysis of the individual reports shows that U1 services were fully addressed by the projects. For example, the registration assistance service was demonstrated by the 'D-flight internet of drones environment' (DIODE) project, with use cases involving one single U-space service provider (USSP) which corresponds to a low-complexity environment (see Figure X).

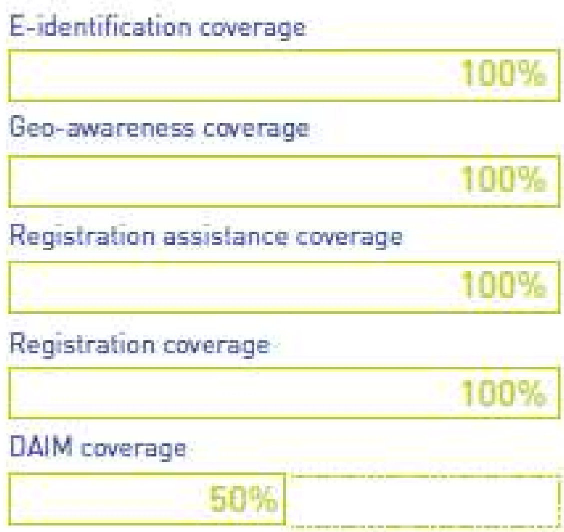


Figure X U1 coverage

### D.2.3 Initial services (U2)

**Due to activities taking place in parallel, the demonstration projects based their work on the CONOPS** (first edition – June 2018), while the current analysis considers the latest CONOPS (third edition – September 2019) as the reference. It is therefore not surprising to see that U2 services introduced in this latest edition (e.g. citizen reporting) are only partially covered by the projects. This is also the case for other services first introduced in the third edition, such as the population density map or electromagnetic interference information services. The overall U2 coverage is shown in Figure X.

However, some projects address services that were not featured in the first CONOPS, such as geospatial information service. The Finnish-Estonian 'Gulf of Finland' very large U-space demonstration (GOF U-space) project and the 'European UTM testbed for U-space' (EuroDRONE) project demonstrated this service by addressing some cases involving only one unique USSP. The scenarios were based on partially automated flights in controlled airspace and fully automated flights in uncontrolled VLL airspace.

U2 is the main block of services for U-space when considering the services initially defined at the start of the research activities by the SESAR JU. As shown in Figure 2, almost all these services are fully covered.

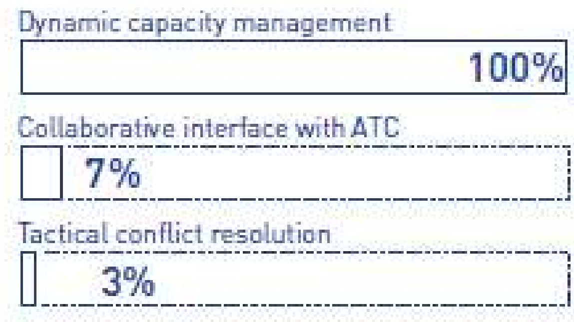


Figure x U3 coverage

### D.2.5 How mature is U-space?

In order to assess the maturity of U-space technologies, the SESAR JU research programme worked from two basic assumptions: the first assumed that U1 services are ready and available now; the second assumed that U2 services are technically possible and can be realised today. SESAR JU projects were then designed to test these assumptions and report on the extent to which they were true.

While the projects provide plenty of examples where U1 (foundation) services, such as geofencing and identification are already available, they also clearly showed that a lack of standardisation has led to variations in performance. In addition, there are gaps in capability, for example in sharing information with other stakeholders or operating multiple drones. Similarly, while advanced technology supports many U2 (initial) services, including tracking and monitoring, flight planning and communications, delivery of these services was characterised by underperformance in connectivity and interoperability.

Results coming from this first round of SESAR exploratory research and demonstration activities allow, for the first time in Europe, conclusions to be drawn from a series of projects that address the full range of issues that need to be covered to implement U-space. This allows for a rigorous analysis of both where we stand and how to focus further work to enable U-space to reach a higher level of maturity. For example, many business models need drones to safely carry out long-distance operations known as beyond visual line of sight (BVLOS). These include reliable two-way communications during flight and the means to identify and track drones while in the air so that the flight can be safely managed and deconflicted from manned aircraft and from other drones.

In conclusion, the projects demonstrated that U1 and U2 services are ready for environments with a low level of complexity (rural areas, segregated airspace) and a low density of traffic. At the same time, conclusions show the need to further develop and validate U-space to fit with the high complexity / density (urban operations, mixed traffic) of the future operating environments.

As further explained, all the U2, U3 and U4 services are subject to future research and innovation activities. Some of them are more critical: conflict management, emergency management and monitoring services are those that will make U-space scalable and robust to support dense and complex operations in U2 and will ensure a transition to U3 and U4.

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#### D.2.6.4 Increasing situational awareness through information exchange

A basic function of U-space is to bring situational awareness to all actors, and information exchange is fundamental to achieving this. Safe drone integration in the GOF U-space trial established an interoperability architecture to integrate existing solutions and used this to support operations ranging from parcel delivery, inspection services, police operations and search and rescue in maritime and city environments. The architecture relies on standard protocols to exchange data and serves as a flight information management system, which disseminates information about manned and unmanned vehicles to a wide range of stakeholders including local and national authorities, air navigation service providers (ANSPs) and USSPs. By using an open platform and system-wide information management, the solution collectively and cooperatively manages all drone traffic in the same geographical region. In the real-life demonstrations, the platform enabled manned and unmanned aircraft to safely share the same airspace by providing operators and pilots access to common flight information.

#### D.2.6.5 Focusing on tracking and monitoring

GOF U-space was one of several projects that also showed the importance of reliable tracking data for all airspace users. Flight tests assessed the performance of multiple collision avoidance and tracking systems (e.g. automatic dependent surveillance – broadcast (ADS-B), FLARM) and, while these technologies could all support surveillance, experience revealed inconsistencies in performance. Project results thus highlighted the need for interoperability and for further work on standardising such technologies. Similarly, the reliability of data communications is key to the timely delivery of information, so U-space services need to be resilient to loss of mobile network coverage. Another project that tested secure tracking and identification of drones was U-space initial services (USIS). During long-distance flights in France and Hungary, SESAR JU partners relied on advanced flight planning, authorisation and tracking services and successfully used cloud-based platforms to manage multiple numbers of unmanned operations. USIS validated the integration between the UTM platform and the e-identification and tracking of drones; it also showed how flexible flight planning supports multiple drone operations and recommended more research involving more participants. Meanwhile partners in the Technological European research for RPAS in ATM (TERRA) project assessed whether machine learning can help monitor VLL operations, including early detection of off-nominal conditions such as trajectory deviations. They found that artificial neural networks modelling could be used for predicting and classifying drone trajectories in urban scenarios

#### D.2.6.6 Addressing the interface with manned aviation

Interaction with manned aviation proved to be one of the most challenging areas of research. For unmanned and manned vehicles to share the same airspace, flights need to be visible to other airspace users. This is especially important in the lower airspace where general aviation accounts for over 100 000 users in Europe. Maintaining the safety of air operations when drones and conventional aircraft share low-level airspace, close to an airport for example, will require a high degree of digitalisation and automation. This was one of the key areas addressed by partners in the SAFEDRONE project. Over the course of 2 years, the project partners looked at the increased levels of autonomy necessary to operate in non-segregated airspace and to carry out dynamic in-flight activities such as on-board replanning trajectories within the U-space approved flight plan, and autonomous generation of coordinated trajectories within an approved U-space area of operation. It assessed the viability of using 4G networks for communication during BVLOS flights and global navigation satellite system (GNSS) technologies for drones to report an accurate altitude so that the UTM system can use it.


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A growing number of manufacturers are working on UAM solutions and eVTOL technologies to enable runway-independent operations, with very high degrees of automation, up to and including fully self-piloted aircraft. Most operators envisage a significant number of simultaneous operations around metropolitan areas at altitudes of up to 5 000 feet and speeds of up to 150 knots. These aircraft will typically carry cargo or 1–4 passengers on short trips (e.g. less than 100 km) (4).

UAM is one of the most demanding use cases for U-space services: it requires exploring dependencies between services and approaching U-space as a system of services from the operational and performance perspective. Future R & D has to explore these dependencies between services to make U-space robust and scalable and to maintain the safety level.

Looking at UAM, a review of the European Drones Outlook Study should be made to update the predicted drone traffic and expected business activity regarding UAM. A study of the social acceptance of the expected traffic would be beneficial to support the future development and implementation of UAM. The take-off and landing solution for UAM (often called a vertiport) will have to be defined and developed to address all weather conditions for which operations will be authorised, as well as all contingencies.

In addition to flying taxis, UAM covers all types of urban air operations that will require the extension of U-space services beyond the VLL limit. Drone operators and UAM operations will require access to higher altitudes and areas close to commercial manned aviation (e.g. airports) when at the same time flying manned aircraft in or adjacent to VLL could make use of U-space services. A safe and equitable integration of these operations with manned aviation will require additional U3–U4 services.

