

# SESAR INNOVATION PIPELINE

*Air traffic management  
research & innovation  
2020 highlights*



EXPLORING THE  
BOUNDARIES OF  
ATM RESEARCH

DELIVERING  
SESAR  
SOLUTIONS

DEMONSTRATING  
SESAR  
SOLUTIONS

ENABLING  
SAFE AND  
SECURE  
INTEGRATION  
OF DRONES



## Horizon 2020

All the projects outlined in this publication were co-funded by the European Union.



Horizon 2020 research and innovation framework programme

© SESAR Joint Undertaking, 2021

Reproduction of text is authorised, provided the source is acknowledged.

For any use or reproduction of photos, illustrations or artworks, permission must be sought directly from the copyright holders.

More information on the European Union is available on the internet (<http://europa.eu>)

Luxembourg: Publications Office of the European Union, 2021

Print:

ISBN 978-92-9216-164-4

doi:10.2829/534711

catalogue number: MG-03-20-794-EN-C

PDF:

ISBN 978-92-9216-165-1

doi:10.2829/861551

catalogue number: MG-03-20-794-EN-N

Cover photo: © Avinor

Printed by the Publications Office of the European Union in Luxembourg

PRINTED ON WHITE CHLORINE-FREE PAPER

# TABLE OF CONTENTS

- 3 About SESAR Joint Undertaking
- 4 SESAR 2020 and the innovation pipeline
- 5 A 2020 snapshot of the programme
- 6 COVID-19 – A game changer for ATM?
- 7 Offering support in a time of crisis
- 7 Digital Sky Vodcasts focus on building back better
- 8 Preparing for the Digital European Sky

## 9 Exploring the boundaries of ATM research *SESAR exploratory research*

- 9 Ready, steady, go! New exploratory research projects get underway
- 19 Flying, the multimodal way!
- 20 Rain or shine? Improving weather forecasting in air traffic management
- 22 Preparing the ground for safe and efficient higher airspace operations in Europe
- 22 Publication highlights latest exploratory research results
- 23 SESAR Innovation Days showcases scientific excellence in air traffic management
- 24 2020 SESAR Young Scientist Award an “asset” for ATM

## 25 Delivering SESAR Solutions *Industrial research & validation*

- 25 New portfolio of SESAR industrial research launched
- 30 Aviation industry tests key solution to fly seamlessly and with more efficiency in Europe
- 31 AI powered tool to help monitor network performance
- 32 How innovation can support airport operations in a post-COVID world
- 34 World’s largest remote tower centre opens in Norway
- 35 Automating complex clearances in support of free-route airspace operations
- 36 Predicting conflict-free trajectories using supervised machine learning

## 37 Demonstrating SESAR *Very large-scale demonstrations*

- 37 Sustainability and resilience - focus of latest very large-scale demonstrations
- 41 Four-dimensional trajectory data: a pathway to decarbonisation
- 42 Ask the flight crew: how SESAR project keeps pilots in the loop in digital map design

## 44 Enabling the safe and secure integration of drones *U-space*

- 44 Report published with consolidated U-space research findings
- 45 New U-space research projects take off!
- 49 Taking safely to the skies
- 50 A universal approach to altitude measurement

## 51 Coming up in 2021

- 51 SESAR Digital Academy webinars
- 51 SESAR Solution Catalogue – 4<sup>th</sup> edition



Images: © freepik.com/macrovector; © freepik.com/stories

## PIONEERING DIGITAL TECHNOLOGIES



## BRINGING BENEFITS TO EUROPE'S ECONOMY AND CITIZENS



### About SESAR Joint Undertaking

SESAR is the technological pillar of the EU's Single European Sky policy and a key enabler of the EU Aviation Strategy. SESAR defines, develops and deploys technologies to transform air traffic management in Europe. The SESAR Joint Undertaking (SESAR JU) is the public-private partnership set up to define and deliver technological solutions to make this transformation a reality. It works with all actors in the aviation value chain to agree on the research and development priorities, as well as technology roll-out plans, which are documented in the European ATM Master Plan - a collaboratively-agreed roadmap for ATM modernisation.

Founded by the European Union and Eurocontrol, the SESAR JU has 19 members, who together with their partners and affiliate associations represent over 100 companies working in Europe and beyond. The SESAR JU also works closely with staff associations, regulators, airport operators, airspace users, the military and the scientific community.

# SESAR 2020 AND THE INNOVATION PIPELINE

**SESAR 2020 is a European research and innovation programme,** which aims to transform air traffic management into a more modular, scalable, automated, interoperable system that takes advantage of advances in digital and virtualisation technologies.

The programme builds on its predecessor, SESAR 1, to deliver high-performing operational and technological solutions for uptake by the aviation industry.

Guided by the European ATM Master Plan, SESAR 2020 focuses on developing solutions in several key areas:



**High-performing airport operations,** including total airport management, remote towers, runway throughput capabilities, navigation and routing tools, airport safety alerts for controller and pilots



**Advanced air traffic services,** including time-based separation and European wake vortex re-categorisation (RECAT-EU), better sequencing of traffic, automation support tools, integration of all vehicles



**Optimised network operations,** including dynamic collaborative tools to manage ATC airspace configuration (sectors), and civil-military collaboration for greater predictability and management of operations and airspace use



**Enabling infrastructure,** including CNS integration to facilitate economies of scale and seamless service delivery; and system-wide information management governance, architecture and technology solutions and services for information exchange

## U-space

**Drone integration,** covering technologies and service solutions to support complex drone operations with a high degree of automation in all types of airspace, including urban areas

*This brochure provides highlights of some of the SESAR research and development (R&D) activities that took place over the course of 2020 as well as what is coming in 2021.*

The research is categorised into three strands: exploratory research, industrial research and validation and very large-scale demonstrations. These strands have been designed as an innovation pipeline through which ideas are transformed into tangible solutions for industrialisation.

### EXPLORATORY RESEARCH

Explores new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods: The knowledge acquired can be transferred into the SESAR industrial and demonstration activities.

### INDUSTRIAL RESEARCH & VALIDATION

Assesses and validates technical and operational concepts in simulated and real operational environments according to a key performance area. This process transforms concepts into SESAR Solutions.

### VERY LARGE SCALE DEMONSTRATIONS

Test SESAR Solutions on a much larger scale and in real operations to prove their applicability and encourage the early take-up of solutions

