sesar JOINT UNDERTAKING

EASA European Union Aviation Safety Agency

EUROCONTROL

MAKING EUROPE THE **MOST EFFICIENT** AND **ENVIRONMENTALLY FRIENDLY** SKY TO FLY IN THE WORLD

A JOINT DISCUSSION PAPER

PURPOSE OF THIS DISCUSSION PAPER

This paper aims to prompt discussions among Europe's aviation stakeholders and policymakers on the contribution that air traffic management (ATM) needs to make towards the aviation sector's climate neutrality ambitions, in accordance with the European Green Deal, Sustainable and Smart Mobility Strategy, European Climate Law and the Fit For 55 plan for green transition.

The paper has been prepared to support the update of the European ATM Master Plan, the roadmap for the modernisation of Europe's ATM and for implementing the Digital European Sky. The theme chosen for the 2024 edition is to make Europe the most efficient and environmentally friendly sky to fly in the world and corresponds to a new objective of the SESAR 3 Joint Undertaking, underlining the critical contribution of ATM to climate neutrality[1].

The paper makes use of recent EU and global studies on environmental sustainability in aviation, taking into account challenges and trends, and what they mean for the European aviation sector.

The paper discusses how already validated SESAR solutions have laid the foundation for a breakthrough to sustainability and summarises the questions that need to be answered to further progress making use of this foundational work.

The purpose of this document is to stimulate discussions on the following:

- What would it mean in concrete terms to become the most efficient and environmentally friendly sky to fly in the world?
- What has SESAR delivered so far and how does that match Europe's policy ambitions?
- What does the next edition of the Master Plan need to capture in order for Europe to meet the climate neutrality objective?

THESE OPEN QUESTIONS ARE DISPLAYED IN BOXES THROUGHOUT THE PAPER

This paper is the starting point for more detailed stakeholder-wide consultation on the continuous modernisation of ATM during the European ATM Master Plan update campaign.

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1 Regulation (EU) 2021/2085, Article 142, 1 (c) establishing the SESAR 3 Joint Undertaking: "develop and accelerate the market uptake of innovative solutions to establish the Single European Sky airspace as the most efficient and environmentally friendly sky to fly in the world."

1 EUROPE AS THE **MOST EFFICIENT** AND **ENVIRONMENTALLY FRIENDLY** SKY TO FLY IN THE WORLD

Currently, aviation's sectoral share of global CO_2 emissions stands at approximately 2.5% on an annual basis[2]. The most recent estimates suggest that global demand for air transport will increase by an average of 4.3% per annum over the next 20 years[3]. In Europe, flights are expected to grow 44%, from 11 million pre-pandemic in 2019, to 16 million in 2050.[4]. In parallel to these growth projections, there is rising passenger demand for sustainable travel choices, including aviation[5]. Increasing traffic means the aviation industry will have an ever-increasing share of global emissions. There is therefore a need to accelerate and intensify the decarbonisation of air transport, including air traffic management (ATM).

There are commonly-agreed multiple pathways to address emissions and make aviation more sustainable, like ICAO's basket of measures, which includes aircraft technology improvements, operational improvements, sustainable aviation fuels, and market-based measures[6]. In the medium to long term, the biggest reductions in carbon emissions will be achieved by bio or synthetic sustainable aviation fuels (SAF). Several SAF pathways have been approved for safe usage and many initiatives are underway to incentivise investment and scale up these alternatives, such as ReFuelEU Aviation[7]. However, although SAF fuels will significantly reduce the climate impact of aviation, some emissions will remain.

Aircraft design, the performance of the aircraft itself and fleet composition favouring efficient conventional aircraft (evolutionary) and electric and hydrogen powered vehicles (revolutionary) will also make a significant contribution to emissions reduction, as well as mitigate noise even further than today.

Given that these advancements are contingent on factors such as the development of high-energy batteries, certification of new aircraft, and the establishment of cost-effective supply chains, their benefits will only materialise further down the line, from 2040 onwards[8].

DISCUSSION POINT

WHAT IS THE ROLE OF ATM IN ADDRESSING THE CLIMATE IMPACT OF AVIATION?