The development of interoperability and a collaborative decision-making process between the urban operations, ATM and city authorities is key for future urban operations. It will therefore be necessary to consider the roles and responsibilities of the national and local stakeholders (including USPs, UAS/UAM operators and ATM units involved). It will also be imperative to study the workflows they collectively engage in: defining solutions for ensuring the effective interoperability of USSPs and a proper interface with ATM, focusing on urban/suburban/airport scenarios, classes of airspace and addressing governance and regulatory challenges, security and non-aviation aspects for easing social acceptance.

Further guidance is required on how urban ground and air risks should be addressed or airspace designed over these densely populated environments. It is still unclear how these proposed data and information services, managed by ATM and USSPs, can be integrated and implemented in the busy urban U-space to adequately manage the relevant risks; properly design the relevant airspace; efficiently and safely manage high volumes of UAS/UAM traffic.

Some initial information services for these three aspects have already been defined, but it is less clear how these inputs will be integrated and structured into a practical urban/suburban U-space system to manage potentially hundreds, if not thousands, of UAS/UAM movements per hour over and around.

The primary safety hazards posed by UAS/UAM traffic operating in an urban/suburban/interurban environment are collisions between a drone and another airspace users, as well as the impact on infrastructure, objects and people on the ground, causing damages, injuries or possibly fatalities. The risks associated with these safety hazards must be addressed through the appropriate certification of drones for operation over an urban environment, coupled with comprehensive airspace architecture and dependable traffic management. Conventional drone risk analysis modelling methodologies, such as specific operational risk assessments (SORA), are useful for assessing risk for a single or low number of drones operating in relatively uncomplicated real-world environments (e.g., sparsely populated, rural areas). However, this methodology may not be best suited in scenarios where high volumes of drone traffic are projected to operate in the near future over densely populated environments.


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### D.3.3 Advanced U-space services

The SESAR JU projects defined and demonstrated U1 and U2 services, as well as some early U3 services. It is now time to start work on the definition, design and development of the most advanced U-space services (U3/U4), which will also enable UAM missions in high-density and high-complexity areas. The required technologies to enable performance-based communications, navigation and surveillance (CNS) services in U-space need to be identified and assessed in operational environments. These advanced steps in the deployment of U-space require advanced strategic/tactical conflict resolution, advanced DAA systems and a suitable communication infrastructure. This also goes together with the multiple USSPs principle: multiple USSPs working at the same time in the same geographical area.

#### D.3.3.1 Strategic/tactical conflict resolution

U-space services and capabilities will support a range of UAS/UAM operations ranging from rural sparsely populated areas with marginal manned aviation operations to urban operations with considerable manned aviation operations, terrain and surface obstacles to be considered. The corresponding requirements for separation provision / conflict resolution – in terms of data exchange / tracking / monitoring services, on-board aircraft capabilities / avionics and operators responsibilities – will be adequate to the relevant risks for people and properties.

UAS and UAM operators operating in areas with high-density or heterogeneous/mixed types of traffic may be required to be equipped with DAA technologies to meet these requirements. Low-level manned aircraft operations in both uncontrolled and controlled airspace should have access to, and are encouraged to utilise, U-space mission management services to deconflict their operations from potentially conflicting unmanned operations in the same portion of airspace. Low-level manned aviation pilots will then share some responsibility with UAS/UAM operators for maintaining separation from each other (even if they will not share responsibility for separation from VLOS UAS operators).

U-space, within its defined airspace, should be ultimately responsible for maintaining an adequate separation among UAS/UAM, manned aircraft, airspace, weather events, terrain and other relevant hazards, and for avoiding unsafe conditions throughout the relevant operations. Separation/conflict management service provision will be achieved via shared intent, shared awareness, strategic deconfliction of airspace volumes, tracking and monitoring, some digital technologies supporting tactical deconfliction and the establishment of ad hoc operational rules and procedures. U-space services will support operations planning, intent sharing, strategic and tactical conflict resolution/management, conformance monitoring, operations authorisation, airspace management functions and management of off-nominal situations.

Until Europe has validated more advanced services and relevant technologies, U-space services supporting strategic and tactical conflict management cannot be fully deployed; yet these services are key for the adequate functioning of initial U-space implementations.

With its first portfolio of research projects, the SESAR JU has demonstrated several initial solutions for strategic conflict resolution (e.g. on delay in SAFIR and EuroDRONE; rerouting without considering terrain or other issues in DOMUS), however these were limited in their ability deconflict given the level of uncertainty: during the flight trials, no vertical separation was used.

Advanced conflict detection is essential for multiple drones to operate simultaneously. U-space systems must be implemented in a common way to be able to efficiently exchange data, and all systems have to be able to use the exchanged data. Low quality / delay of input data from the other

### D.3.3.3 Mobile telecommunication infrastructure and its suitability for U-space

Mobile telecommunication networks could be the best solution to provide scalable connectivity solutions for U-space services and BVLOS operations in the future. Mobile telecommunication infrastructures/solutions for the U-space services should enable increased flexibility in the design and implementation of new types of services making reference to the U-space services requirements. The mobile telecommunication infrastructure should be capable of meeting appropriate U-space services performance requirements for coverage, quality of service, safety, security and reliability (resilience, failure modes, redundancy), while minimising environmental impacts and respecting the privacy and safety of citizens.

Current mobile telecommunication networks can already provide sufficient connectivity and enable U-space services in some environments and use cases. In the future, developed mobile telecommunication solutions for U-space services could enable scalable, flexible and adaptable services, also for demanding environments and use cases.

However, there are some challenges to meet to enable cooperation in the telecoms and aviation sectors. The telecoms industry providing the mobile telecommunication services is market driven. In addition, current commercial mobile networks are typically built and optimised for users on the ground. Large numbers of users in the air will cause interference to the mobile networks and users on the ground, if not implemented in a controlled manner. Coverage and service requirements are also not currently optimised for users in the air. Close cooperation between the two sectors is needed, firstly to understand the performance requirements that U-space services put on the mobile telecommunication services, and secondly to develop a compromise on how the requirements can be met by the mobile telecommunication networks and services. The technical requirements of U-space services should be realistic and possible to meet in practice. This will also require developing new common business models for the cooperation between U-space and mobile telecommunication service providers.

U-space must be able to adapt to new communication technologies and automation, both ground-based and airborne, and increasingly allow for more advanced forms of interaction with the overall U-space ecosystem, predominantly through interoperable communication systems capable of digital information and data exchange such as the 5G mobile telecommunication infrastructure. Ultimately, the next generation of mobile telecommunication infrastructure must be persuaded to encompass the range of UAS/UAM demand, business models, applications and technologies, and to support safe and efficient U-space operations that also include manned aviation and existing ATM systems to ensure a fair and equitable access to the airspace.

Although mobile telecommunication networks can provide connectivity for many challenging environments and operations in the future, there will always be environments where mobile networks are not the optimal connectivity solution, such as high altitudes or remote locations.

### D.3.3.4 Multiple U-space service providers

When U-space services, such as mission management or conflict management, are centralised this can work relatively well (as there is one decision made by the ecosystem). The complexity comes when multiple USSPs have to exchange information and to make collective/coordinated decisions that are consistent. Research needs to be carried out on specific use cases and safety-critical services that are impacted by this federated approach e.g. tactical resolution services.

| R & D needs | Relevant U-space services |
|---|---|
| Safety/risk assessment, including risks related to multiple drones interaction in the same area of operations/<br>CARS, in particular addressing the vertical separation within VLL and with regard to manned aviation too<br>*(Source: DIODE)* | Airspace Management/geofencing<br>Separation/conflict management<br>Emergency management<br>Monitoring<br>Interface with ATC |
| Definition of separation minima UAS/UAS and unmanned versus manned<br>Tactical conflict resolution service integration WRT DAA airborne capabilities<br>Interaction of dynamic geofencing with tactical geofencing/conflict resolution service<br>Analysis of U-space centralised architecture versus federated architecture performance *(Sources: DOMUS)* | Separation/conflict management<br>Interface with ATC<br>Airspace Management/geofencing<br>Monitoring<br>Emergency management |
| Automation of ATM to U-space interfaces, including linking with tracking and monitoring activities<br>Integration of unmanned eVTOL WRT other AUs<br>Onboard DAA with non-cooperative intruders Minimum separation distance among UAVs, taking into account their performance, systems on board, and mandatory flying dynamics<br>CARS<br>*(Source: EuroDRONE)* | Interface with ATC<br>Airspace Management/geofencing<br>Separation/conflict management<br>Emergency management |
| Integration of U-space into eVTOL avionics eVTOL integration with regard to general and manned aviation<br>High levels of automation and increased reliance on V2I, V2V and ATC/UTM communication links and cybersecurity<br>*(Source GOF U-space)* | Interface with ATC<br>Airspace Management/geofencing<br>Separation/conflict management<br>Emergency management |
| Conflict resolution capabilities and how to exchange flight plan data between the drone operation plan processing and operation plan preparation assistance services during the conflict management phase<br>Definition of standards for inter-USSP communication without centralised services<br>Impact of federated architecture on U-space services provision (e.g. for separation/conflict management).<br>Data integrity and consistency within a fully federated U-space service architecture<br>Weather information service in an urban scenario<br>Monitoring and traffic information contingency scenarios<br>Tactical deconfliction and dynamic capacity management services | Airspace Management/geofencing<br>Separation/conflict management<br>Emergency management<br>Monitoring |