# SESAR 2020 at a glance

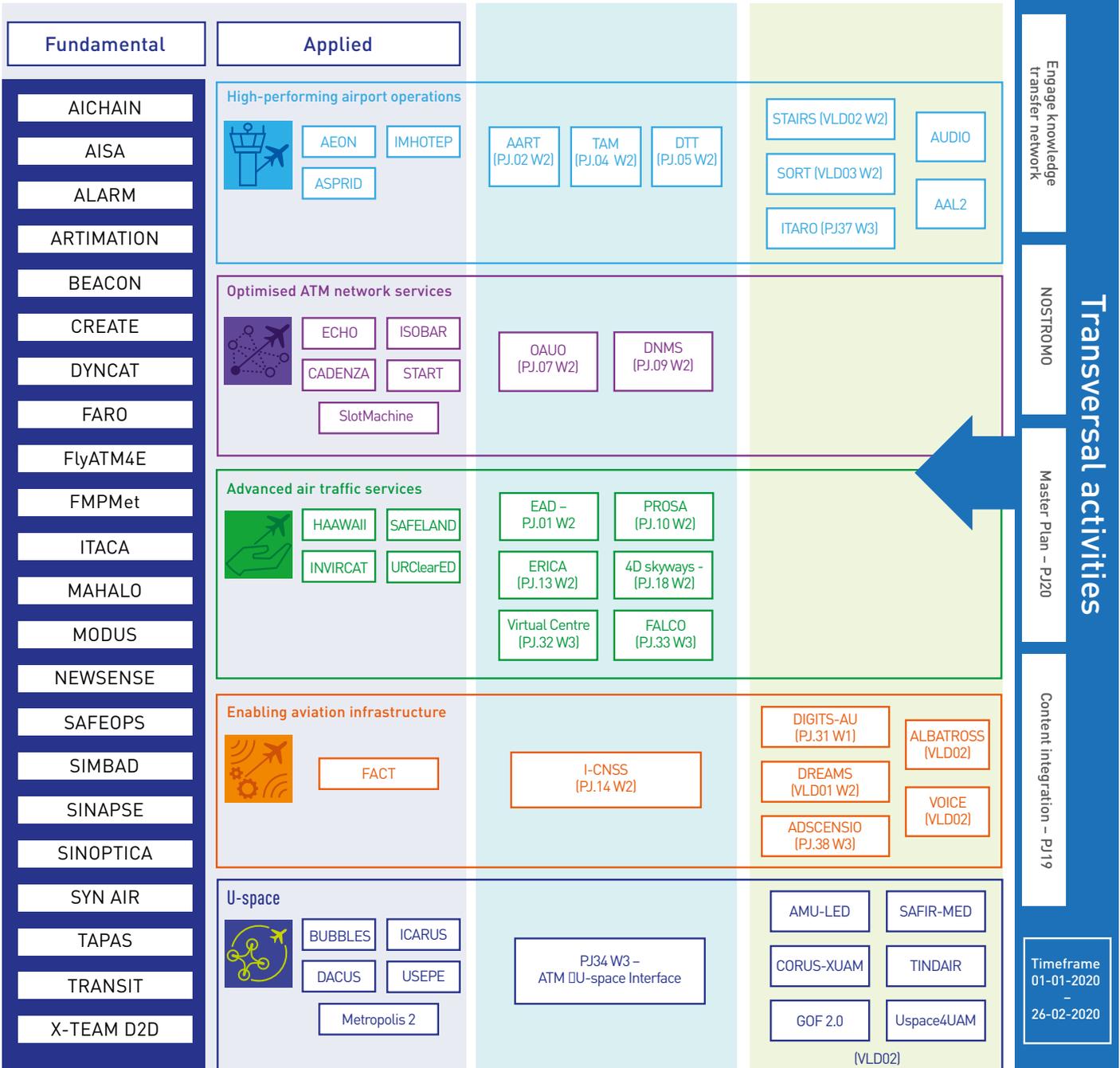
EXPLORATORY RESEARCH



INDUSTRIAL RESEARCH & VALIDATION



VERY LARGE SCALE DEMONSTRATIONS



Engage knowledge transfer network

NOSTROMO

Master Plan - PJ20

Content integration - PJ19

Timeframe 01-01-2020 - 26-02-2020

Transversal activities



## COVID-19 – A GAME CHANGER FOR ATM?

Since March 2020, the aviation community has been dealing with a crisis on scale never seen before. It has brought into focus the limitations of the ATM system, in terms of its ability to handle disruptions of this nature and to scale up or down its operations according to the traffic demand. While air navigation service providers (ANSPs) have managed to adapt their operations to meet the social distancing requirements while maintaining their

“ *The crisis is an opportunity to implement the solutions that have been proven will make ATM more resilient to disruptions, building in flexibility to shift capacity in line with demand, rather than managing demand to fit available capacity.* ”

service provision, the crisis is challenging the economic and operational viability of the underlying infrastructure to support more flexible ways of working and cope with varying levels of traffic in the long term.

The biggest sticking point is the traditional structure of ATM in Europe. Traditionally, ANSPs have worked vertically, with little interaction with neighbouring ANSPs other than at a tactical, operational level. To be resilient ATM needs to be less geographically specific. That calls for significantly more horizontal interaction between ANSPs and the Network Manager (NM). Going forward, the focus will need to be on flows and on trajectories, rather than sectors. That will require effective data transfer between stakeholders, and that in turn will require standards to allow seamless connectivity.

The crisis is an opportunity to implement the solutions (e.g. automation, virtualisation and trajectory-based operations) that have been proven will make ATM more resilient to disruptions, building in flexibility to shift capacity in line with demand, rather than managing demand to fit available capacity. Although published prior to the pandemic, the Airspace Architecture Study and the follow-up Transition Plan capture many of these solutions and offer a pathway to recovery in the short term, while also laying the foundations for a more far reaching transformation of ATM.

The issue is not technology, since the necessary solutions are already available. Rather, it is about introducing incentives to build horizontal connections; developing standards to facilitate horizontal communications; and redesigning sectors along trajectories and in accordance with traffic flows.

With the low levels of traffic in 2020, people have grown accustomed to clearer skies and less noise, and are calling on the aviation sector to reassert their commitment to

making flying more sustainable. Strong cooperation and investment in innovation will be needed over the next ten years if we want to meet the ambitions set out by the European Green Deal. That means redoubling efforts to improve the fuel efficiency of flights through optimised “greener” trajectories. It means as well focusing on network centrality, new ways of flying taking advantage of advances in avionics, and emission-free taxiing techniques.

### OFFERING SUPPORT IN A TIME OF CRISIS

Early on in the crisis, the SESAR JU, with the support of the European Commission, put in place a basket of measures to assist its members, many of whom are facing unprecedented economic challenges due to the coronavirus pandemic. In doing so, the measures helped also to preserve the overall scope and level of ambition of the SESAR research and innovation programme by providing much-needed breathing space to the aviation industry in the short term so that it can deal with the crisis while continuing to prepare for the future.

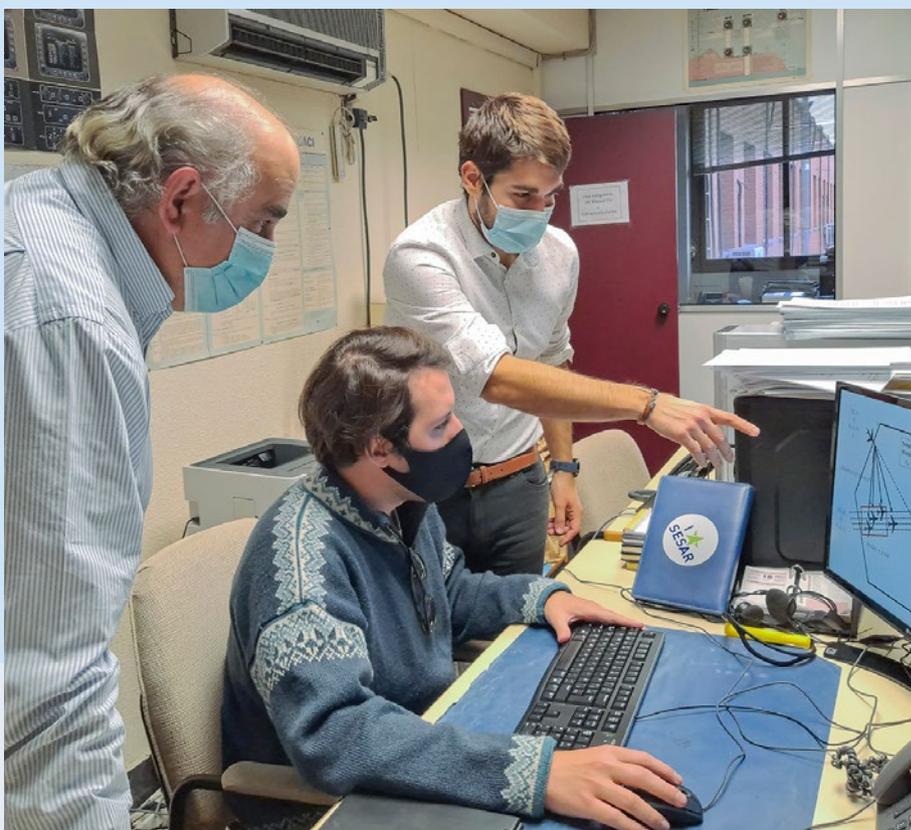
The measures included showing flexibility towards projects, many of which involve airlines and other operational stakeholders whose operations are severely curtailed at present. Deadlines have been extended for recently published open calls to allow additional preparation time for the ATM stakeholders to prepare their proposals. In addition, the SESAR JU injected additional budget into the programme and increase pre-financing support to members and beneficiaries. At the same time, it will limit members’ financial contributions for a period of time, facilitated by cutting the running costs of the SESAR JU to a strict minimum.

### DIGITAL SKY VODCASTS FOCUS ON BUILDING BACK BETTER



Over the course of 2020, the SESAR JU organised the Digital Sky Vodcasts, a series of live sessions with industry thought leaders to discuss the pandemic and how to build back better. Read the key takeaways from the discussions or watch the vodcasts again:

[www.sesarju.eu/vodcasts](http://www.sesarju.eu/vodcasts)



© AISA project



## Preparing for the Digital European Sky

In 2020, a draft Strategic Research and Innovation Agenda (SRIA) for the Digital European Sky was prepared. It details the research and innovation roadmaps to achieve the Digital European Sky including the integration of drones, matching the ambitions of the 'European Green Deal' and the 'Europe fit for the digital age' initiative.

The priorities 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.

Complementing the European ATM Master Plan 2020, the SRIA will serve as the basis for the work programme of the future ATM research partnership, within the framework of Horizon Europe - the next EU Research and Innovation Programme (2021-2027).

Over the course of 2020, preparations got underway to establish this future partnership, now called the SESAR 3 Joint Undertaking, a Joint Memorandum of Understanding for which was signed by 46 aviation industry stakeholders.

The future partnership will build on the success and momentum generated by its predecessor to deliver the Digital European Sky, making air transport smarter, more sustainable, resilient and accessible to all airspace users, including new entrants.

[www.sesarju.eu/sria](http://www.sesarju.eu/sria)



*Exploring the boundaries  
of ATM research:*

## **SESAR exploratory research**

**T**hrough its exploratory research, the SESAR JU looks beyond the current R&D and what is already identified in the European ATM Master Plan. The aim is to investigate new ideas, concepts, and technologies, but also challenge pre-conceived notions about air traffic management and the aviation value chain.

The SESAR exploratory research activities are overseen by a scientific committee, established in 2017, bringing together independent and highly-regarded academics from across Europe and the aviation research domain, as well as observers from the European Commission, Eurocontrol and the SESAR Programme Committee.

**Ready, steady, go!**  
**New Exploratory  
research projects  
get underway**

Artificial intelligence, intermodal transport and common altitude reference for drone operations are among the topics to be addressed by a portfolio of 41 new exploratory projects, launched in 2020.

