

# Outlook on the future of ATM research beyond 2028

SESAR 3 JU Scientific Committee:

*Tatjana Bolić Chair, Juan Besada Vice-Chair; Rosa Arnaldo, Sara Bagassi, Andrew Cook, Daniel Delahaye, Peter Hecker, Efsthios Malakis, Feđa Netjasov, Rita Somogyi*

## Introduction

As stated by the European Union, transport is an important pillar of the economy that connects people, goods, and cultures while supporting millions of jobs<sup>1</sup>, aviation being an important part of the pillar. Efficient and safe air traffic management (ATM) is vital to ensuring the continued success and sustainability of aviation. The Single European Sky Air Traffic Management (ATM) Research (SESAR) project<sup>2,3</sup> was established as an element of the European Union's Single European Sky (SES) initiative to modernise and streamline Europe's fragmented ATM. The SESAR project encompasses the SESAR Joint Undertaking (JU), which leads the research and innovation (R&I) programme, while harmonised deployment is managed by the SESAR Deployment Manager.

**This White Paper argues that the *SESAR JU and the R&I it leads, is crucial to the future of European ATM and aviation and must remain a top priority for European policymakers, industry stakeholders, and international partners.***

## Background

European ATM R&I has been performed under three consecutive SESAR JUs for the past 16 years. SESAR1 was established in 2007<sup>4</sup>, to fund industry-driven ATM research and development in a coordinated manner, at the EU level. Nevertheless, low-maturity, mainly academic, ATM research received very limited funding in SESAR1 (and no EU-level grants outside SESAR1), producing very good results despite low financing.

By the end of SESAR1, the notion of the ATM '**innovation pipeline**' matured, where Exploratory Research (ER), mainly academic, furnished new ideas, up to technology readiness level (TRL) 2. The higher TRL levels (3-6) were covered by Industrial Research (IR), maturing successful ideas

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<sup>1</sup> Draghi, Mario, THE FUTURE OF EUROPEAN COMPETITIVENESS, September 2024

<sup>2</sup> Council regulation (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR),

<sup>3</sup> Bolić, Tatjana, Ravenhill, Paul. SESAR: The Past, Present, and Future of European Air Traffic Management Research, 2021, doi: 10.1016/j.eng.2020.08.023

<sup>4</sup> Council regulation (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR).

from lower maturity levels. Further, through the SESAR1 and SESAR2020<sup>5</sup> programmes it became clear that the ATM innovation pipeline is a continuous lifecycle driven through updates to the European ATM Master Plan<sup>6</sup> (MP). The MP updates involve all the stakeholders, and the MP represents a joint vision on research and innovation needed in ATM. The SESAR R&I programme is structured in such a way that promising topics<sup>7</sup> from low TRL research are included in the subsequent calls for higher maturity projects, when in line with the MP vision and Strategic Research and Innovation Agenda (SRIA)<sup>8</sup>. The SESAR 3 JU<sup>9</sup> manages the **R&I** components of the pipeline, and **MP updates**, while deployment continues to be managed by the SESAR Deployment Manager, or directly by the various stakeholders interested in voluntary deployment of SESAR Solutions. The European ATM Master Plan (2024 edition; to be published) establishes a goal to “make Europe the most efficient and environmentally friendly sky to fly in the world by 2045”<sup>10</sup>. To achieve that goal and maintain such a position, the SESAR innovation pipeline must be streamlined, strengthened, and the time to Solution delivery shortened, as recommended by the consecutive SESAR JU evaluations<sup>11,12,13</sup>.

The composition of the SESAR JU membership and the project beneficiaries continues to expand, bringing new players and different fields of expertise, thus strengthening the research programme. Membership of the JU grew from 15, then 37, and now 57 members<sup>10</sup> in the current programme, covering a wide range of stakeholders, including new entrants. A similar trend is observed in the number and variety of beneficiaries participating in the funded projects.