| R & D needs | Relevant U-space services |
|---|---|
| ▸ Conflict resolution capabilities and how to exchange flight plan data between the drone operation plan processing and operation plan preparation assistance services during the conflict management phase<br>▸ Definition of standards for inter-USSP communication without centralised services<br>▸ Impact of federated architecture on U-space services provision (e.g. for separation/conflict management).<br>▸ Data integrity and consistency within a fully federated U-space service architecture<br>▸ Weather information service in an urban scenario<br>▸ Monitoring and traffic information contingency scenarios<br>▸ Tactical deconfliction and dynamic capacity management services *(Source IMPETUS)* | ▸ Airspace Management/geofencing<br>▸ Separation/conflict management<br>▸ Emergency management<br>▸ Monitoring |
| ▸ UTM/GCS full integration (Source SAFEDRONE/GOF–USPACE)<br>▸ ATC/U-space interfaces<br>▸ Separation minima<br>▸ Common altitude reference system Telecommunications networks for U-space<br>▸ U-space services in urban or semi-urban environments<br>▸ Multi-USPs sharing the same portion of airspace responsibility for the provision of services (Source SAFEDRONE) | ▸ Interface with ATC<br>▸ Airspace Management/geofencing<br>▸ Separation/conflict management<br>▸ Emergency management<br>▸ Environment |
| ▸ Strategic and tactical deconfliction in a federated ecosystem<br>▸ Tactical deconfliction with regard to manned aviation<br>▸ Tracking (multiple sources) in a federated system<br>▸ Priority/emergency services<br>▸ Analysis of mobile telecommunication network for U-space (coverage, data integrity, authorisation, location based services...)<br>▸ Full testing, in all operational circumstances, of individual U-space services.<br>▸ Further in-depth testing and standardisation of U-space services in ground control station applications. (Source SAFIR) | ▸ Emergency management<br>▸ Environment<br>▸ Separation/conflict Management |
| ▸ Relevant CNS technologies for U-space services supported by them<br>▸ Conflict detection and tactical deconfliction (DAA) (Source TERRA) | ▸ Separation/conflict management<br>▸ Relevant CNS services to support the required U-space services deployment |
| ▸ Deconfliction strategy rules (Source USIS) | ▸ Separation/conflict management |
| ▸ Streamlining information exchange between USPs<br>▸ R&D and governances needs to be established at EU level in or to deliver/validate U-space. (Source VUTURA) | ▸ Airspace Management/Geofencing<br>▸ Interface with ATC and other USPs |
| ▸ Non-cooperative DAA solutions<br>▸ U-space reference communications backbone<br>▸ Further definition of the full set of U-space services and capabilities with an ad-hoc inventory (Source AirPASS) | ▸ Separation/conflict management<br>▸ Relevant communication backbone services and performances to support U-space Services deployment |
| ▸ Specific U-space reference communication backbone services (Source DROC2COM) | ▸ Relevant communication backbone services and performances to support U-space Services deployment |

A quality analysis was conducted to categorise the requirements and to assess their relevance (i.e. well defined and/or corresponding to services cited in the CONOPS – third edition) and value as input to standardisation/regulation work.

A scoring of their value was established - requirements with a score lower than six mainly correspond to the those that cannot be linked to the CONOPS.

Figure Z indicates that a large part of the existing requirements are highly valuable, with almost 75 % of the requirements meeting the minimum level of quality (i.e. above X).

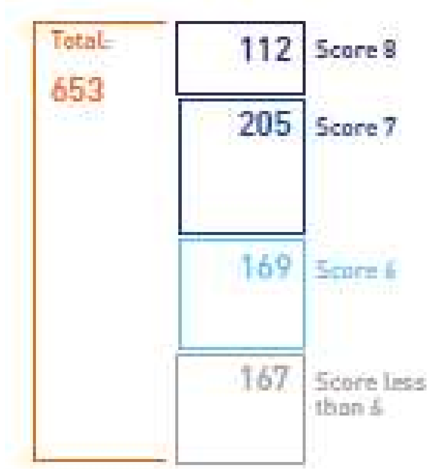


**Figure 18: Quality analysis of identified requirements**

Figure A shows the distribution of all the requirements among the categories. A requirement may be allocated to more than one category. Consequently, the total number of allocated requirements (1 205) is higher than the total number of Baseline #3 requirements (653).


**Figure 19: Categories of requirements**

This view identifies the categories that could be strengthened in the future. In particular, 'acceptability' needs to be further addressed in terms of requirements

In addition to providing a breakdown of the development work still required, the SESAR results feed directly into the regulation and standardisation process underway in Europe, as well as in other world regions. Research findings and demonstrationss provide valuable performance data to support coordinated and common standards for drone operations. For example, only by testing the performance of geofencing technology on board drones can appropriate minimum standards be drawn up. U-space demands a risk-based and performance-driven approach when setting up requirements for safety and security. This requires comprehensive understanding of the performance of drones in operational scenarios.

U-space implementation is dependent on the available technologies and the use of harmonised standards, as well as the maturity of the U-space services. These services are scaled to integrate drones' operations in the airspace and to enable them to operate together with manned aircraft, in a safe, efficient and sustainable manner. The findings from the SESAR JU projects pave the way for this implementation and for the required standards, protocols and regulations. An initial conclusion is to use and maintain the U-space CONOPs developed by CORUS as the common reference for future validation, regulation and/or standardisation activities.

Another key conclusion of the projects is the need to support the standardisation process by collecting data. This need for data is essential to elaborate the necessary minimum operational performance standards (MOPS) for U-space services' equipment/systems and capabilities as well as for drones. This is also needed for the enabling infrastructure to be set to support U-space operations. Those performances have to be commensurate to the traffic and traffic complexity to ensure the safety of operations.

This could be done through the development of a number of R & D projects that focus on large-scale demonstrations of cooperative and non-cooperative traffic, and of manned and unmanned traffic. These demonstrations should be large-scale scenarios with tens, hundreds or even thousands of participating drones and USSPs, and the implementation of flight corridor testing and hardware and software robustness testing. Regarding security, penetration testing of U-space services must be organised by an independent party: an ethical hacking approach for testing the implemented security measures of a U-space service would be beneficial. In addition to the MOPS, these R & D activities will be the basis for the development of acceptability criteria and best practices needed to support all the open-source or proprietary developments done in parallel.

From the experience gained from the demonstration projects, it can be concluded that until advanced services are developed, U-space services supporting strategic conflict management are key for the functioning of initial U-space airspace implementations. The operation risk assessment to consider air collisions also needs to be updated to ensure safe implementation.

Guidance material needs to be developed to support the application of the regulation, including a common terminology and a clear definition of roles and responsibilities. This addition to the existing regulation will support the safe management of the traffic.

As U-space is about the safe integration of drones in the airspace, project conclusions and recommendations on standardisation and regulation naturally fall in the safety area. A common and unique set of exchanging information needs to be shared between all involved stakeholders, whether they are manned or unmanned; clarifying the information and data required to access an airspace managed by U-space. One piece of information that must be shared, in a cooperative way between the airspace users, is the traffic information.

This information sharing goes with data exchange. In this respect, standards are required related to protocol, data models, interfaces and services behaviour, time synchronisation method, encoding mechanisms and failure modes. Standards must also be developed related to the notion of a single


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| Title | Description |
|---|---|
| e-registration | The operator shall complete the e-registration process before starting operations. |
| Registration process | The system shall facilitate the storage of registration information about drone/ pilot/operator in a national/local database. The registration information contains at least an electronic identifier to link the e-registration and the e-ildentification. |
| e -registration validation | The relevant national authority should confirm what the drone/operator/pilot is allowed to fly when submitting the registration acknowledgement. |
| Authorisation acknowledgement | The system should confirm what the drone/operator/pilot has been allowed to fly by the authority, when submitting the registration acknowledgement. |
| e- registration validation | The authority shall provide an e-registration certificate. |
| User profiling | The system shall allow user profiling: restricted content and functionalities will be accessible depending on the profile of the authenticated user. Access to each content and function type must be configurable by the supervisor. |
| Registering information for law enforcement agencies | Law enforcement units shall be able to access drone/operator/pilot registration information when required. |
| Provision of pilot location and operator contact details to law enforcement units | The system shall provide pilot location and operator contact details for drones in flight to law enforcement agencies when required. |
| Drone capabilities e-registration | To develop complex operations (e.g. Urban, BVLOS, etc.), the operator shall register drones capabilities and sensors. |

**Figure 21: Registration service requirements (non-exhaustive)**

### D.6.1.2 Remote identification and e-identification service

Broadcast remote identification is a drone capability that allows operators or authorities nearby to receive some information about the drone and its operator. The network remote identification service allows a drone to be identified by comparing the position reported by the observer with the known position as tracked by U-space.

The e-identification service is used primarily, but not only, by law enforcement agencies. It takes the remote identification information and uses it to retrieve operator details from the registry and operation details from a set of current and known operations. A simpler version of the service, which protects the privacy of the drone operator, is expected for public use.