At the same time, market-based measures, such as ICAO's carbon offsetting and reduction scheme for international aviation (CORSIA) and the EU emissions trading system (ETS), as well as carbon capture and storage technologies, are complementing in-sector measures to address the climate impact of aviation.

When it comes to the short to medium term, introducing new technologies and procedures into ATM could provide a significant and more immediate impact on making aviation climate neutral (see *What SESAR has delivered so far*). This involves eliminating inefficiencies in all phases of flight and in how airspace is used. It also means addressing non-CO_2 emissions. While scientific research is ongoing on this topic, recent estimates suggest that overall, the non-CO_2 climate impacts of aviation activities are at least as significant as those of CO_2 alone.

2 2022 European Aviation Environmental Report, p.45
3 https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx
4 Aviation Outlook 2050, EUROCONTROL, 2022
5 Passenger IT Insights, SITA, 2020
6 Introduction to the ICAO Basket of Measures to Mitigate Climate Change, ICAO Secretariat
7 Fit for 55: Parliament and Council reach deal on greener aviation fuels | News | European Parliament (europa.eu)
8 EUROCONTROL Aviation Outlook 2050, 2022

Finally, ATM improvements can bring other environmental benefits, such as noise mitigation and improved local air quality. In an efficient and environmentally friendly sky, the design of the ATM system would be able to scale up or down in line with demand. It would not generate unnecessary emissions and would maintain safety as a paramount feature. As the challenge to achieve climate neutrality goes beyond CO_2, the future design of the system should be able to adapt and strike the right balance between CO_2 and non-CO_2 emissions, while addressing noise and local air quality.

DISCUSSION POINT

WHAT DOES IT MEAN TO BE THE MOST EFFICIENT AND AN ENVIRONMENTALLY FRIENDLY SKY?

When the European Commission established a set of high-level performance ambitions for ATM back in 2005, it included within the Single European Sky (SES) framework the goal to enable a 10% reduction in CO_2 emissions per flight. That high-level ambition of 10% reduction in CO_2 emissions has remained stable over the years, but different approaches and baselines have been applied to determine the potential range of fuel efficiency gains from operational ATM improvements. For example, calculations from one study estimate an average fuel inefficiency between 8.6% to 11.2%[9] from take-off to landing on flights within the EUROCONTROL Network Manager area in 2019[10].

DISCUSSION POINT

DO WE HAVE THE RIGHT AMBITION LEVEL FOR ENVIRONMENTAL PERFORMANCE IN THE EUROPEAN ATM MASTER PLAN? IS 5-10% SUFFICIENT? WHAT ABOUT OTHER NON-CO_2 IMPACTS?

This calculation does not consider the fuel inefficiencies that could be eliminated from the ground phase of the trajectory.

The European ATM Master Plan defines the performance ambition for the Digital European Sky, currently setting fuel burn and CO_2 emissions reduction targets at between 5% and 10% per flight (gate-to-gate) by 2035 - against a 2012 baseline[11].

While the SES goal on emissions and the corresponding Master Plan ambition remain focused on CO_2 emissions, indicators on non-CO_2, noise and air quality have since been introduced to the SESAR research and innovation performance framework. Consequently, it is the right moment to accommodate new environmental performance ambitions that embrace broader emissions: CO_2 and non-CO_2, noise and local air quality.

9 Depending on the reference used for the calculation
10 Environmental Assessment: European ATM Network Fuel Inefficiency Study, EUROCONTROL 2020
11 2020 European ATM Master Plan, p.37

2 WHAT SESAR HAS **DELIVERED** SO FAR

To date, the SESAR research and innovation programme has delivered a total of 127 digital solutions[12]. It is estimated that over 100 of these solutions could bring significant direct and indirect environmental improvements to ATM operations. When implemented, these solutions could already result in a 4% direct reduction in CO_2 emissions per flight[13].

Much of the focus of these solutions has been on making taxi-out and runway operations more predictable and efficient, reducing holding patterns and vectoring in terminal airspace upon arrival, and optimising trajectories with i4D, among other technologies. All of which bring fuel savings. Some of these solutions also support local environmental performance objectives through noise mitigation and air quality improvements.