Bringing together academia, research centres, SMEs and larger industry players from across Europe, the projects aim to foster new and innovative ideas on the digital transformation of air traffic management (ATM) in Europe.

The projects were selected based on the needs identified in the Aviation Strategy for Europe, the European ATM Master Plan, Flightpath 2050 - Europe's Vision for Aviation and the ACARE's Strategic Research and Innovation Agenda (SRIA). The projects will build on the results from current and previous SESAR research, relevant Horizon 2020 projects and other research activities.

**Ready, steady, go!**  
SESAR digital transformation projects get underway

Information  
Network  
U-space  
Automation  
Environment  
Artificial intelligence

founding members  
EUROPEAN UNION EUROCONTROL

Co-funded by the Horizon 2020 programme of the European Union

**SESAR**  
JOINT UNDERTAKING

The graphic features a central wireframe airplane silhouette against a blue background with a network of white dots and lines. The text is arranged in a clean, modern layout with various font weights and colors (white, blue, yellow) to highlight key elements.

## Spotlight on latest exploratory research projects



### AUTOMATION, ROBOTICS AND AUTONOMY

**ARTIMATION** – Transparent artificial intelligence and automation to air traffic management systems

ARTIMATION aims to investigate AI methods in predicting air transportation traffic and optimizing traffic flows based on explainable artificial intelligence (XAI) to address the challenge related to transparency of automated system in the ATM domain. ARTIMATION will provide a proof-of-concept of transparent AI models that includes visualisation, explanation and generalisation to ensure safe and reliable decision support.

Web: [www.sesarju.eu/projects/artimation](http://www.sesarju.eu/projects/artimation)

**AISA** - AI situational awareness foundation for advancing automation

To implement advanced automation, AI and human need to be able to share situational awareness. Therefore, AISA project is exploring the effect of, and opportunities for, distributed human-machine situational awareness in en-route ATC operations. The project is developing an intelligent situationally-aware system by combining machine learning with reasoning engine.

Web: [aisa-project.eu/](http://aisa-project.eu/)

**MAHALO** - Modern ATM via human/automation learning optimisation

To answer the question if automation should match human behaviour or be understandable to humans, MAHALO aims to develop an individually-tuned ML system to solve ATC conflicts and couple this to an enhanced en-route CD&R display. Insights will be used to define a framework to guide design of future AI systems.

Web: [mahaloproject.eu](http://mahaloproject.eu)

**TAPAS** -Towards an automated and explainable ATM system

TAPAS aims to explore highly automated AI-based scenarios through analysis and experimental activities applying explainable artificial intelligence (XAI) and visual analytics, in order to derive general principles of transparency which pave the way for the application of AI technologies in ATM environments, enabling higher levels of automation.

Web: <https://tapas-atm.eu/>



## COMPLEXITY, DATA SCIENCE AND INFORMATION MANAGEMENT

**AICHAIN** - A platform for privacy-preserving federated machine learning using block chain to enable operational Improvements in ATM

AICHAIN proposes an innovative digital information management concept combining federated machine learning (FedML) and blockchain technologies. This enables the cyber-secured exploitation of large private data sets by an privacy-preserving federated learning architecture in which neither the training data nor the training model need to be exposed.

Web: [www.aichain-h2020.eu/](http://www.aichain-h2020.eu/)



## ENVIRONMENT AND METEOROLOGY FOR ATM

**CREATE** - Innovative operations and climate and weather models to improve ATM resilience and reduce impacts

Air operations largely use weather information to make the air traffic flow safe, continuous and efficient. As climate changes are ongoing, available information on the weather on short and longer notice are increasing and technology is being improved. CREATE aims to achieve innovative procedures in ATM to reduce climate and environmental impact, while becoming more resilient to weather phenomena.

Web: <https://create-project.eu/>

**DYNCAT** - Dynamic configuration adjustment in the TMA

DYNCAT aims to enable more environmentally friendly and more predictable flight profiles in the TMA, namely on approach, by supporting the pilots in configuration management. The project will analyse the existing aircraft in operation and air traffic control procedures and propose improvements to on-board and ground procedures. The project will also identify the necessary technological and regulatory changes for improved airborne procedures and will assess the environmental potential of improved operations.

Web: [www.sesarju.eu/projects/DYNCAT](http://www.sesarju.eu/projects/DYNCAT)

**FlyATM4E** - Flying ATM for the benefit of environment and climate

FlyATM4E aims to expand approved climate-assessment methods and optimization of aircraft trajectories to identify promising mitigation options suitable to solve the task of reducing overall climate impact of aircraft operations. The project will assess the feasibility of a concept for environmental assessment of ATM operations working towards environmental optimisation of air traffic operations.

Web: [flyatm4e.eu/](http://flyatm4e.eu/)

**FMPMet** - Meteorological uncertainty management for flow management positions

FMPMet aims to integrate meteorological forecast uncertainty information into the decision-making process for flow management position (FMP). FMPMet aims to provide the FMP with an intuitive and interpretable probabilistic assessment of the impact of convective weather on the operations, up to 8 hours in advance.

Web: [fmp-met.com](http://fmp-met.com)

See page 20 for more about this project!

**SINOPTICA** - Satellite-borne and in-situ observations to predict the initiation of convection for ATM

SINOPTICA aims to explore the potential of assimilating remote sensing, GNSS-derived datasets and in situ weather stations data into very high-resolution, very short-range numerical weather forecasts to provide improved prediction of extreme weather events to the benefit of ATM operations.

Web: <http://sinoptica-project.eu/>

**ALARM** - Multi-hazard monitoring and early warning system

ALARM aims to develop a prototype global multi-hazard monitoring and early warning system (EWS). A global multi-hazard monitoring means near-real time and continuous global Earth observations from satellite, with the objective to generate prompt alerts of natural hazards affecting ATM and to provide information for enhancing situational awareness and providing resilience in crisis.

Web: [www.sesarju.eu/projects/ALARM](http://www.sesarju.eu/projects/ALARM)



## PERFORMANCE, ECONOMICS, LEGAL AND REGULATION

**FARO** - Safety and resilience guidelines for aviation

FARO aims to bring new insights about safety and resilience in ATM, with four objectives: to exploit existing safety knowledge, to quantify the impact of increasing automation on ATM safety, to analyse the impact of increasing automation on ATM resilience, and to provide design guidelines and identify future research needs.

Web: [faro-h2020.eu/](http://faro-h2020.eu/)

**BEACON** - Behavioural economics for ATM concepts

BEACON aims to study the feasibility of extending user-driven prioritisation process (UDPP) to allow multi-prioritisation processes in the airspace and exchange of slots between airlines. It will build two models: a strategic model and a detailed tactical simulator. To properly capture the agents' behaviours, BEACON will make use of behavioural economics.

Web: [www.sesarju.eu/projects/beacon](http://www.sesarju.eu/projects/beacon)

**ITACA** - Incentivising technology adoption for accelerating change in ATM

ITACA aims to accelerate the development, adoption and deployment of new technologies in ATM. ITACA will develop a new set of methodologies and tools enabling the rigorous and comprehensive assessment of policies and regulations aimed at amplifying the uptake of new technologies within ATM.

Web: <https://www.itaca-h2020.eu/>

**SafeOPS** - From prediction to decision support - strengthening safe and scalable ATM services through automated risk analytics based on operational data from aviation stakeholders

Maintaining safety and cost-efficiency of air transport operations while increasing the capacity will push the next generation of ATM systems towards digitalisation. In the mid-term, a digitalised system in the human operated ATM environment will be capable of delivering reliable predictive analytics based on automated information processing. SafeOPS aims to support these future services by investigating the use of big data analytics together with new risk assessment methodologies.

Web: [www.sesarju.eu/projects/SafeOPS](http://www.sesarju.eu/projects/SafeOPS)

**SIMBAD** - Combining simulation models and big data analytics for ATM performance analysis

SIMBAD aims to develop and evaluate a set of machine learning approaches aimed at providing state-of-the-art ATM microsimulation models with the level of reliability, tractability and interpretability required to effectively support performance evaluation at ECAC level. The project will demonstrate and evaluate the newly developed methods and tools through a set of case studies.

Web: [www.sesarju.eu/projects/SIMBAD](http://www.sesarju.eu/projects/SIMBAD)



## INTERMODALITY

**Modus** - Modelling and assessing the role of air transport in an integrated, intermodal transport system

Modus analyses the performance of the overall transport system by considering the entire door-to-door journey holistically. The project identifies (future) drivers for passenger demand and supply and assesses the impact on airside and landside processes and capacities. Based on these analyses, potential solutions to meet high-level European transport objectives are proposed.

Web: [modus-project.eu/](http://modus-project.eu/)

See page 19 for more about this project!

**TRANSIT** - Travel Information management for seamless intermodal transport

TRANSIT aims to develop a set of multimodal key performance indicators (KPIs), mobility data analysis methods and transport simulation tools, allowing the evaluation of the impact of innovative intermodal transport solutions on the quality, efficiency and resilience of the door-to-door passenger journey.