Following are the requirements for the implementation of these services that were identified by the Advanced integrated RPAS avionics safety suite (AIRPASS), Drone European AIM study (DREAMS), IMPETUS and TERRA projects– Refer to the latest available baseline for more requirements and details.

sent by the position report submission sub-service, but combines other sources such as drone detection systems, if any are available. The tracking service will provide both tracks and an indication of the uncertainties associated with these tracks. The extent of these uncertainties will determine what can be done with the track information, or the margin which must be applied when the track is used. The technical requirements associated with some airspace volumes will often be in terms of tracking performance.

The surveillance data service supports exchanges between the tracking services and other sources or consumers of tracks, such as air traffic control or drone detection systems.

Below are the requirements for the implementation of these services that were identified by the Clear air situation for UAS (CLASS), DREAMS, GOF U-space, IMPETUS and TERRA

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### D.6.2 Airspace management and geofencing

#### D.6.2.1 Geoawareness, geofencing provision and drone aeronautical information management services

The geoawareness service provides geofence data for use by the drone operator, pilot and the drone itself. The geofence data is delivered in a standard format that can be interpreted by operation plan preparation optimisation tools and services. The geofencing provision service extends this and provides capable drones and remote pilot stations directly with geofences, even during flight. The drone aeronautical information management service allows authorised organisations to create, update or remove geofences and other geographic data at any time.

Below are the requirements for the implementation of these services that were identified by the DREAMS, IMPETUS and TERRA projects. Refer to the latest available baseline for more requirements and details.

| Title | Description |
|---|---|
| Temporary segregation of area | The tactical geofencing service shall enable authorised users to segregate areas dynamically and temporarily. |
| Dynamic geofencing | The dynamic geofencing system shall provide drone operators and users with coordinates of dynamic geofence polygons with a minimum accuracy level of 1 metre. |
| Safety requirements for U-space service providers deriving from specific operational risk assessment (SORA) | In accordance with SORA Annex E, the provision of external services (as the U-space services) shall comply with safety requirements. The higher the SAIL, the most demanding are these requirements. For operations dealing with SAIL IV, service providers shall be subject to oversight mechanisms (a competent third party shall be involved). |
| Transaction time requirement for pre-tactical geofencing | The pre-tactical geofencing service shall deliver information with a maximum transaction time of 120 seconds. |
| Continuity requirement for pre-tactical geofencing | The pre-tactical geofencing service shall deliver information with a continuity (max tolerable probability of interruption of service per flight/hour) equal to 1E-02. |
| Availability requirement for pre-tactical geofencing | The pre-tactical geofencing service shall deliver information with an availability (max tolerable probability of non-availability of service per flight/hour) equal to 1E-02. |
| Integrity requirement for pre-tactical geofencing | The pre-tactical geofencing service shall deliver information using a software with a minimum design assurance level (DAL) equal to C. |
| Transaction time requirement for tactical geofencing | The tactical gefoencing service shall deliver information with a maximum transaction time of 10 seconds. |
| Continuity requirement for Tactical Geofencing | The tactical gefoencing service shall deliver information with a continuity (max tolerable probability of interruption of service per flight/hour) equal to 1E-05. |
| Availability requirement for tactical geofencing | The tactical gefoencing service shall deliver information with an availability (max tolerable probability of non-availability of service per flight/hour) equal to 1E-05. |
| Integrity requirement for tactical geofencing | The tactical gefoencing service shall deliver information using a software with a minimum DAL equal to B. |
| Human-machine interface | Geofencing information should be received and displayed through by the ground control station so as enhance human performance and to allow for automation. |

**Figure 24: Geoawareness requirements (non-exhaustive)**



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| | |
|---|---|
| **Approved mission plan modification** | The operator shall receive alerts about modifications and updates of the approved mission plans when they have to be adapted due to new restrictions (geofenced areas, etc.) or optimisation of trajectories to increase capacity. |
| **Approved mission plan modification airspace (Classes A-D)** | The operator shall receive alerts about modifications to the airspace class (A-D) approved flight plans, requested by the ANSP, when required for the operation. |
| **Mission plan status accessibility** | The operator shall have access to the system before starting the flight to confirm that the accepted route is still valid or if there has been any modification. |
| **Impact of flight planning management, Pre-tactical geofencing, tactical geofencing and emergency management services on SORA based-risk assessment** | Flight planning management, pre-tactical geofencing, tactical geofencing and emergency management services shall be used as M3 mitigation to the ground risk in SORA. |
| **Trajectory alerts processing for pre-tactical deconfliction** | The operator shall receive alerts to modify drone trajectories in order to avoid potential conflicts with other drone operators or manned aviation. |
| **Data quality** | Operation plan data should be identical in U-space and in drone ground control station, and be available in four dimensions. |
| **Efficient use of airspace** | It shall be possible to divide a flight plan into segments with ability do defined minimum and maximum altitude separately for each segment. |

**Figure 25: Mission management requirements (non-exhaustive)**

### D.6.3.2 Dynamic capacity management service

Strategic and tactical conflict resolution services reduce the probability of collision to a residual level, albeit not to zero. As the number of operations planned in a volume of airspace rises, so do the cumulative residual risks of conflict. When the residual risk reaches the maximum acceptable level, then capacity is reached. The dynamic capacity management service calculates this residual risk and detects when capacity is reached. It then either takes measures to provide more capacity or to limit the traffic. The dynamic capacity management service is one of the services that approves an operation plan submitted to the operation plan processing service.

Below are the requirements for the implementation of these services that were identified by the Drone critical communications (DROC2OM), DREAMS, IMPETUS and TERRA projects. Refer to the latest available baseline for more requirements and details.

| Title | Description |
|---|---|
| **Flight plan approval process** | The FPM service shall only approve the flight plan after validation through the deconfliction and the airspace capacity management functions. |
| **Area density** | During the validation phase, the system should take into account the availability of the area, considering all the missions within the same space/time horizon |
| **Datalink interoperability** | The C2 link system underlying network shall support interoperability with multiple ground operators and multiple communication service providers simultaneously. |
| **Approved mission plan modification** | The operator shall receive alerts about modifications and updates of the approved mission plans when they have to be adapted due to new restrictions (geo-fenced areas, etc.) or optimisation of trajectories to increase capacity. |

**Figure 26: Dynamic capacity management requirements (non-exhaustive**



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| | |
|---|---|
| **Mission plan status accessibility** | The operator shall have access to the system before starting the flight to confirm that the accepted route is still valid or if there has been any modification. |
| **Trajectory alerts processing for pre-tactical de-confliction** | The operator shall receive alerts to modify drone trajectories in order to avoid potential conflicts with other drone operators or manned aviation. |
| **Mission Request privacy of information provided** | The system shall not show information about other drone operators. |
| **Area density** | During the validation phase, the system should take into account the availability of the area, considering all the missions within the same space/time horizon. |
| **Raise conflict alert** | The conflict detection service shall raise conflict alerts to drone operator 1 and 2 based on the deconfliction functionality. |
| **Mission plan status accessibility** | The operator shall have access to the system before starting the flight to confirm that the accepted route is still valid or if there has been any modification. |

**Figure 27: Strategic and tactical conflict resolution requirements (non-exhaustive)**

### D.6.4.2 Emergency management service

The emergency management service of U-space has two aspects:

- giving assistance to a drone pilot experiencing an emergency with their drone;
- communicating emergency information to the drone pilot, for example that there is danger nearby or some function of U-space is impaired.

The communications channel of the emergency management service is an essential safety feature as it is the only way to deliver emergency messages to the drone operator.

Below are a small number of the many requirements common to these services and developed by the DREAMS, IMPETUS, DROC2OM and TERRA projects. Refer to the latest available baseline for more requirements and detail

| Title | Description |
|---|---|
| **Emergency communication submission** | The operator shall be able to communicate emergencies to the system in real time. |
| **Operator/Pilot /Drone communication performance** | Drone pilot/operator shall be continuously connected to the system to know if their drone has to land in case of emergency flight, using an APP or by cellular. |
| **Temporary segregation of area** | The tactical geofencing service shall enable authorised users to segregate areas dynamically and temporarily. |
| **Alerts to drone operators** | Drone pilots/operators shall receive alerts to land or modify their trajectory in case a manned aircraft is operating near them. |
| **Bounding volume for emergency procedures** | The traffic information service shall extend the information area for a certain operation in cases where emergency procedures have been activated in the surroung airspace. |
| **Approved mission plan modification** | The operator shall receive alerts about modifications and updates of the approved mission plans when they have to be adapted due to new restrictions (geo-fenced areas, etc.) or optimisation of trajectories to increase capacity. |
| **Weather updated information** | Sudden local weather changes should be notified to operators to mitigate potential risks. |
| **Detection of loss of information periods** | The role in charge shall be able to detect periods in which the information is not available and raise and alert that will scale to the Orchestrator, which will be in charge of activating the emergency procedure. |
| **Flight control functions for emergency management** | The on-board flight control system shall be able to perform risk mitigating activities like flight termination or mission abortion on request of U-space services immediately. Ground control station and U-space services should be informed accordingly. |