The implementation of some of these solutions is already mandated by law (Common Project 1[14]), prioritising key enablers for trajectory-based operations and for establishing a digital backbone for the SES. The content of CP1 directly derives from SESAR solutions. It is estimated that the SESAR solutions captured in the CP1 projects could already contribute 2% in emissions reductions per flight, compared to the 2012 baseline.[15].

DISCUSSION POINT

WE HAVE SOLUTIONS TO REDUCE EMISSIONS AVAILABLE FOR IMPLEMENTATION NOW. HOW CAN WE SPEED UP THEIR IMPLEMENTATION?

EXCESS FUEL CONSUMPTION BY FLIGHT PHASES FOR AN AVERAGE FLIGHT IN EUROPE, WITH SUPPORTING FUNCTIONALITIES FROM COMMON PROJECT 1 (CP1)*

PLANNING | MEDIUM AND SHORT TERM PLANNING | PRE-DEPARTURE | TAXI-OUT AND TAKE-OFF | CLIMB | CRUISE | DESCENT | LANDING AND TAXI-IN | POST FLIGHT

Average fuel burn during flight phase (total 5-7 tonnes)	130kg 10kg/min	660kg 60kg/min	4260kg 60kg/min	600kg 40kg/min	60kg 8kg/min
CP1 supporting functionalities	• Departure manager • Arrival manager / Departure manager integration • Airport operations plan • Airport safety nets	• Extended projected profile	• Flexible use of airspace • Management of predefined airspace configuration • Free route airspace • Extended projected profile	• Arrival manager • Cross-border arrival management • Arrival manager / Departure manager integration • Extended projected profile	• Airport operations plan • Airport safety nets

* **SOURCE:** European Aviation Environmental Report with the addition of extended projected profile

12 Refers to the solutions delivered by the SESAR Joint Undertaking through two research and innovation programmes: SESAR 1 (2008-2016) and SESAR 2020 (2017 – 2022). View the delivered solutions in the SESAR Solutions Catalogue

13 SESAR 3 JU internal estimations to be confirmed by the Final SESAR 2020 Performance Assessment and Gap Analysis Report (pending)

14 Commission Implementing Regulation (EU) 2021/116 on the establishment of the Common Project One supporting the implementation of the European Air Traffic Management Master Plan / The Common Project 1 is managed by the SESAR Deployment Manager

15 2022 European Aviation Environmental Report, p. 95-96

CP1 places Europe at the forefront of progress on deploying the enablers of trajectory-based operations (TBO). At network level, the new flight plan format and basic services have already been deployed by the European network manager. At air traffic control (ATC) level, the air-ground data exchange has been revolutionised by the introduction of the Automatic Dependent Surveillance-Contract (ADS-C) downlink of the Flight Management System (FMS) predicted trajectory and the corresponding Controller Pilot Data Link Communications (CPDLC) processes.

At the same time, under the new Digital European Sky programme[16] and in close coordination with CINEA[17], early movers can receive financial support from the Connecting Europe Facility to demonstrate and deploy environmentally friendly solutions that go beyond the currently regulatory obligations to help shorten the innovation cycle in ATM.

In addition to facilitating an accelerated deployment of solutions, research groundwork has been laid for a range of new technologies addressing the environment, which will be taken forward in the Digital European Sky (see *What is on the horizon*).

There is further room for environmental benefits to be gained from the SESAR innovations that address airspace capacity[18]. When implemented, these solutions are expected to result in more efficient use of airspace, with a decrease in airborne re-routings and aircraft flying at suboptimal altitudes to avoid congested areas. These include technologies offering automated support to controller tasks in all phases of flight, or delegation of air traffic services to ensure the balance of traffic and available staff, among others.

DISCUSSION POINT

DO WE HAVE THE RIGHT METRICS TO FULLY MEASURE, MONITOR AND MANAGE ENVIRONMENTAL BENEFITS FROM ATM IMPROVEMENTS?

16 SESAR 3 JU multi-annual work programme, 2022
17 European Climate, Infrastructure and Environment Executive Agency
18 SESAR 3 JU estimates that if all the solutions delivered at the end of SESAR 2020 were deployed, they would enable a 60% increase in airspace capacity (SESAR 2020 and SESAR 1) to be confirmed by the Final SESAR 2020 Performance Assessment and Gap Analysis Report (pending).