Web: [www.transit-h2020.eu/](http://www.transit-h2020.eu/)

**X-TEAM D2D** - Extended ATM for door2door travel

X-TEAM D2D aims to define, develop and initially validate a concept of operations for the seamless integration of ATM and air transport into an overall intermodal network, including other available transportation means (surface, water), to enable the door-to-door connectivity, in up to 4 hours, between any location in Europe.

Web: [xteamd2d.eu/](http://xteamd2d.eu/)

**SYN+AIR** - Synergies between transport modes and air transportation

SYN+AIR aims to generate common goals for transport service providers, which will justify data sharing while facilitating the user to execute a seamless D2D journey. SYN+AIR will generate customer door-to-door journeys and will analyse how those journeys can be facilitated through improved planning and operations activities powered by data sharing.

[www.sesarju.eu/projects/synair](http://www.sesarju.eu/projects/synair)



## CNS FOR ATM

**NewSense** - Evaluation of 5G network and mmwave radar sensors to enhance surveillance of the airport surface

NewSense aims to improve safety and efficiency of operations primarily in secondary airports with innovative low-cost surface surveillance solutions, based on 5G cellular networks for the long term, and msafmWave radar for the medium term, allowing the implementation of affordable advanced-surface movement guidance and control systems (A-SMGCS).

Web: [www.sesarju.eu/projects/NewSense](http://www.sesarju.eu/projects/NewSense)

**SINAPSE** - Software defined networking architecture augmented with artificial intelligence to improve aeronautical communications performance, security and efficiency

SINAPSE aims to propose an intelligent and secured aeronautical datalink communications network architecture design, based on the software defined networking (SDN) architecture model augmented with artificial intelligence (AI) to predict and prevent safety services outages, to optimise available network resources and to implement cybersecurity functions protecting the network against digital attacks.

Web: [5.196.117.230/sinapse/](http://5.196.117.230/sinapse/)



## HIGH-PERFORMING AIRPORT OPERATIONS

**AEON** - Advanced Engine Off Navigation

AEON aims at defining a concept of operations focusing on engine-off taxiing techniques, and a set of dedicated tools to support the operators. The project defines how to determine, in real time, efficient and conflict-free routing plans for autonomous and non-autonomous aircraft taxiing from gates to the corresponding runways and the other way around.

Web: [www.sesarju.eu/projects/AEON](http://www.sesarju.eu/projects/AEON)

**ASPRID** - Airport system protection from intruding drones

ASPRID aims to develop a service-oriented operational concept and system architecture to protect airport operations from unwanted drones. To do so, the project will analyse aircraft and airport (runway and ground) operations to pinpoint possible vulnerabilities. With this, the project aims to identify possible technologies, procedures and regulations that could help better safeguard against drone incursions and/or can help them recover from any disruptions as quickly and as efficiently as possible. In doing so, the project proposes a more integrated and coordinated approach to handling drone incursions.

Web: [www.sesarju.eu/projects/ASPRID](http://www.sesarju.eu/projects/ASPRID)

**IMHOTEP** - Integrated multimodal airport operations for efficient passenger flow management

IMHOTEP aims to develop a concept of operations and a set of data analysis methods, predictive models and decision support tools that allow information sharing, common situational awareness and real-time collaborative decision-making between airports and ground transport stakeholders.

Web: [www.imhotep-h2020.eu/](http://www.imhotep-h2020.eu/)



## ADVANCED AIR TRAFFIC SERVICES

**HAAWAII** - Highly automated air traffic controller workstations with artificial intelligence integration

HAAWAII aims to research and develop a reliable, error resilient and adaptable solution to automatically transcribe voice commands issued by both air-traffic controllers and pilots, and to perform proof-of-concept trials in challenging environments. Also, the objectively estimated controllers' workload utilising digitised voice recordings of the complex London TMA will be assessed.

Web: [www.hawaii.de](http://www.hawaii.de)



## OPTIMISED ATM NETWORK SERVICES

**CADENZA** - Advanced capacity and demand management for European network performance optimisation

CADENZA aims to develop a detailed trajectory broker concept for the European network, incorporating advanced demand-capacity balancing mechanisms. The trajectory broker will balance capacity and demand through a coordinated capacity provision process and collaborative trajectory management (including a novel trajectory charging scheme). Significant improvements in cost-efficiency and delay are expected.

Web: <https://cadenza-project.eu/>

**ECHO** - European concept of operations for higher airspace operations

ECHO aims to deliver a comprehensive demand analysis and innovative and feasible concept of operations enabling near term and future higher airspace operations in a safe and orderly manner. The higher airspace including the operators forms a new, almost legacy free environment enabling an expeditions uptake of innovations or extrapolated SESAR solutions.

Web: <https://higherairspace.eu/>

**ISOBAR** - Artificial intelligence solutions to meteo-based DCB imbalances for network operations planning

ISOBAR aims at the provision of a service- and AI-based network operations plan, by integrating enhanced convective weather forecasts for predicting imbalances between capacity and demand and exploiting AI to select mitigation measures at local and network level in a collaborative ATFCM operations paradigm.

Web: [isobar-project.eu/](https://isobar-project.eu/)

**START** - A stable and resilient ATM by integrating robust airline operations into the network

START aims to develop, implement, and validate optimisation algorithms for robust airline operations that result in stable and resilient ATM performance even in disturbed scenarios. The main focus of the project is the optimisation of conventional traffic situations while considering disruptive weather events such as thunderstorms.

Web: [start-atm.com](https://start-atm.com)



## ENABLING AVIATION INFRASTRUCTURE

**FACT** - Future all aviation CNS technology

FACT aims to increase safety, security, efficiency, and robustness of future air traffic environment through development of integrated CNS functional architecture supporting the use of common performance based approach, addressing needs of large spectrum of airspace users across varied operational environments.

Web: [www.sesarju.eu/projects/FACT](http://www.sesarju.eu/projects/FACT)



## ATM OPERATIONS, ARCHITECTURE, PERFORMANCE AND VALIDATIONS

**NOSTROMO** - Next-generation open-source tools for ATM performance modelling and optimisation

The ATM system is composed of elements that interact with each other generating a number of properties characteristic of complex adaptive systems. NOSTROMO aims to develop new approaches to ATM performance modelling able to reconcile model transparency, computational tractability and ease of use with the necessary sophistication required for a realistic representation of the ATM system.

Web: [www.sesarju.eu/projects/NOSTROMO](http://www.sesarju.eu/projects/NOSTROMO)

**SlotMachine** - A privacy-preserving marketplace for slot management

Until now, ATFM slots have only been subject to intra-airline swaps, used by airlines to prioritize expensive flights and thus minimise overall costs. Airlines want to keep the cost structure of their flights confidential, as they fear a competitive disadvantage when disclosed. This desire for confidentiality has hampered slot swapping between different airlines. SlotMachine aims to employ blockchain technology and secure multi-party computation to extend the existing UDPP solution with the possibility to keep private the participating airlines' confidential information, such as the cost structure of flights.

Web: [www.sesarju.eu/projects/SlotMachine](http://www.sesarju.eu/projects/SlotMachine)



## RPAS

**INVIRCAT** - IFR RPAS control in airports and TMA

INVIRCAT aims to create a concept of operations for remotely piloted aircraft systems in the terminal manoeuvring area of airports, assessing it through simulations and draft a set of recommendations for rulemakers and standardisation bodies.

Web: [www.invircat.eu/](http://www.invircat.eu/)

**SAFELAND** – Safe landing through enhanced ground support

SAFELAND aims to support flight and landing of aircraft operated by a single pilot, in case of partial or total incapacitation of the pilot. SAFELAND will focus on the ground side, specifically on the role ATM could have in managing the transition from a single pilot operated flight to a status with reduced or absent contribution of the onboard pilot to landing.

Web: [www.sesarju.eu/projects/SAFELAND](http://www.sesarju.eu/projects/SAFELAND)

**URClearED** - A unified integrated remain well clear concept in airspace D-G class

URClearED aims to support current study activities on the RWC functionalities by defining and analysing operational scenarios, which allow to assess requirements and assumptions made in current standards and applicable documents, and then paving the way to future industrial level activities on such system.

Web: [www.sesarju.eu/projects/URClearED](http://www.sesarju.eu/projects/URClearED)



## DRONES

See page 46 for more details of the projects that kickstarted in 2020

## Flying, the multimodal way!

Planes, trains and automobiles, not to mention micro-mobility options like bikes and scooters. Would-be travellers have never had so many mobility options to choose from for getting from A to B. But what combination of these offers the quickest, most affordable, reliable and greenest option for getting from door to door, especially for journeys that involve air travel? That's the challenge that researchers in the Modus project will seek to address, as Annika Paul, Modus coordinator from Bauhaus Luftfahrt, explains.

Intermodality is a top priority in high-level European transport agendas, such as [Flightpath 2050](#) with the stated goal of enabling 90% of citizens to reach any place in Europe within 4 hours door to door by 2050, for journeys including an air segment. Air transport is therefore an important contributing mode to reaching this vision. The challenge is understanding the competition and the complementarity between different transport modes, addressing capacity shortages in the respective modes, while also meeting passengers' increasing demand for mobility choices that are smarter and greener.