**Figure 28: Emergency management requirements (non-exhaustive)**

| Title | Description |
|---|---|
| Trajectory alerts reception | In case the flight is going to be conducted in a volume that cannot be geocaged for the user, the operator shall be alerted if a minimum separation distance with other drones cannot be maintained, to guarantee that the risk of collision is negligible over populated areas and low enough in sparsely populated areas. |
| Pilot accessibility to nearby unmanned traffic information | Operators shall be able to receive the location of nearby drones and other aircraft, although not their private data (Traffic Information), to improve situational awareness. |
| Geographical extension of the information | The traffic information service shall provide all the relevant information about traffic within a geographic bounding volume dimensioned large enough to ensure the safety of all the operations contained within. |
| Bounding volume for emergency procedures | The traffic information service shall extend the information area for a certain operation in case of emergency procedures has been activated in the surroundings of its bounding volume. |
| Mission Request privacy of information provided | The system shall not show information about other drone operators. |
| Traffic information to operators | In urban or high drone density areas, the system should provide traffic information to operators to allow adequate situational awareness. |
| VFR information | The system should provide information of geo-caged areas to VFR aviation. |
| Monitoring | The system shall allow monitoring of the functional status of each capability. |
| Display of the flight track of drones | The UTM system shall display the tracks of the drones to:<br>- other drone operators<br>- The authority responsible for the area |
| Front end track filtering | The UTM system shall filter the tracks to show:<br>- Non cooperative tracks<br>- Cooperative tracks<br>- Fused tracks<br>- A combination of the upper |
| Maximum allowed latency in UTM system of 1 second | The UTM system shall show all the data (positions, tracks, zones, alerts,...) with a maximum latency of 1 second. |

Figure 30: Monitoring requirements (non-exhaustive)

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#### D.6.5.2 Legal recording and digital logbook services

The legal recording service supports accident and incident investigation. The service should record all inputs to U-space and allow the full state of the system at any moment for post-analytical purposes. In view of the commercial sensitivities of drone operators, access to the recordings will be restricted. The digital logbook service extracts some information from the legal recordings. Drone operators and pilots will be able to see summaries and statistics for flights they have been involved in.

The following are some requirements common to these services and developed by the DREAMS, IMPETUS, CLASS and TERRA projects. Refer to the latest available baseline for more requirements and details.

### D.6.6 Environment

#### D.6.6.1 Weather information service

The weather information service provides current and forecast weather information relevant for drone operation. The service should include hyperlocal weather information when available and required.

The following are some requirements common to these services and developed by the DROC2OM, DREAMS, IMPETUS and TERRA projects. Refer to the latest available baseline for more requirements and details.

| Title | Description |
|---|---|
| Weather information accessibility | The operator shall have access to weather information when preparing the mission plan to confirm that meteorological conditions are acceptable for the flight. |
| Hyperlocal weather information | The weather management system shall provide drone operators and users with minute-by-minute hyperlocal weather data. |
| Local-scale weather information aspects to be provided | The local-scale weather information service shall provide a configurable combination of the following weather information:<br>▸ Weather information provider ID [unique identifier]<br>▸ Look-ahead type [nowcast/forecast]<br>▸ Data generation time [Julian date & time of data generation]<br>▸ Applicability timeframe [period of time of data applicability since data generation]<br>▸ Temperature [K]<br>▸ Pressure [Pa]<br>▸ Icing [ % probability]<br>▸ Visibility [m]<br>▸ Precipitation [[ % probability, type]; type: [freezing] rain/sleet/snow]<br>▸ Convective precipitation [ % probability]<br>▸ Lightning [ % probability]<br>▸ Average wind [u,v,w] [m/s]<br>▸ Turbulence [Turbulent Kinetic Energy (TKE) $m^2/s^2$]<br>▸ Gusts [frequency spectrum of specific kinetic energy J/kg]<br>▸ Thermals [ % probability]<br>▸ Forecast/nowcast uncertainties [STD associated with data items 5] to<br>or such data items are N-tuples, N being the number of members of an ensemble meteorological forecast/nowcast]<br>▸ Reminders, warning and alerts [new dataset available, expiration of applicability timeframe, data items 5] to 15] exceeding predefined thresholds or nowcasted data items 5] to 15] deviating from the forecasted versions of the same data items beyond the estimated uncertainty] |
| Geospatial domain | The weather information provided by the service shall correspond to the geographical domain specified by the petitioner. To specify such domain, the service shall provide the following geospatial primitives: 1] Geolocation [geodetic longitude, latitude and altitude in a geodetic reference system, e.g. WGS-84]; 2] Geocube [interval of geodetic longitudes, latitudes and altitudes in a geodetic reference system]; and 3] Geoprism [base geopolygon plus interval of altitudes in a geodetic reference system]which the petitioner can instantiate to make the petitions of weather information. |

| Title | Description |
|---|---|
| Geospatial information | The service shall programmatically access geospatial information to enable drones to carry out safe operations. The data set should include both airborne and ground hazards. Therefore the service requires access to geospatial data, which needs to include some or all of the following: ground hazards, obstacles, terrain, city maps, etc., in addition to airspace restrictions such as airspace classifications. |
| Terrain model service | The U-space shall provide geographic information services to users with digital cartographic information and digital elevation model. The proposed accuracy of the model is 1 metre (horizontal and vertical). The proposed resolution of map is 0,5 metre. |
| Obstacle information | The flight planning management system shall provide obstacle data with a minimum resolution of 1m (both horizontal and vertical). |
| Vertical separation in VLL airspace | The U-space shall ensure a common reference frame for vertical separation of drones in VLL airspace. |
| Mission planning Management – data visualisation | The MPM service shall visualise the types of information to the operator that are relevant for mission planning |
| Flight plan approval | A flight conformance module built in the FPM service shall be the instance responsible for approving or rejecting the individual flight plans based on defined rules and prioritization criteria. |

**Figure 34: Map-based services (non-exhaustive)**

### D.6.7 Interface with air traffic control

#### D.6.7.1 Procedural and collaborative interfaces with air traffic control

The procedural interface with ATC is a service to coordinate an entry/exit of a flight into controlled airspace. The interface works before the flight. The operation plan processing service will invoke the service and through it:

- ATC can accept or refuse the flight;
- ATC can describe the requirements and process to be followed before and during the flight.

The collaborative interface with ATC is a service providing communication between ATC and the remote pilot or the drone itself in case of automatic flight. The service is used when the drone is in a controlled area and allows flights to receive instructions and clearances in a standard and efficient manner.

An example involving both would be a drone flight that starts and ends in uncontrolled airspace but during the flight crosses an airport (controlled airspace). The operation plan would trigger the procedural interface with ATC, who would either respond with a standard set of instructions or combine that with a process to give approval for the flight. The standard instructions might be to fly to some particular point and then hover or circle and contact the tower by telephone. If a collaborative interface with ATC were available, the instructions given with the plan approval would involve using the collaborative interface to coordinate with the tower. The collaborative interface would enable the tower to communicate with the drone pilot in real time.

Below are the requirements for the implementation of these services that were identified by the AIRPASS, DROC2OM, DREAMS, IMPETUS and TERRA projects. Refer to the latest available baseline for more requirements and details.

## E. Innovation Pipeline 2020

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| | | |
|---|---|---|
| TRL-1.10 | | Have initial scientific observations been communicated and disseminated (e.g. technical reports/journals/conference papers)? |
| TRL-1.11 | | Are recommendations for further scientific research documented? |

## F.2 TRL 2

| Thread | Criteria ID | Sub-Criteria ID | Criteria |
|---|---|---|---|
| OPS | OPS.V1.1 | | Is the initial documented description of the concept consistent with the SESAR Concept of Operations and the High Level Operational Requirements? |
| OPS | OPS.V1.2 | | Is there an initial identification and description of the SESAR Solution and related OI steps available in EATMA? |
| OPS | OPS.V1.3 | | Are the different concept variants (if any) described? |
| OPS | OPS.V1.4 | | Have potential (sub)operating environments (Impacted OEs) been identified where, if deployed, the SESAR Solution could bring performance benefits?<br><br>*Note: the relevant (sub)operating environments associated to the SESAR Solution shall be consistent with those available in EATMA* |
| OPS | OPS.V1.5 | | Have representative stakeholders been identified, are their needs and expectations for the SESAR solution documented? |
| SYS | SYS.V1.1 | | Has the potential impact of the concept on the target architecture been identified? |
| SYS | SYS.V1.2 | | Are different supporting technological alternatives defined, if any? |
| SYS | SYS.V1.3 | | Are there needs for supporting CNS infrastructure (if any) adequately identified and justified for the different (sub)operating environments relevant for the SESAR Solution? |