3 WHAT IS ON THE **HORIZON**

ATM has an important role to play in making flying more sustainable and is an integral part of Europe's multimodal transport system[19]. Let's take a look behind the scenes of ATM and imagine how operations could be transformed by digital technologies, with the support of SESAR research and innovation.

Starting well before an aircraft takes off, at the network level, more data enriched flight plans could allow airspace users to **fully optimise the trajectory** during the execution of the flight, including the possibility to negotiate changes to the flight plan after the departure of the flight. At the same time, technologies will support a **dynamic configuration of the airspace**, balancing traffic loads while factoring in environmental needs.

With the introduction of alternative fuels and technologies, integrated data systems will provide information on fuel availability, infrastructure locations, and aircraft compatibility. In this future **data intensive ATM ecosystem**, environmental data will be updated continuously in real-time and made available to all actors to enable the continuous re-optimisation of flights.

At the airport, green taxiing solutions will cut ground emissions and improve air quality for passengers, staff and neighbouring communities. SESAR is supporting ongoing work to encourage large-scale uptake of these new taxi concepts in the short to medium term, building on progress made in the areas of surface management services and advanced collaborative decision-making at the airport.

All aspects affecting the environmental performance of the airport will be monitored by feeding data from the airlines, ground handlers and airport authorities into commonly shared dashboards[20]. This will enable transparency and efficient collaborative management of the environmental performance of airside and relevant landside operations.

Arrivals and departures will be managed using **AI-enabled systems**, which will generate traffic sequences that minimise the environmental impact, factoring in advanced metrics including weather, noise, air quality and emissions. As aircraft take off, routes connecting the runway to en-route airspace[21] will be dynamically generated and uplinked to the aircraft, incorporating flight-specific noise abatement procedures adapted to the specific meteorological and local time-sensitivity conditions (e.g. time of day, day of the week).

DISCUSSION POINT

IS THIS VISION INNOVATIVE ENOUGH?
IS IT COMPREHENSIVE?

En-route, aircraft will save energy by slipstreaming[22] each other in order to take advantage of the decreased wind resistance effect (e.g. wake energy retrieval). Advanced ATM digital tools will support controllers in monitoring the grouping and ungrouping, and ensure a fair and equitable system. It is estimated an aircraft flying in the wake of another aircraft can burn 5-10% less fuel.[23] Indeed, in November 2021 Airbus achieved a 5% gate-to-gate fuel saving for the follower.

19 COM/2020/789 Sustainable and Smart Mobility Strategy – putting European transport on track for the future / Potential of Formation Flight for Commercial Aviation: Three Case Studies / Thomas E. Kent and Arthur G. Richards / Journal of Aircraft 2021 58:2, 320-333.
20 The dashboards could include data, for example, from infrared sensors installed to track combustion engine activity on the airport surface, while air quality monitoring stations would record data on the airport surface and surrounding communities.
21 RNAV and RNP Standard Instrument Departures (SIDs) are instrument flight procedures that connect a runway to the en-route airspace. RNAV and RNP Standard Instrument Arrivals (STARs)
22 A current of air behind a quickly moving object
23 Potential of Formation Flight for Commercial Aviation: Three Case Studies / Thomas E. Kent and Arthur G. Richards / Journal of Aircraft 2021 58:2, 320-333. https://arc.aiaa.org/doi/abs/10.2514/1.C035954

In the future, improved understanding of the effects of non-CO_2 will allow better decision making on what measures to put in place to minimise the overall climate impact of flight. The differences in the non-CO_2 impact between fossil fuels and SAF and between different types of SAF will be factored into flight trajectory optimisation strategies.

Satellite technology will open up the possibility of reviewing vertical separation minima, increasing airspace capacity and hence permitting more flights to maintain their optimal cruising altitudes. Looking further ahead, a substantial transition from barometric to geometric altimetry could enhance compatibility between the management of unmanned vehicles (e.g. U-space), higher airspace operations and conventional aviation. Satellite technologies will **enhance further air-ground** communication, especially in remote or oceanic areas, increasing flight efficiency and with that deliver much-needed fuel efficiencies for long-haul journeys.

The skies of tomorrow will be more diverse with electric and hydrogen aircraft, large remotely piloted, unmanned and autonomous aircraft and high-altitude vehicles entering the mix of operations, in addition to the evolving needs of the military.