“ **Intermodality is a top priority in high-level European transport agendas, such as [Flightpath 2050](#) with the stated goal of enabling 90% of citizens to reach any place in Europe within 4 hours door to door by 2050, for journeys including an air segment.** ”

Modus aims to provide important insights into the passenger experience by significantly improving the knowledge of travellers' preferences and expectations, and on how different factors influence the demand for air and rail transport. This includes the detailed analysis of passengers' preferences with regard to a modal choice, going beyond the mere travel time and price parameters, and taking into account aspects such as



© Modus

environmental considerations, or comfort during the journey.

The aim is to develop a holistic modelling approach that covers the door-to-door travel and illustrates the impact on (air) transport capacity - in particular at airports - and passenger flows. For this purpose, the Modus consortium plans to make use of various data sources to model the interaction between different transport modes including, for example, Eurostat database, World Bank database, or national statistical databases providing transport statistics, drawing on the consortium's experience in other EU-projects, such as DATASET2050 or Domino.



© Shutterstock

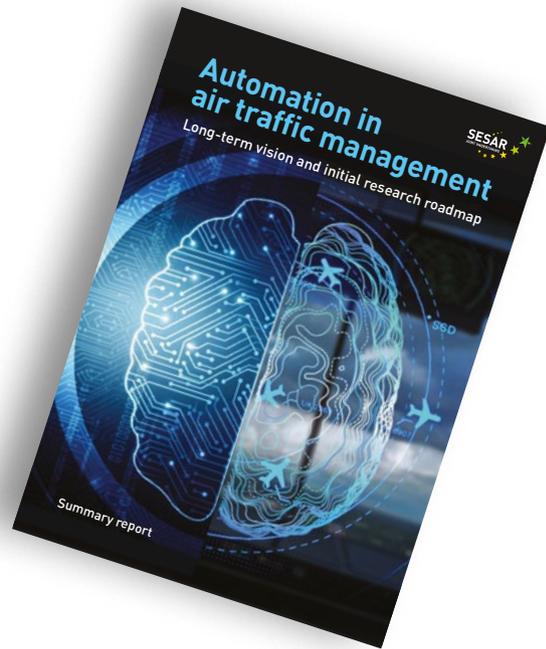
Web: [www.sesarju.eu/projects/MODUS](http://www.sesarju.eu/projects/MODUS)

*The Modus project has received funding from the European Union's Horizon 2020 SESAR research and innovation programme on the topic SESAR-ER4-10-2019 ATM Role in Intermodal Transport under grant agreement No. 891166 with a 998.875 Euros grant amount.*

## Long term vision and initial research roadmap

Higher levels of automation supporting air traffic controllers controller workload and stress is key for a future-proofed ATM system. Published in 2020, this brochure provides a long-term vision and research roadmap for automation in ATM, as a basis for the definition and coordination of future research activities.

Web: [www.sesarju.eu/automation](http://www.sesarju.eu/automation)



## Rain or shine? Improving weather forecasting in air traffic management

© FMP-MET



“ *... poor meteorological conditions is the cause of an estimated 20 % of all traffic delays in Europe ...* ”

Bad weather can play havoc with the best-laid plans. This is especially true in air traffic management, where poor meteorological conditions are the cause of an estimated 20 % of all traffic delays in Europe. Predicting the weather relies on timely and accurate forecasts, which is easier said than done given how quickly the conditions can evolve. A newly-launched SESAR project, FMP-MET will look at how to better predict and assess the impact of the weather on air traffic operations, as Alfonso Valenzuela, one of the principal researchers in the project explains in this interview.

### How does weather currently impact the planning and management of flights? How easy is it to predict the impact of this weather on operations?

Adverse weather has a significant impact on air traffic. It is estimated that poor meteorological conditions en-route are responsible for about 4 million minutes of delay every year in Europe. Delays come about because bad weather makes air traffic difficult to predict and complex to manage, resulting in reduced airspace capacity. It is quite challenging, mainly because forecasting adverse weather is very difficult, even for short lead times. Furthermore, the accuracy of the weather prediction rapidly degrades with the forecasting horizon. Quantifying the weather forecast uncertainty is the main difficulty, and its analysis requires a probabilistic approach.

### How much in advance are weather forecasts currently integrated into the system?

Every air traffic control centre has a flow management position (FMP), the job of which includes the mitigation of bad weather effects. The flow manager consults several meteorological

“ *Delays come about because bad weather makes air traffic difficult to predict and complex to manage, resulting in reduced airspace capacity.* ”

© FMP-MET



forecasts daily to build a picture of the weather phenomena; based on this data and their own judgement of the situation, they estimate the impact on traffic and their specific sector of the airspace. However, these forecast estimations often lack sufficient accuracy due to the stochastic or random evolution of the atmosphere, which makes predicting the real impact of a thunderstorm, for example, very challenging.

#### **How does FMP-Met project aim to address the challenges associated with forecasting?**

We plan to utilise ‘Ensemble Weather Forecasting’, a technique that provides an ensemble of deterministic forecasts (referred to as members of the ensemble), so that the output is a representative sample of the possible weather realisations. The spread given by all the ensemble members allows to quantify the forecast uncertainty. We will use different ensemble forecasts (the best available at each time and location), with different time and spatial scales, which will be combined seamlessly to provide a single probabilistic prediction of the air traffic.

#### **Is this first time such research has been done? Or are you building on previous research?**

The integration of weather uncertainty into the air traffic management is an active field of research. FMP-Met is a direct continuation of two SESAR projects: [TBO-Met](#), where we provided a probabilistic analysis of the impact of weather on trajectory optimisation and sector demand, and [PSA-Met](#), where we addressed the problem of probabilistic storm avoidance.

#### **How do you hope the results of your project will be used?**

The aim is to develop a concept to assess the impact of convective weather on traffic flow management (TFM) using probabilistic weather forecasts. We will provide probabilistic predictions of sector demand, complexity and capacity reduction, and will also provide guidelines for their use and visualisation. The ultimate goal is that, at each control centre, the FMP have a tool to predict the impact of severe weather on the air traffic.

#### **What benefits do you hope your project will bring?**

Early warnings of capacity reduction and sector congestion due to convective weather will allow for better-informed decision making in TFM, and this, in turn, will improve the effectiveness of the actions taken by the FMP. Consequently, we expect that the methodologies developed in this project will help to reduce the weather-dependent delays, reducing air traffic costs and improving the passenger trip experience.

Web: [www.sesarju.eu/projects/FMPMET](http://www.sesarju.eu/projects/FMPMET)

*This project has received funding from the SESAR Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 885919*

## Preparing the ground for safe and efficient higher airspace operations in Europe

In 2020, SESAR partners started work on a comprehensive demand analysis and concept of operations for higher airspace, with the objective of allowing safe, efficient and scalable operations above the flight levels where conventional air traffic operates.

New airspace users and operations are increasingly emerging in this higher airspace. There is a broad diversity of vehicles, ranging from unmanned balloons, airships and solar planes capable of persistent flight, collectively known as high-altitude platform systems (HAPS) to supersonic and hypersonic aircraft, and trans-atmospheric and suborbital vehicles. Commercial and State space operations are also transiting through the higher airspace for launches and re-entries.

“Higher airspace operations represent a unique opportunity for innovation and the ECHO project will help unleash the great potential of this new frontier for flight. I am delighted to be in charge of the coordination in the ECHO consortium, which comprises the leading European



© Airbus

industry, organisations, institutes and research centres dealing with higher airspace operations”, says Henk Hof, EUROCONTROL, ECHO project manager.

The European concept for higher airspace operations (ECHO) project’s work on the future definition of a European concept of operations for higher airspace will feed into the ICAO global framework, ensuring a global harmonised approach for higher airspace operations. It will also constitute the foundation and the starting point for

the development of the future European higher airspace operation regulatory framework by the European Union Aviation Safety Agency (EASA).

<https://higherairspace.eu/>

*This project has received funding from the SESAR Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 892928*



## Publication highlights latest exploratory research results

In 2020, the SESAR JU published the results of some 36 completed exploratory projects (1). Taking place between 2016–2019, the projects brought together over 100 academic and industry partners, such as universities, SMEs, research centres, airlines, manufacturers, air navigation service providers from across the European

Union and EU Associated Countries. The projects explored innovations and technologies coming not just from aviation and air traffic management, but also other sectors, such as automotive, robotics or system engineering, as well as in other safety critical industries, such as nuclear, space, etc. The most promising and mature technologies are continuously considered for inclusion in the industrial research strand of the SESAR programme.

[www.sesarju.eu/exploratoryresearch](http://www.sesarju.eu/exploratoryresearch)

(1) SESAR-ER3-01-2016



## SESAR Innovation Days showcases scientific excellence in air traffic management

The 10<sup>th</sup> SESAR Innovation Days (SIDs) took place on 7-10 December 2020 as a virtual conference, gathering over 1000 participants for 4 days of keynotes, technical paper sessions and a virtual poster exhibition showcasing some of the breakthrough concepts from the SESAR JU's exploratory research portfolio, as well as novel research from the broader ATM research community.

Celebrating its tenth anniversary, the research presented reflects Europe's vision to make its airspace the most efficient and environmentally friendly sky to fly in the world, and will contribute to the long-term sustainability of the aviation industry and its recovery from the COVID crisis. This was the message delivered by keynote speakers throughout the conference.