| | | | |
|---|---|---|---|
| | | PER.V1.2.2 | Do validation results provide the qualitative and quantitative (at least estimated by expert judgement) evidences about impact on the most significant KPAs which are relevant (e.g. Capacity, Operational Efficiency, Cost-efficiency, Predictability, Flexibility etc.), using KPIs/PIs from SESAR Performance Framework (or a clear description of the mathematical translation mechanism when using other metric)?<br><br>*Is the ECAC extrapolation performed following PJ.19-04 guidance and based on the exercises results, covering all the applicable OEs/sub-Oes?*<br><br>**ECAC extrapolation should be done:*<br>*1) using common assumptions or justified assumptions*<br>*2) presenting information about traffic used (and the date used) to which the solution is beneficial available (because of equipment or of type of operations)*<br>*3) aligned with PJ.19-04 guidelines and webinars*<br>*4) the obtained results should provide a rank in terms of benefits to identify the most promising alternative, and in the most relevant (sub) operating environments relevant for the SESAR Solution (extrapolation to other relevant (sub)operating environments are available to facilitate the consolidation of performance results at ECAC level)*<br><br>*Note: In the corresponding VALP V1, the project should have planned per SESAR Solution the qualitative and quantitative (if possible, or at least estimated) measurement of the impact on those KPAs that are applicable to the SESAR Solution (according to the VALS) and confirmed through the benefit mechanisms for the different alternatives to the solution* |
| | | PER.V1.2.3 | Are the validation results in line with what is targeted for the SESAR Solution? In case of deviation, has the project identified a concept/solution refinement to mitigate the gap? |
| | | PER.V1.2.4 | Were the V1 Validation exercises executed in validation scenarios that are representative of the (sub) operating environments where the solution could be deployed identified in EATMA for that solution? |
| | | PER.V1.2.5 | Are Baseline, Reference and Solution scenarios definition aligned with SESAR guidelines?<br><br>*Note: The baseline (2012) provides the absolute values of KPIs and PIs at the start of the timeframe covered by SESAR1 (2005) and SESAR2020 (2012)* |
| | | PER.V1.2.6 | Have potential interactions with related SESAR Solutions been considered? What are the solution relationship (e.g. cross effect, interdependent, mutually exclusive) and relative contribution to performance (e.g. weight per KPA) |

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|---|---|---|---|
| | | PER.V1.4.3 | Does the SESAR Solution Safety Plan ( Part II of the VALP) determine a preliminary list of hazards that could be generated by the reference functional system (before the introduction of the Change) and which are identified as being potentially impacted by the Change (to support understanding the potential safety implication of the solution)? |
| | | PER.V1.4.4 | If ATS ops solution: Does the SESAR solution Safety Plan ( Part II of the VALP) contain a list of suitable Safety Criteria for the solution operations and the justification for their selection?<br><br>If Other than ATS ops solution: Does the SESAR solution Safety Plan ( Part II of the VALP) contain a list of intended operational use (identified from SESAR ATS ops solutions and from outside SESAR) and the design safety drivers in terms of outline specification of the changed service limited to the potential safety implication on the side of the ATS service provider or aviation undertaking (e.g. airline) using that service, and potentially, any recognized operational or technical standards and/or codes of practice that apply to the “Other than ATS” operational solution ? |
| PER & CBA | PER.V1.5 | *Sub-criteria below shall be consolidated at criterion level* | Has the V1 preliminary security assessment been carried out in conformance with the SESAR Security Reference Material? |
| | | PER.V1.5.1 | Have the security risk assessment scope and security assumptions on the environment been identified (at high level)? |
| | | PER.V1.5.2 | Have primary assets been identified (at high level)? |
| | | PER.V1.5.3 | Has the primary assets impact assessment been carried-out (at high level)? |
| | | PER.V1.5.4 | Have supporting assets been identified (at high level)? |
| | | PER.V1.5.5 | Has the valuation on supporting assets been identified (at high level)? |
| | | PER.V1.5.6 | Have security vulnerabilities been identified (at high level)? |
| | | PER.V1.5.7 | Have security threats been identified (at high level)? |
| | | PER.V1.5.8 | Have security threat-combinations been identified (at high level)? |
| | | PER.V1.5.9 | Have security controls been identified (at high level)? |
| | | PER.V1.5.10 | Have security residual risks been identified (at high level)? |

| | | | |
|---|---|---|---|
| PRG | PRG.V1.2 | | Have the dependencies with other SESAR Solutions (and relevant OI steps) been analysed, identified and described?<br><br>*Note: Dependency between SESAR solutions is understood here:*<br>*- uni-directional: one SESAR solution requires another one to be ready (validated / implemented) in the same sub-operating environment, but this second solution can be validated and implemented independently. Example: solution #02 "Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances" requires solution #22 "Automated assistance to controllers for surface movement planning and routing". However solution #22 does not require #02.*<br>*- Bi-directional: both SESAR solutions require to be ready (validated / implemented) together in the same sub-operating environment.* |
| PRG | PRG.V1.3 | | Are there evidences that dependant SESAR Solutions (and related OI steps) are at the expected level of maturity? |

## F.3 TRL 4

| Thread | Criteria ID | Sub-Criteria ID | Criteria |
|---|---|---|---|
| OPS | OPS.V2.1 | | Is the operational concept apportioned to the SESAR Solution developed and described in the SPR-INTEROP/OSED and consistent with the SESAR Concept of Operations and the High Level Operational Requirements?<br><br>*The description of the operational concept shall include the new operating method and the difference with the previous operating method (reference scenario), roles and responsibilities, operational procedures, use cases, applicable assumptions, etc...)* |
| OPS | OPS.V2.2 | | Are the Operational, Performance and Safety Requirements (including information exchange requirements (IERs)) available and updated with feedback from V2 validation activities in the SPR-INTEROP/OSED? |
| OPS | OPS.V2.3 | | Is the definition of the SESAR Solution updated and refined capturing the feedback from V2 activities?<br><br>*Note: If V2 validation activities results have justified the need to change/update (including potential alternatives) the SESAR Solution and related OI steps subsequent change requests (CRs) should have been created to update EATMA e.g. Update* |



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| | | | |
|---|---|---|---|
| SYS | SYS.V2.5 | | Are the System Requirements (TS/IRS) stable and verified? Have the Verification of the research prototype, underlying algorithms and technology been successful?<br><br>*System Requirements are traced to operational, performance and interoperability requirements captured in the SPR-INTEROP/OSED V2.*<br>*Impact of verification results on the validation activities e.g. coverage of TS requirements by the prototype(s) is provided in the Availability Note V2* |
| SYS | SYS.V2.6 | | Are there evidences (qualitative and quantitative) of the technical feasibility of the SESAR Solution? |
| PER & CBA | PER.V2.1 | *Sub-criteria below shall be consolidated at criterion level* | Has a V2 Human Performance assessment been performed and documented following SESAR HP Reference Material?<br><br>*Note: In the corresponding VALP V2, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the V2 VALP itself* |
| | | PER.V2.1.1 | Are the benefits and issues in terms of human performance related to the proposed SESAR solution assessed on the level required for V2? |
| | | PER.V2.1.2 | Have potential interactions from the HP point of view with related SESAR Solutions been considered? |
| | | PER.V2.1.3 | Have V2 validation activities provided evidence that the level of human performance needed to achieve the desired system performance for the proposed solution is consistent with human capabilities? |
| | | PER.V2.1.4 | Has the proposed solution been tested with end-users and under sufficiently realistic conditions, including relevant abnormal and degraded conditions? |
| | | PER.V2.1.5 | Have the major HP issues been identified that could become an impediment to concept implementation (e.g. changes in automation levels, changes in staff requirements, need for relocation of the workforce)? Are there any potential mitigation identify on how to overcome these issues? |
| | | PER.V2.1.6 | Have any impacts been identified that may require changes to regulation in the area of HP/ATM? This includes changes in roles & responsibilities, competence requirements, or the task allocation between human & machine |
| | | PER.V2.1.7 | Are the Human Performance related requirements identified from the HP assessment captured and documented in the SPR-INTEROP/OSED? |

| | | | |
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| | | PER.V2.2.2 | Do validation results provide quantitative evidences (by validation exercises with the required confidence, especially where there is high impact, the rest could be estimated by expert judgment) about impact on the most relevant KPAs for the solution (e.g. Capacity, Operational Efficiency, Cost-efficiency, Predictability, Flexibility etc.), using KPIs/PIs from SESAR Performance Framework (if other metrics are used, proper rationale needs to be provided in the PAR document and the mechanism used to obtain PJ19 Performance Framework PF KPIs/PIs)?<br><br>*Is the ECAC extrapolation performed following PJ.19-04 guidance and based on the exercises results, covering all the applicable OEs/sub-Oes?*<br><br>**ECAC extrapolation should be done:*<br>*1) using common assumptions or justified assumptions*<br>*2) presenting information about traffic used (and the date used) to which the solution is beneficial available (because of equipment or of type of operations)*<br>*3) aligned with PJ.19-04 guidelines and webinars*<br>*4) the obtained results should provide a rank in terms of benefits to identify the most promising alternative, and in the most relevant (sub) operating environments relevant for the SESAR Solution (extrapolation to other relevant (sub)operating environments are available to facilitate the consolidation of performance results at ECAC level)* |
| | | PER.V2.2.3 | Are the validation results in line with what is targeted for that SESAR Solution? In case of deviation, has the project identified a concept/solution refinement to mitigate the gap? |
| | | PER.V2.2.4 | Were the V2 Validation exercises executed in validation scenarios that are representative of the (sub) operating environments where the solution could be deployed identified in EATMA for that solution? |
| | | PER.V2.2.5 | Are Baseline, Reference and Solution scenarios considered in the V2 validation exercises aligned with SESAR guidelines?<br><br>*Note: The baseline (2012) provides the absolute values of KPIs and PIs at the start of the timeframe covered by SESAR1 (2005) and SESAR2020 (2012)* |
| | | PER.V2.2.6 | Did the validation scenarios address the most relevant non-nominal situations for the SESAR Solution? |
| | | PER.V2.2.7 | Have potential interactions with related SESAR Solutions been considered? What are the solution relationship (e.g. cross effect, interdependent, mutually exclusive) and relative contribution to performance (e.g. weight per KPA) with the other solutions once the solutions will be deployed? |