The SESAR 3 JU programme connects academia and industry stakeholders, through research projects, collaborations and support to the education of future ATM researchers, through the Engage 2 Knowledge Transfer Network (KTN). The Engage KTN (in SESAR 2020) and Engage 2 KTN continue to support PhD students in ATM. The educational needs for the future ATM workforce, to embrace the envisioned technological and social changes, are being formulated through KTN activities with a wide stakeholder base. Participation in SESAR 3 JU projects represents the only funding source for ATM research for the majority of EU Member States’ higher

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<sup>5</sup> Council of the European Union. Council regulation (EU) No 721/2014 of 16 June 2014 amending Regulation (EC) No 219/2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR) as regards the extension of the Joint Undertaking until 2024

<sup>6</sup> The first Master Plan was endorsed by the Council on 30 March 2009, and was updated in 2012 and 2015, a new edition was published in 2019. The latest edition is about to be published. (<https://atmmasterplan.eu/>)

<sup>7</sup> Where low TRL level projects demonstrate that the Solutions under development can bring benefits to the overall SESAR programme.

<sup>8</sup> SRIA describes the current SESAR 3 JU research priorities, in terms of nine Flagship research areas:

<https://www.sesarju.eu/sites/default/files/documents/reports/SRIA%20Final.pdf>

<sup>9</sup> Council of the European Union Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

<sup>10</sup> <https://www.sesarju.eu/news/campaign-update-european-atm-master-plan-enters-final-straight>

<sup>11</sup> Final evaluation of the SESAR Joint Undertaking (2014-2016) operating under the SESAR 1 Programme (FP7) (<https://data.europa.eu/doi/10.2832/96511>)

<sup>12</sup> Interim evaluation of the SESAR Joint Undertaking (2014-2016) operating under Horizon 2020 (<https://data.europa.eu/doi/10.2832/69327>)

<sup>13</sup> Partnership Evaluation Report: Single European Sky ATM Research 3 Joint Undertaking (SESAR 3 JU) (<https://data.europa.eu/doi/10.2777/7895247>)

education institutions, as those States which no longer have national ATM programmes<sup>14</sup>. As research performed by academia often shapes educational profiles, and future ATM requires changes in education, it is important to nurture both the research and educational capabilities of academia and its close links to industrial partners.

The SESAR 3 JU continues to strengthen the influence of European ATM globally, having created a brand of European leadership in ATM research. This is further visible through direct involvement in ICAO expert groups, and the ICAO's Global Air Navigation Plan updates, as it now adopts the layout and approach of the European ATM MP, enhancing Europe's role in shaping the future of global ATM<sup>15</sup>. Europe, through the SESAR 3 JU, and the US, are innovation leaders at ICAO, while the other states tend to follow their lead.

## Future research elements

The European ATM Master Plan and SRIA (*ibid.*) are informed by extensive stakeholder consultations<sup>16</sup>, and are ambitious. It is unlikely that all the SRIA and MP research priorities of the current programme will reach TRL6, by the end of the programme. Furthermore, recent years saw technological, social and political changes that will likely require adjustment of directions for future research.

The following have been identified as such complementary research directions, supporting the wider objectives of the SRIA and MP. There is some overlap with the retained priorities of the 2024 edition of the MP, and subsequent SESAR 3 funding calls, which have been developed over a similar timeframe to this White Paper. It is also to be expected that there will be some overlap with the future ATM concepts roadmap being developed by the Engage 2 KTN<sup>17</sup> (to be released as a first draft in 2025). The areas summarised below are in no implied order of priority, with specific elements preceding transversal aspects. The specific elements are divided into those that are covered by current MP ER priorities, requiring attention beyond 2028, and those that go beyond these priorities. The transversal aspects build on recommendations made by the SESAR 2020 and SESAR 3 Scientific Committees.