*"The crisis has severely hit Europe's aviation industry, jeopardising millions of jobs and livelihoods. We do what is necessary to get the industry back on its feet as quickly as possible, but we must do it in a way that supports a sustainable and smart recovery, as well as strengthens the resilience of the sector,"*

says Henrik Hololei, Director General of the Directorate General for Transport and Mobility (DG MOVE), European Commission, and Chair of the SESAR JU Administrative Board. *"We also need to think long-term by investing in innovation and research to allow us to go towards technologies that will give us a global competitive edge."*

*"If the COVID19 crisis has shown us anything, it is that we can only deal with challenges if we innovate, think out of the box, take a risk and dream big,"* said Eamonn Brennan, Director General, EUROCONTROL, and Vice-Chair of the SESAR JU Administrative Board. *"The crisis of this past year gives us even more reason to look for innovative concepts and solutions to drive the digital transformation that will ensure we can build back better with a sustainable, resilient, and scalable ATM industry able to deliver the services needed for 21<sup>st</sup> century aviation."*

*"The pandemic has highlighted the urgent need to move ahead with the digital transformation of air traffic management in Europe, to build greater resilience, scalability and sustainability into the system,"* said Florian Guillermet, Executive Director of the SESAR Joint Undertaking. *"This not only requires stakeholders to implement the new technologies that are already available, but also to continue to invest in the innovative concepts of the future. For*

**“ We need to think long-term by investing in innovation and research to allow us to go towards technologies that will give us a global competitive edge. ”**

*this, the continuing engagement of the ATM research community is essential, harnessing the young talent and collaborations that we see every year at the SESAR Innovation Days. We have a chance to build back better – let's take it!"*

For its 10<sup>th</sup> edition, the SIDs joined forces with two other major aviation events: the ICAO Global Symposium on the Implementation of Innovation in Aviation and ATCA's Annual Conference to host a joint panel on higher airspace operations – a new frontier for aviation.

[www.sesarju.eu/sesarinnovationdays](http://www.sesarju.eu/sesarinnovationdays)



## 2020 SESAR YOUNG SCIENTIST AWARD AN “ASSET” FOR ATM

Europe’s most promising young minds in ATM research were celebrated at the SESAR Young Scientist Award ceremony, which took place during the closing plenary of the SESAR Innovation Days virtual conference on 10 December.

Awarded annually, the prize aims to recognise young scientists, who have demonstrated excellence in ATM and aviation-related research fields. The award also provides researchers starting out in their career with an opportunity for further professional development. A further objective of the award is to showcase the potential of young talent to formulate fresh ideas and solutions to the challenges facing ATM and aviation.

**“The fresh thinking that Christian brings to his research and the collaborative spirit he demonstrates through his participation in numerous SESAR projects, makes him an asset for the ATM community”**

*Florian Guillermet,  
Executive Director of the  
SESAR Joint Undertaking*

The award was presented during a virtual ceremony, presided over by Dr.-Ing. Peter Hecker, Chair of the SESAR Young Scientist jury/evaluation, and featured presentations from all three short-listed scientists.

In third place, Eulalia Hernández Romero, Universidad de Sevilla was recognised for her research into how available meteorology data can be better integrated into conflict detection and resolution processes – the jury commended the research for trying to solve a very realistic, everyday problem.

Alvaro Rodriguez Sanz, Universidad Politécnica de Madrid (UPM), was awarded the second place for his thesis work on uncertainty management and performance optimisation in airport operations using probabilistic reasoning and reinforcement learning techniques, which the jury described as innovative, scientifically sound and convincing.

Finally, the top award went to Christian Eduardo Verdonk Gallego, CRIDA, for his research into data-driven trajectory prediction. While the basic concept of trajectory prediction has been extensively studied, the jury commended Verdonk Gallego for adopting state-of-the-art approach, broadening the scope of data and operational factors that impact the trajectory and looking at the wider air transport system.

*“I want to congratulate all the applicants, short-listed candidates, and Christian Gallego, our overall winner. The fresh thinking that Christian brings to his research and the collaborative spirit he demonstrates through his participation in numerous SESAR projects, makes him an asset for the ATM community,”* said Florian Guillermet, Executive Director of the SESAR Joint Undertaking. *“Seeing the talent displayed during this year’s SESAR Innovation Days, I am confident that we can deliver innovative solutions to build a smart and sustainable aviation for generations to come!”*

# Delivering SESAR Solutions

*Industrial research & validation*

**S**ESAR Solutions refer to new or improved operational procedures or technologies that aim to contribute to the modernisation of the European and global ATM system.

To deliver solutions ready for pre-industrialisation, the SESAR JU and its members have built a process, known as the release process, whereby solutions are tested or validated in real operational environments, including direct airport interfaces. The solutions are validated according to key performance areas such as safety, cost and operational efficiency, capacity and the environment.

## **New portfolio of SESAR industrial research launched**

In early 2020, the SESAR JU and its members started a second wave of industrial research projects, aimed at delivering more digital solutions to transform Europe's air traffic management.

The projects take forward the results from the first wave of research, focusing on solutions that can bring the most benefits in terms of the environment, capacity, safety and cost efficiency. The end of 2020 saw the launch of two further projects, focusing on taking forward two key components of the future system, the virtual centre and LDACs.

Below are short descriptions of the second and third wave of industrial research projects, followed by highlights including recently closed wave 1 projects and the implementation of solutions as a result of SESAR research and innovation.



© SESAR Joint Undertaking



**NEW!**

**AART** - Airport airside and runway throughput

(PJ.02 W2)

To improve the efficiency and resilience of arrival and departure operations at capacity constrained airports and access to secondary airports, the project addresses human, technical, procedural and performance aspects of the following proposed solutions: advanced geometric GNSS based procedures; separation minima for increased runway throughput; improved access to secondary; digital evolution of integrated surface management; and safety support tools for avoiding runway excursions.

Web: [www.sesarju.eu/projects/aart](http://www.sesarju.eu/projects/aart)



**NEW!**

**TAM** - Total airport management

(PJ.04 W2)

European airports need become more operationally efficient. To this end, the project is developing concepts, tools and procedures to increase the predictability and resilience of airport operations, improving the punctuality of flights in a safe and environmentally sustainable manner. The aim is to improve airport/network integration for large and medium/regional airports, improve airport airside/landside integration, and reduce the impact of MET aspects on airport operations. The project is also investigating how environmental aspects can be better monitored and managed in day-to-day airport operations.

Web: [www.sesarju.eu/projects/TAM2](http://www.sesarju.eu/projects/TAM2)



**NEW!**

**DTT** - Digital technology for tower

(PJ.05 W2)

The project aims to deliver two solutions: multiple remote tower and remote tower centre and human machine interaction (HMI) modes for airport tower. Those solutions are expected to positively contribute to safety and increase situation awareness and controllers' productivity. The variety of partners and validation activities will ensure that the variety of operational needs are reflected in technical solutions.

Web: [www.sesarju.eu/projects/DTT](http://www.sesarju.eu/projects/DTT)

**TRANSVERSAL PROJECT**

Content integration, performance management and business case development

(PJ.19 W2 CI)

This project assesses the performance of the SESAR Solutions compared with the performance ambitions set out in the European ATM Master Plan. This is done in close collaboration and coordination with all SESAR 2020 projects through a continuous, rolling and iterative content integration process.

**TRANSVERSAL PROJECT**

Master planning

(PJ.20 W2 AMPLE)

The project brings together the SESAR community, ensuring the broad ATM representativeness required from air navigation service providers, airports, airborne and ground industry and Network Manager, in order to maintain the European ATM Master Plan, the roadmap on ATM modernisation.

**NEW!**

**EAD** - Enhanced arrivals and departures

(PJ.01 - W2)

The project is developing concepts, tools and procedures to optimise terminal manoeuvring areas (TMAs) in a safe, cost-efficient and environmentally sustainable manner. This will be achieved by taking advantage of the latest technological developments from both an airborne and a ground-system perspective and through the secure sharing of data. The needs of all airspace users are being addressed including rotorcraft. The aim is to exploit the environmental benefits achieved from continuous climb operations (CCO), continuous descent operations (CDO) and improved arrival sequencing. A focus is to minimise delays and improve resilience and predictability for high-density/complex TMAs.

Web: [www.sesarju.eu/projects/EAD](http://www.sesarju.eu/projects/EAD)

**NEW!**

**PROSA** - Separation management and controller tools (PJ.10 W2)

The project is validating a series of separation management and controller tools aimed at boosting the performance of the air traffic system across all key areas. The project will focus on three solutions: flight-centric ATC and improved distribution of separation; delegation of airspace amongst air traffic service units (ATSU); HMI interaction modes for ATC centres.

Web: [www.sesarju.eu/projects/PROSA2](http://www.sesarju.eu/projects/PROSA2)

**NEW!**

**ERICA** - Enable RPAS insertion in controlled airspace

(PJ.13 W2)

The project is developing and validating the key operational and technological enablers that are necessary to ensure the integration of remotely-piloted aircraft systems (RPAS) into non-segregated airspace. These include a detect and avoid (DAA) system for IFR RPAS operating in airspace A to C for collision avoidance and a framework for allowing routine access and operations by RPAS.