| | | | |
|---|---|---|---|
| PER & CBA | PER.V2.5 | *Sub-criteria below shall be consolidated at criterion level* | Has a V2 safety assessment been performed and documented as a Safety Assessment Report ( Part II of the SPR-INTEROP/OSED?<br><br>Note: In the corresponding SPR-INTEROP/OSED Part II, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the V2 SPR-INTEROP/OSED Part II itself.<br>The Solution safety validation objectives included in the VALP V2 Part I shall be traced to the Safety Criteria (ATS ops solutions only), and Safety Requirements at Service level (SRS) and Design level (SRD) as relevant and should be demonstrated in VALR V2 |
| | | PER.V2.5.1 | Does the V2 SPR-INTEROP/OSED Part II include the list of the key properties of the Operational Environment (or User Domain) that could have an effect on safety? |
| | | PER.V2.5.2 | Does the V2 SPR-INTEROP/OSED Part II include:<br>- if ATS ops solution: the relevant Safety Criteria, which cover both pre-existing and system-generated risk, and the justification for their selection?<br>- if Other than ATS ops solution: a list of intended operational use (identified from SESAR ATS ops solutions and from outside SESAR) and the design safety drivers in terms of outline specification of the changed service limited to the potential safety implication on the side of the ATS service provider or aviation undertaking (e.g. airline) using that service, and potentially, any recognized operational or technical standards and/or codes of practice that apply to the “Other than ATS” operational solution ? |
| | | PER.V2.5.3 | Does the V2 SPR-INTEROP/OSED Part II identifies the operational services which support the Solution operations? |
| | | PER.V2.5.4 | Does the V2 SPR-INTEROP/OSED Part II provide, at the level of the operational services, the Service level Safety Requirements (SRS):<br>- With regards to the success approach:<br>-- If ATS ops solution, mitigating the pre-existing aviation risk under normal and abnormal operational conditions<br>-- If Other than ATS ops solution, specifying the changed service considering normal and abnormal conditions of operation, limited to the potential safety implication on the side of the ATS service provider or aviation undertaking (e.g. airline) using that service and;<br>- With regards to the failure approach: limiting the frequency of occurrence of system-generated operational hazards? |
| | | PER.V2.5.5 | Does the V2 SPR-INTEROP/OSED Part I includes the initial design safety requirements (functionality and performance properties from the success approach)? |
| | | PER.V2.5.6 | Does the V2 SPR-INTEROP/OSED Part II describes how the above initial design safety requirements have been derived to satisfy the success Service level Safety Requirements? |



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| | | | requirements) need to be monetised.<br><br>*(Validation exercises provide the evidence needed for a building a credible CBA)* |
| STD & REG | S&R.V2.1 | | Have applicable standards and/or new standardisation needs been identified? |
| STD & REG | S&R.V2.2 | | Has the solution produced material that can be used to support the initial development or update of operational and technical standards (if required)? |
| TRA | TRA.V2.1 | | Are there any major transition issues identified e.g. institutional changes, infrastructure changes, training, etc.? |
| TRA | TRA.V2.2 | | Are there recommendations proposed to be addressed during V3 related activities? E.g. additional testing conditions, open HP issues to be addressed in V3,… |
| VAL | VAL.V2.1 | | Were the V2 Validation activities executed using a validation technique suitable for V2 objectives e.g. Real Time Simulation providing the stakeholders the requisite confidence in the results obtained? |
| VAL | VAL.V2.2 | | Do the validation activities (e.g. validation objectives) at V2 conform to the VALS content apportioned to the SESAR Solution?<br><br>*Note: In the corresponding VALP V2, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the V2 VALP itself* |
| VAL | VAL.V2.3 | | Has the V&VI (Validation and Verification Infrastructure) been successfully verified and accepted prior to the validation activity? |



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| | | | *For dependant SESAR Solutions, their integration have been trialled at V2 level and have demonstrated that they are feasible* |
| PRG | PRG.V2.5 | | Are there evidences that dependant SESAR Solutions (and related OI steps & enablers) are at the expected level of maturity e.g. are feasible/operable/beneficial? (V2 for an individual SESAR solution can only be achieved if other dependant SESAR Solutions have also achieved the same level of maturity). |

## F.4 TRL 6

| Thread | Criteria ID | Sub-Criteria ID | Criteria |
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| **OPS** | OPS.V3.1 | | Is the operational concept apportioned to the SESAR Solution refined and further detailed and documented after V3 activities in the SPR-INTEROP/OSED and consistent with the SESAR Concept of Operations and the High Level Operational Requirements?<br><br>*The description of the operational concept includes roles and responsibilities, the new operating method and the difference with the previous operating method, operational procedures, use cases, applicable assumptions, training needs, etc...* |
| **OPS** | OPS.V3.2 | | Are the OI steps under the scope of the SESAR Solution fully described and documented e.g. IOC-dates estimated and confirmed, description and rationale are updated based on the feedback from validation results, etc...? |



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| **SYS** | SYS.V3.2 | | Are the System Requirements (TS/IRS) verified, stable and updated after V3 activities?<br><br>*The verification of the integrated prototype, HMI, system architecture, underlying algorithms and technology has been successfully performed. The impact of verification results on the validation activities e.g. coverage of TS/IRS requirements by the prototype(s) and/or V&VI is provided in the Availability Note V3* |
| **SYS** | SYS.V3.3 | | Are the Interoperability requirements (SPR-INTEROP/OSED) updated after V3 activities? |
| **SYS** | SYS.V3.4 | | Are the requirements on underlying CNS infrastructure documented? |
| **SYS** | SYS.V3.5 | | Are the requirements on underlying SWIM infrastructure documented? |
| **SYS** | SYS.V3.6 | | Are the evidences (quantitative and qualitative) on the technical feasibility of the SESAR Solution obtained in previous V phases confirmed? |
| **PER & CBA** | PER.V3.1 | *Sub-criteria below shall be consolidated at criterion level* | Has a V3 Human Performance assessment been performed and documented following SESAR HP Reference Material?<br><br>*Note: In the corresponding VALP V3, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the V3 VALP itself* |
| | | PER.V3.1.1 | Are the benefits and issues in terms of human performance related to the proposed SESAR solution assessed on the level required for V3? |
| | | PER.V3.1.2 | Have potential interactions with related SESAR Solutions been considered? |
| | | PER.V3.1.3 | Have V3 validation activities provided evidence that the level of human performance needed to achieve the desired system performance for the proposed solution is consistent with human capabilities? |
| | | PER.V3.1.4 | Has the proposed solution been tested with end-users and under sufficiently realistic conditions, including relevant abnormal and degraded conditions? |
| | | PER.V3.1.5 | Have the major HP issues been identified that could become an impediment to concept implementation (e.g. changes in automation levels, training needs of human actors, changes in staff requirements, need for |

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| | | | mechanism when using other metric)?<br><br>*Note: All the KPAs/KPIs with an apportioned Validation Target shall be described in the BIMs and in the VALP.* |
| | | PER.V3.2.2 | Do validation results (quantified by validation exercises with the required confidence) confirm the quantitative evidences obtained in previous V phases about impact on all KPAs which are relevant (e.g. Capacity, Operational Efficiency, Cost-efficiency, Predictability, Flexibility etc.), using KPIs/PIs from SESAR Performance Framework (if other metrics are used, proper rationale needs to be provided in the PAR document and the mechanism used to obtain PJ.19 Performance Framework KPIs/PIs)?<br><br>*Is the ECAC extrapolation performed following PJ.19-04 guidance and based on the exercises results, covering all the applicable OEs/sub-Oes?*<br><br>**ECAC extrapolation should be done: 1) using common assumptions or justified assumptions 2) presenting information about traffic used (and the date used) to which the solution is beneficial available (because of equipment or of type of operations) 3) aligned with PJ.19-04 guidelines and webinars 4) the obtained results should provide a rank in terms of benefits to identify the most promising alternative, and in the most relevant (sub) operating environments relevant for the SESAR Solution (extrapolation to other relevant (sub)operating environments are available to facilitate the consolidation of performance results at ECAC level)* |
| | | PER.V3.2.3 | Are the assessments results at SESAR Solution Level in line with what is targeted for that SESAR Solution? In case of deviation, has the project been able to identify the origin of the gap (programme, concept, others)? |
| | | PER.V3.2.4 | Were the V3 Validation exercises executed in validation scenarios that are representative of the (sub) operating environments where the solution could be deployed identified in EATMA for that solution? |
| | | PER.V3.2.5 | Are Baseline, Reference and Solution scenarios considered in the V3 validation exercises aligned with SESAR guidelines?<br><br>*Note: The baseline (2012) provides the absolute values* |