### **(a) Specific elements covered by current MP ER priorities (still requiring attention beyond 2028)**

- Measurement and monitoring **aviation climate and environmental impact**, decreasing the ATM contribution. New metrics are needed, especially regarding non-CO<sub>2</sub> impacts and

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<sup>14</sup> Interim evaluation of the SESAR Joint Undertaking (2014-2016) operating under Horizon 2020 (<https://data.europa.eu/doi/10.2832/69327>)

<sup>15</sup> Partnership Evaluation Report: Single European Sky ATM Research 3 Joint Undertaking (SESAR 3 JU) (<https://data.europa.eu/doi/10.2777/7895247>)

<sup>16</sup> All ATM stakeholders, but also EU Member States, research community, etc.

<sup>17</sup> The KTN is also collaborating with other institutions, and conducting primary research, to investigate and map the impacts on, and requirements of, a future, interdisciplinary, skilled workforce for aviation and ATM.

bridging the gap between strategic and tactical policy and regulation. The impact of climate change on ATM, and on pax demand, also need to be considered.

- Integration of **new types of aircraft** (e.g. hybrid, electrical, hydrogen), mindful of unknown performance characteristics, diverse missions (e.g. commercial, governmental and military).
- Integration of highly **automated, remotely controlled or autonomous systems** and their interaction with new and extant infrastructure, such as vertiports and airports. This requires the definition of new processes of managing and interacting with other aircraft types.
- Virtualisation and **digitalisation collaboration of ANSPs** - analysis of the impact of these technologies for virtual centres and remote towers, as enablers of new business models for service providers, initially in UAM/AAM, and later in wider services (e.g. CNS, MET).
- Trusted, **human-centric deployment of AI technologies** is needed, supported by an appropriate evolution of education and training. Ethical, legal and liability (risk-based) aspects of higher automation levels and service-oriented provision, must be included.
- **Quantum computing** research could already identify commonly used (classical) tools/ algorithms in ATM, which could benefit from being quantised, identifying the benefits and impacts thereof. Quantum annealing exemplifies a short-term, high-yield, low-risk method.

#### **(b) Specific elements beyond current MP priorities:**

- Integration of **new types of aircraft**, taking into account the transition periods and downstream effects (e.g. airports) on network performance and efficiency. Inclusion of supersonic aircraft under development.
- **Cybersecurity** is dynamic and constantly adjusting to changing threats, and this landscape needs to be an integral part of future ATM. Existing frameworks and legislation need to be reviewed and tailored for use in ATM, considering coexistence with legacy systems.
- Role of aviation in **future passenger-centric mobility**, mindful of the Sustainable and Smart Mobility Strategy<sup>18</sup>, decarbonisation efforts and efforts on increasing multimodality, at the door-to-door level and with high-speed rail integration / substitution.
- Diverse **operating modes in higher airspace** pose a challenge for efficient co-management with conventional flights. Space traffic management - ATM interfaces, ConOps, services and new business models need to be matured in the fragmented European environment.

#### **(b) Transversal elements**

- The SRIA and new Master Plan (*ibid.*) endorse the extension of scope from a flight-centric approach towards a more passenger-centric view. The **SESAR Performance Framework** needs to be extended to embrace multimodality, with appropriate new KPIs, mindful of the scale of door-to-door mobility, plus data sharing and ticket integration needs across transportation modes.
- The initiative formally launched at the SESAR Innovation Days in 2023, proposing an **open science alliance for ATM**, advocating for open data in such a framework, is endorsed by this Committee. This includes the promotion of (1) open access to scientific methods and

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<sup>18</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789>

data utilised; (2) open access to (analytical) code and methods; and (3) open review of reported analyses/research. The main objective being the enabler for fast-tracking of the innovation pipeline.