Web: [www.sesarju.eu/projects/ERICA](http://www.sesarju.eu/projects/ERICA)

**NEW!**

**4D Skyways** - Improving trajectory management for European air transport

(PJ.18 W2)

The project builds on research outcomes on trajectory management to enable a move towards trajectory-based operations (TBO). The focus is now on improving the ground trajectory prediction and separation management/ monitoring tools by using aircraft trajectory data, more precise weather data, improved algorithms and machine-learning techniques. The project is exploring new automation techniques that can support trajectory exchanges (big data, machine learning, voice recognition, etc) and define a common trajectory service as an alternative architecture for trajectory exchanges between ground ATM actors compared to the current fragmented approach.

Web: [www.sesarju.eu/projects/4DSkyways](http://www.sesarju.eu/projects/4DSkyways)



**NEW!**

**VC - Virtual centre**  
(PJ.32 W3)

Traditionally, ANSPs host a monolithic ATM system in each air traffic system unit (ATSU) with very few information services and infrastructure elements being shared between the different centres. In the virtual centre approach, the controller working positions are decoupled and may even be geographically separated from the ATM information services that they consume, and these ATM information services may be shared between different ATSUs or even between ANSPs. The project is further investigating the air traffic flow and capacity management (ATFCM) aspects of such airspace delegation among ATSUs.

[www.sesarju.eu/projects/VC](http://www.sesarju.eu/projects/VC)



**NEW!**

**FALCO - Flexible ATCO endorsement & LDACS complement** (PJ.33 W3)

The project is investigating and validating technologies and procedures, enabling a more flexible and efficient re-organisation and endorsement of air traffic controllers (ATCOs), based on traffic complexity, sector classes and the level of skills, experience and training a controller has received on a specific class of working environment and supporting system. The project is also working on replacing analogue voice communication with a capability supported by l-band digital aeronautical communication system (LDACS) in order to improve air-ground connectivity.

[www.sesarju.eu/projects/FALCO](http://www.sesarju.eu/projects/FALCO)



© DLR

**NEW!**

**I-CNSS** - Integrated CNSS (PJ.14 W2)

The project is developing the future technologies coming from the communication, navigation and surveillance (CNS) domains in order to support and manage operational services, like the 4D trajectory management, in the future ATM system. Performance requirements for CNS systems are becoming increasingly complex and demanding and must be considered as part of an integrated and holistic system of systems and a unified concept of operations, where possible.

Web: [www.sesarju.eu/projects/ICNSS](http://www.sesarju.eu/projects/ICNSS)

**CLOSED  
IN 2020**

**4DTM** - 4D trajectory management (PJ.18 W1)

Harmonised and global trajectory information sharing, including improved negotiation mechanisms, enables significant operational benefits. The project delivered a solution that allows control centres involved in the management of a flight to share reliable, complete and updated flight trajectory information from take-off to landing, taking into account any existing and shared internal restrictions in the airspaces that the flight will cross.

Web: [www.sesarju.eu/projects/4dtm](http://www.sesarju.eu/projects/4dtm)

**NEW!**

**OAUO** - Optimised airspace users operations (PJ.07 W2)

The project aims at defining and validating improved airspace user processes and tools in order to optimise ATM Network operations. The project is developing a collaborative framework managing delay constraints on arrivals; and mission trajectory management with integrated dynamic mobile Areas (DMA) Type 1 and Type 2. It is also looking at developing requirements and validating procedures and workflows for flight/wing operations centre to enable collaborative decision making between stakeholders throughout the flight trajectory. Other areas of focus include integrating airspace user (AU) priorities and preferences in airport and Network processes; making use of automation in collaborative decision making and coordination; better interoperability between AU and the NM operations.

Web: [www.sesarju.eu/projects/OAU02](http://www.sesarju.eu/projects/OAU02)

**NEW!**

**DNMS** - Digital network management services (PJ.09 W2)

The project focuses on improving the network traffic prediction for all stakeholders involved in demand capacity balancing, dynamic airspace configurations, integrated network management and ATC planning and collaborative network performance management. This project is structured around three solutions: dynamic airspace configurations (DAC); enhanced network traffic prediction and shared complexity representation; and a prediction algorithm to anticipate the performance degradation in identified areas within the network.

Web: [www.sesarju.eu/projects/DNMS](http://www.sesarju.eu/projects/DNMS)

## Aviation industry delivers key solution for seamless skies

An essential component of the future system is ground-to-ground interoperability, a solution designed to enable the swift and seamless exchange of flight trajectory information in real time between Europe's network of 63 air traffic control centres.

Europe's aviation industry completed the final test of a SESAR Solution on ground-to-ground interoperability, which is designed to allow the network of 63 European en-route control centres to exchange information on the flight trajectories in real time, thus supporting seamless operations and improving flight efficiency.

The solution addresses a frequent problem that affects Europe's air traffic, whereby flights crossing borders or different airspace sectors have to adjust their trajectory or speed to avoid conflicts with other aircraft. The problem is caused largely by en-route control centres sharing information in a sequential way and updating the trajectory information.

To address this situation the SESAR JU '4DTM' ground-to-ground interoperability (IOP) project, coordinated by Indra, put the

finishing touches to a solution that allows the sharing of information in real time.

With this solution, control centres involved in the management of a flight can share reliable, complete and updated flight trajectory information from take-off to landing, taking into account any existing and shared internal restrictions in the airspaces that the flight will cross.

Final tests of this solution – following the first trials successfully held in April 2019 – took place last June 2020 during two weeks in an environment simulating the operations of the Maastricht UAC, Reims UAC, Karlsruhe UAC, Geneva and Zurich UACs, Padua and Milan UACs.

Thanks to the IOP solution, all actions carried out in one centre are immediately visible in all other centres, removing any uncertainty over the conditions under which a flight would enter another airspace.

The end goal is to attain a smoother control process, which will improve the efficiency of air traffic control in Europe and make it possible to manage more flights with greater precision and punctuality, offering cost savings to airlines, reductions in CO<sub>2</sub> emissions and ultimately providing a better service for passengers.

The solution will also help carry out the ATC process "quietly", without the need for the air traffic controller to coordinate with his/her counterparts in adjacent centres by phone. For this purpose, and implementing the "flight object" concept, all control centres share the same information and have the possibility to request changes to flight trajectories in real time.

IOP is the enabling ground-ground communication technology and protocols for seamless flight operation across regions and national boundaries, and underpins the 4D flight trajectory with the real-time sharing of the trajectory among all the ATM actors.

The results of these tests are being used to update the ED133 standard developed by the European Organisation for Civil Aviation Equipment (EUROCAE), which will support subsequent industrialisation and implementation.

Web: [www.sesarju.eu/projects/4dtm](http://www.sesarju.eu/projects/4dtm)

*This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 734161.*



## AI powered tool to help monitor network performance

SESAR JU members developed a network performance-monitoring dashboard to anticipate degraded/critical air traffic situations across Europe's network and enable timely and improved decision-making.

The dashboard (integrated network performance management and monitoring) visualises up-to-date operational information obtained from stakeholders (Airspace users, airports, air navigation service providers) and, allows staff in the Network Manager (NM) operations (ops) room to:

- detect and predict degraded situations at local/sub-regional and regional levels within the network;
- manage the network recovery process more efficiently using network-oriented solutions (e.g. Dynamic airspace configuration and/or short-term air traffic flow and capacity management processes – STAM - using enhanced computer-assisted slot allocation – E-CASA);
- collaborate better with stakeholders (FMPs, airports and airlines) using intuitive collaborative tools that support information exchange and improve decision-making.



*Pre-COVID discussions & live observation*

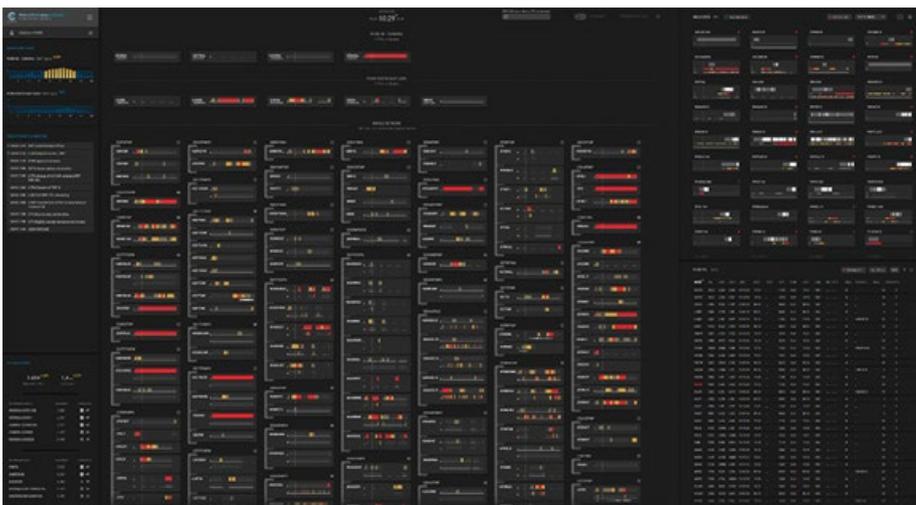
A dashboard demonstrator was developed over 12 months by with live observations in the NM ops room as well as task analysis and design-thinking sessions with ops staff. Just before the first COVID-19 lockdown, the dashboard demonstrator was presented to 15 NM ops staff, who welcomed the interface, which provides them with a global view of the network status, the impact of network measures, and a personalised view on key areas of interest that Network Operations Controllers (NOCs and Senior NOCs) want to monitor.