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| **PER & CBA** | PER.V3.4 | *Sub-criteria below shall be consolidated at criterion level* | Has a V3 safety assessment been performed and documented as a Safety Assessment Report (Part II of the SPR-INTEROP/OSED?<br><br>*Note: In the corresponding SPR-INTEROP/OSED Part II, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the V3 SPR-INTEROP/OSED Part II itself. The Solution safety validation objectives included in the VALP V3 Part I shall be traced to the Safety Criteria (ATS ops solutions only) and Safety Requirements at Service level (SRS) and Design level (SRD) as relevant and should be demonstrated in VALR V3* |
| | | PER.V3.4.1 | Do the V3 SPR-INTEROP/OSED Part I and TS/IRS Part I include the set of refined design safety requirements (functionality and performance properties) from the success approach) for the final system design of the SESAR Solution? |
| | | PER.V3.4.2 | Does the V3 SPR-INTEROP/OSED Part II describe how the above refined design safety requirements have been derived to satisfy the initial design Safety Requirements or corresponding Service level Safety Requirements (both for success and failure approach) that were derived at V2 level? |
| | | PER.V3.4.3 | Do the V3 SPR-INTEROP/OSED Part I and TS/IRS Part I include the set of refined design safety requirements (integrity property) from the failure approach) for the final system design of the SESAR solution? |
| | | PER.V3.4.4 | Does the V3 SPR-INTEROP/OSED Part II describe how the above refined design safety requirements have been derived to satisfy the initial design Safety Requirements (failure approach) or corresponding Service level Safety Requirements (for failure approach) that were derived at V2 level? |
| | | PER.V3.4.5 | Does the V3 SPR-INTEROP/OSED Part I include the ATC/flight crew procedure refined safety requirements? |
| | | PER.V3.4.6 | Does the V3 SPR-INTEROP/OSED Part II describe how the above ATC/flight crew procedure refined safety requirements have been derived to satisfy the initial design Safety Requirements or corresponding Service level Safety Requirements that were derived at V2 level? |

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| **PER & CBA** | PER.V3.6 | | Are the assessments results in line with what is targeted for that SESAR Solution? In case of deviation, Has the impact on the overall strategic performance objectives/targets been analysed? |
| **PER & CBA** | PER.V3.7 | *Sub-criteria below shall be consolidated at criterion level* | In addition to the V2 criteria, are the following elements clearly described in the V3 CBA document report:<br>(1) all evidence gathered in terms of impacts, costs, and benefits of a solution<br>(2) the NPV overall and per stakeholder group,<br>(3) a sensitivity analysis identifying most critical variables to the value of the project,<br>(4) a risk analysis,<br>(5) the CBA model,<br>(6) conclusions and recommendations e.g. for deployment<br><br>*When relevant, the demonstration (VLD) phase may also provide quantitative assessments to confirm and complement the R&D CBA.*<br><br>*Validation exercises provide the evidence needed for a building a credible CBA* |
| **STD & REG** | S&R.V3.1 | | Is the material produced and documented in the solution datapack sufficiently developed and mature to support the development or update of operational and technical standards (if required) during V4 (industrialization)? |
| **STD & REG** | S&R.V3.2 | | Have the regulatory needs been identified? |
| **TRA** | TRA.V3.1 | | Are the major transition issues analysed and mitigation measures proposed taking into account evolution of the SESAR Solution, relevant OI steps and supporting enablers? |
| **TRA** | TRA.V3.2 | | Are there recommendations proposed to be addressed during industrialization and deployment? *E.g. any open HP issues / recommendation for industrialization & deployment have been identified and documented* |
| **VAL** | VAL.V3.1 | | Were the V3 Validation activities executed using a validation technique suitable for that maturity level e.g. shadow mode and / or live trials? |
| **VAL** | VAL.V3.2 | | Do the validation activities (e.g. validation objectives) at V3 conform to the VALS content apportioned to the SESAR Solution?<br><br>*Note: In the corresponding VALP V3, these criteria and* |

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| **PRG** | PRG.V3.4 | | Have the dependencies with other SESAR Solutions (and relevant OI steps & enablers) been analysed, described and successfully validated?<br><br>Note: Dependency between *SESAR solutions is understood here:*<br>*- uni-directional: one SESAR solution requires another one to be ready (validated / implemented) in the same sub-operating environment, but this second solution can be validated and implemented independently. Example: solution #02 "Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances" requires solution #22 "Automated assistance to controllers for surface movement planning and routing". However solution #22 does not require #02.*<br>*- Bi-directional: both SESAR solutions require to be ready (validated / implemented) together in the same sub-operating environment.*<br><br>*For dependant SESAR Solutions, their integration have been trialled at V3 level and have demonstrated that they are feasible* |
| **PRG** | PRG.V3.5 | | Are there evidences that dependant SESAR Solutions (and related OI steps & enablers) are at the expected level of maturity e.g. are feasible/operable/beneficial? (V3 for an individual SESAR solution can only be achieved if other dependant SESAR Solutions have also achieved the same level of maturity). |

### F.5 TRL 7

| Thread | Criteria ID | Sub-Criteria ID | Criteria |
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| **OPS** | OPS.TRL7.1 | | Does the Demonstration Report provide a brief description of the operating method under the scope of the SESAR Solution(s) aligned with the relevant reference documentation for these SESAR Solution(s)?<br><br>*Note: In the corresponding DEMO PLAN, these criteria and sub-criteria should have been already covered* |

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| **SYS** | SYS.TRL7.3 | | Has an "actual system prototype" demonstrated that it meets critical functional and performance requirements in the final intended operating environment? |
| **SYS** | SYS.TRL7.4 | | Has a scalability analysis to handle large scale realistic use-cases been performed and reported in the DEMO Report?<br><br>*Note: In the corresponding DEMO PLAN, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the DEMO PLAN itself* |
| **SYS** | SYS.TRL7.5 | | Has the project **demonstrated** that the integration of the SESAR technological solution(s) in an "actual operational environment" is **technically feasible**? |
| **PER & CBA** | PER.TRL7.1 | | Have the performance assessments been performed and documented following SESAR Performance Assessment Reference Material?<br><br>*Note: In the corresponding DEMO PLAN, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the DEMO PLAN itself.* |
| **PER & CBA** | PER.TRL7.2 | | Have the performance impacts claimed in the V3 benefit mechanisms for the applicable SESAR Solutions confirmed by the VLD project? |
| **PER & CBA** | PER.TRL7.3 | *Sub-criteria below shall be consolidated at criterion level* | Has a safety assessment been performed and documented?<br><br>*Note: In the corresponding DEMO PLAN Part II, these criteria and sub-criteria should have been already covered and they might constitute quality acceptance criteria of the DEMO PLAN Part II itself:*<br>*- Does the demonstration plan include the required documentation of the current safety assurance status in order to make a decision on approval to move a SESAR solution from a pre-industrialization stage to a 'ready for VLD' status? (This includes ensuring that the findings of the safety assessment at V3 are fully accounted for and any safety issues not adequately addressed in the Solution System design are managed and adequately mitigated in the design of operational procedures and training before the VLD takes place);*<br>*- Does the Demo Plan Part II document the safety assurance needs for the VLD per se?*<br>*- Does the Demo Plan Part II document the required* |

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| **PER & CBA** | PER.TRL7.6 | | Have training needs been specified in sufficient detail? |
| **PER & CBA** | PER.TRL7.7 | | Have changes in competence requirements and the impact on recruitment and selection been considered? |
| **PER & CBA** | PER.TRL7.8 | | Has a Environmental Impact Assessment (EIA) been performed and documented following SESAR Environmental Reference Material? |
| **STD & REG** | S&R.TRL7.1 | | Has the VLD project contribution to operational or technical standards been documented? |
| **STD & REG** | S&R.TRL7.2 | | Which means of compliance (MOC) been used/tailored to show compliance with the applicable regulations? |
| **STD & REG** | S&R.TRL7.3 | | Has a Certification Review Item (CRI) for the airworthiness aspect been hold? |
| **TRA** | TRA.TRL7.1 | | Are there recommendations proposed to be addressed during industrialization and deployment? |
| **DEMO** | DEMO.TRL7.1 | | Were the Demonstration activities executed using a demonstration technique suitable for that maturity level e.g. shadow mode and / or live trials? |
| **DEMO** | DEMO.TRL7.2 | | Has the Verification and Demonstration Infrastructure i.e. (demonstration platform) been successfully verified and accepted prior to the demonstration activity? |
| **DEMO** | DEMO.TRL7.3 | | Was the system at or near scale of the operational system, with most functions available for demonstration and test and with EASA proof of concept authorisation if necessary? |
| **PRG** | PRG.TRL7.1 | | Have the demonstration activities provided any result that may impact the IOC-FOC dates of the relevant SESAR Solution(s) in EATMA? |