## Organisation and funding of future ATM research

The current innovation pipeline flows from ER, through IR and fast-track development, to demonstrators<sup>19</sup>, a process which should help to close the gap between SESAR Solutions (at TRL6) and TRL8, as needed for deployment. The SESAR1 and SESAR2020 programmes' innovation pipelines inspired the addition of fast-track projects and demonstrators and their impact on shortening the time from concept to deployment is yet to be seen.

If the European sky is to be the most efficient and environmentally friendly in the world, it should be constantly improved. This desired state can never be taken as accomplished *per se*. European ATM should strive for constant improvement including existing and potential technological improvements, which is the only way to retain its leading role in global ATM. The innovation cycle in ATM often lasts decades, which is not something we can afford in the future. One of the much needed improvements is the shortening of the innovation pipeline timeframe, which needs to embrace technical developments (to evaluate what is possible), with change management, and the subsequently needed legal and regulatory changes, to avoid those being barriers to industrialisation and deployment, and further market uptake. As such, future ATM research needs to continue being coordinated from initial research priorities, through research and innovation developments, legal and regulatory considerations, and on to certification and standardisation.

What is clear today, is that due to the niche aspect of ATM and its high interdependencies with other domains related to infrastructures and vehicle-related research, low and high maturity research needs to be **coordinated** at the European level, to be able to achieve correspondingly coordinated ATM network impacts, and to avoid the previously fragmented state. The innovation pipeline needs to be ensured, in **a coordinated and time-efficient manner**. As industry stakeholders on their own do not have the sufficient know-how and expertise to achieve the envisioned Digital European Sky, some very new concepts will need to be introduced (see research priorities in the previous section). Research establishments and academia need operational insight from industry, in order to steer their research towards common goals. Close collaboration of research, academia and industrial stakeholders is needed to deliver the future Digital European Sky, as quickly and efficiently as possible, and to continue the work on these improvements to avoid falling behind other global players (e.g., the USA and China).

In summary, we believe that a seamless, future **ATM innovation pipeline** can be achieved through a joint undertaking or a public-private partnership supported by the EU, which is able to prioritise the research activities to be funded, their promotion to higher TRL-levels, ensuring proper integration between private and public funding, and thus reducing the time to deployment.

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<sup>19</sup> Funded through CEF funds. See Partnership Evaluation Report: Single European Sky ATM Research 3 Joint Undertaking (SESAR 3 JU)

## Concluding remarks

The SESAR JUs<sup>20,21,22</sup> have evolved over many years, strengthening the R&I programme and innovation pipeline processes, and as such have proven to be an effective force in modernising Europe's ATM system. Their contributions to improving efficiency, safety, and sustainability are evident. 'SESAR' is now also an established and globally recognised brand for fostering ATM research. However, the challenges that lie ahead—ranging from growing air traffic demand to urgent environmental concerns—require that SESAR R&I not only continues but expands its efforts. For Europe to maintain its leadership in aviation and meet its climate and safety targets, SESAR R&I must stay functioning and fully funded.

To ensure that the SESAR R&I programme remains viable and continues to deliver on its mission, the following policy actions are recommended:

**Continued financial support** - the European Commission, national governments, and industry stakeholders must commit to sustained investment in SESAR R&I to ensure that its research, development, and demonstration activities can continue without interruption, feeding the deployment activities.

**Public-private partnership** - the aviation industry, including airlines, ANSPs, airports, and technology and service providers, must continue to collaborate closely with SESAR R&I to ensure that innovations are adopted and operationalised effectively.

**Accelerated deployment of key technologies and Solutions** - policymakers should continue to prioritise the deployment of SESAR Solutions across Europe, ensuring that the benefits of ATM modernisation are realised as quickly as possible.

**Stronger collaboration with international partners** - the SESAR JU should continue to foster international cooperation, particularly with the USA and other key stakeholders, and its representation of a joint European view in ICAO, to ensure global interoperability and standard-setting.

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<sup>20</sup> Council regulation (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR)

<sup>21</sup> Council of the European Union Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

<sup>22</sup> Council of the European Union Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014