DISCUSSION POINT

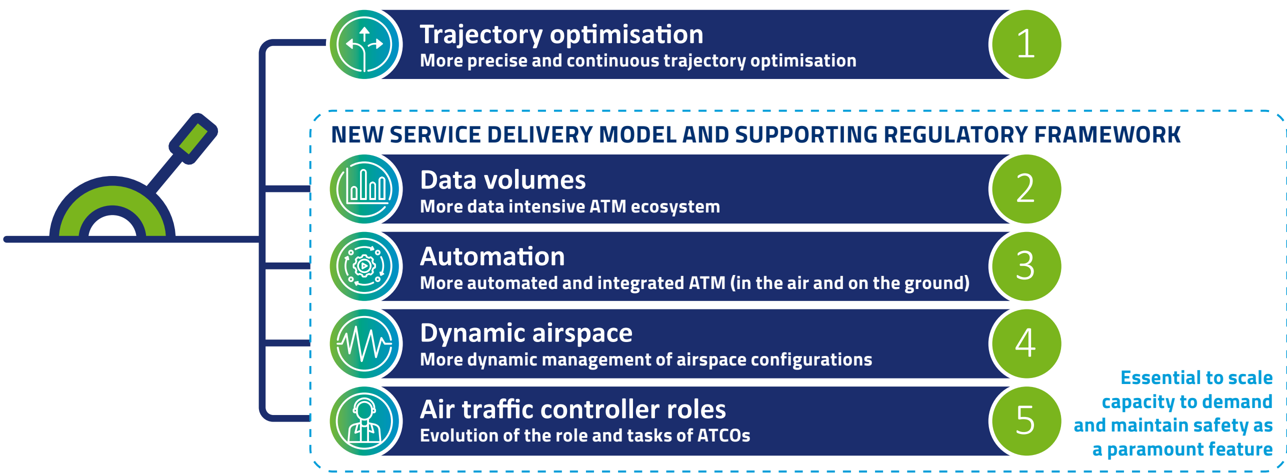
WHAT ARE THE KEY TRANSFORMATION LEVERS WE NEED TO FOCUS ON TO REALISE THIS FUTURE?

Guaranteeing a **more precise and continuous optimisation of trajectories** for this increasing volume and diversity of air vehicles will only be possible through the greater use of data and automation to process it, which in turn will necessitate an **evolution in the way airspace is managed and the role of the air traffic controller**.

Passengers will benefit from an integrated transport system, with multi-modal solutions offering them a seamless travel experience from door to door. This will require, for example, developing a common and collaboratively agreed intermodal operations plan, as well as real time information exchange services between different modes of transport.

Achieving this vision requires several transformational levers, as well as different tools, policy measures and the full collaboration of the various involved aviation stakeholders.[24]

5 KEY TRANSFORMATION LEVERS



24 Environmental Assessment: European ATM Network Fuel Inefficiency Study, 2022, EUROCONTROL

4 GETTING THE **CONVERSATION** STARTED

This paper does not seek to give any definitive answers, rather it presents the role of ATM and its possible contribution to climate neutrality and enabling Europe to become the most efficient and environmentally friendly sky to fly in the world.

A summary of the discussion points raised in the paper are as follows:

- **What is the role of ATM in addressing the climate impact of aviation?**
- **What does it mean in concrete terms to be the most efficient and environmentally friendly sky?**
- **Do we have the right ambition level for environmental performance in the European ATM Master Plan? Is 5-10% sufficient? What about other non-CO_2 impacts?**
- **We have solutions to reduce emissions available for implementation now. How can we speed up their implementation?**
- **Do we have the right metrics to fully measure, monitor and manage environmental benefits from ATM improvements?**
- **Is this vision innovative enough? Is it comprehensive?**
- **What are the key transformation levers we need to focus on to realise this future?**

These open questions will guide discussions during the campaign to update the European ATM Master Plan in the coming months. The campaign will bring together the views of all stakeholders to establish a comprehensive and common roadmap to make Europe the most efficient and environmentally friendly sky to fly in the world.

Visit the SESAR 3 JU website for regular updates about the European ATM Master Plan update:
www.sesarju.eu/masterplan

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