The dashboard is also expected to support the evolution of roles and responsibilities (in critical situations) between local flow managers and the NM, with new working methods and procedures currently investigated by SESAR experts, in order to provide NM with the right information and human-machine interface features to take more responsibilities in critical situations.

Work has now started on the next phase, which is to develop the prototype based on the demonstrator. This shall also include the new AI powered engine currently under development. The goal is to connect the dashboard to the NM validation platform, where NM ops staff can start using the tool to train and validate it with real-time traffic, and to simulate critical days.

[www.sesarju.eu/projects/DNMS](http://www.sesarju.eu/projects/DNMS)

*The Collaborative Network Performance Management solution (#49) is developed within the framework of the SESAR research project - Digital network management services (PJ.09 W2). This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 874463.*



*Network Performance Management Dashboard demonstrator*

**How innovation can support airport operations in a post-COVID world**

How can innovation help airports in a post-COVID world? That is the question that members and partners in SESAR JU investigated in 2020. They looked at solutions in the SESAR research and innovation pipeline that could help airports adapt their operations to the new normal, as well as technologies that could build resilience especially among hard-hit small to medium airports.

From medical screening and checks to physical distancing requirements, airports are already putting in place a whole host of measures to ensure the health and safety of passengers and staff in what is expected to become the new norm in air travel for the foreseeable future. These requirements will have a massive impact on passenger flow, terminal capacity, transfer times and the overall duration

of a journey. They will therefore demand even greater collaboration between the different airport stakeholders, from the airlines, ground handlers and air traffic control to security, emergency services and airport management.

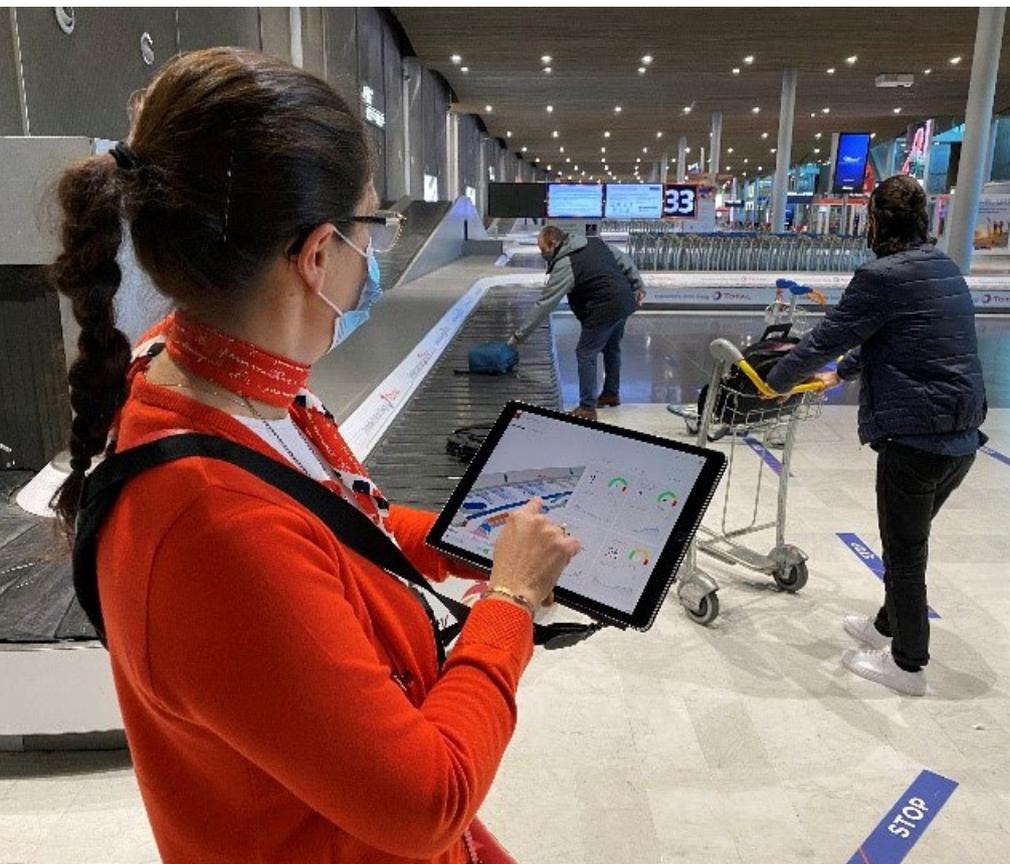
Rather than reinventing the wheel, there are already solutions out there that can help with this adaptation and

ensure that these new requirements are integrated into the overall management of airport operations. As part of its Total Airport Management project, the SESAR JU has developed a series of tools to better integrate airside and landside performance monitoring processes, which can be adapted to any airport setting.

Some airports have already set up operations centres or APOCs to manage these processes collaboratively. In them, stakeholders are offered a shared view of flight prioritisation, runway traffic loads and turn-around times of aircraft, as well as baggage and passenger operations and more generally the status of the overall airport operations. Through real-time monitoring and with the help of automation and decision support tools, the airport can anticipate disruptions allowing airports' stakeholders to take corrective actions, enabling better synchronisation between these operations and improved predictability.

With its airport members and partners, the SESAR JU looked at how APOCs and their performance monitoring and management could be extended to sanitary and physical distancing measures in order to manage their impact on passenger, security, stand allocation and turnaround processes, as well as the predicted time that all the ground-handling activities will be completed. It would also lead to the development of indicators and alerts within the airport operations plan and APOCs to deal with

**“ In 2020, GROUPE ADP - a SESAR member part of the SEAC 2020 consortium gathering European airport operators - trialled the integration of data related to managing in real times passengers flows and also news uses like sanitary procedures at Paris-Charles de Gaulle airport. ”**



© ADP



©O. Chassignole/Aéroports de Lyon

the status of sanitary checks, providing airports with predictability and the required agility to regularly adapt their measures and processes to changing constraints (e.g. a second wave of outbreaks). Some possible adaptations could also include the installation of cameras on the ground, as well as the use of video analytics and artificial intelligence to handle all the data generated by the checks.

With COVID, there is clearly an increasing need for airports to monitor and manage the impact of landside activities on airside operations. That is especially true for smaller airports, whose landside or terminal capacity will be significantly impacted as a result of the sanitary and physical distancing measures that will be put in place. In this context, SESAR members are looking at how the services delivered by the APOC can be made more affordable for regional airports in Europe, by moving from cost-intensive databases to services delivered through the cloud. Another cost saving could be made through the simplification of collaborative decision making for these airports, focusing only on essential milestones. Big data and artificial intelligence could also help, for example by allowing the automation of target-off block and target start-up time calculations.

Smaller airports are particularly vulnerable now and will need to build their resilience at an affordable price in the long term. Given the social and economic importance of these smaller airports for

their surrounding communities, it will be critical to have strategies to ensure their sustainability. Innovation has a role to play, which we are demonstrating with our research portfolio of solutions, many of which are already available for implementation, providing airports with the means to improve accessibility and increase their resilience at a fraction of the cost.

Take satellite-based navigation technologies such as the GBAS Category II/III solution, which enables enhanced arrival procedures at much lower maintenance costs compared to traditional navigation means. Meanwhile, enhanced terminal operations with required navigation performance (RNP) transitions are particularly relevant for airports with geographical constraints to ensure accessibility.

The SESAR JU is also developing low-cost advanced surface surveillance solutions based on cameras and ADS-B, as well as surface safety nets for airports that do not have an A-SMGCS installation. Added to that are the advances that we have made on enhanced vision systems for aircraft, which require minimum changes to the existing air traffic control procedures and no investment in new ground systems. Remote tower service provision is also a proven means to increase cost efficiency of smaller aerodromes that are often connecting the most remote parts of Europe, providing them with an economic lifeline.

**“Smaller airports are particularly vulnerable now and will need to build their resilience at an affordable price in the long term. Given the social and economic importance of these smaller airports for their surrounding communities, it will be critical to have strategies to ensure their sustainability.”**

## World's largest remote tower centre opens in Norway

SESAR JU member, Avinor, the Norwegian airport operator and air navigation services provider, opened the world's largest remote tower centre in Norway on 20 October 2020. This important achievement would not have been possible without the R&D work performed in the SESAR 2020 programme, where Avinor was instrumental in delivering the multiple remote tower solution.

The first tower in Norway to be run through the remote tower technology was rolled out in 2019, while three more towers are being implemented. The remote towers technology will be rolled out at a total of 15 airports in Norway by the end of 2022, which will be run from the centre in Bodø.

Dag Falk-Petersen, CEO Avinor, comments: "This is the beginning of a new era of aviation. Avinor ensures the connectivity of

Norway domestically and internationally. Our goal is to develop a more effective and sustainable aviation infrastructure through digitalisation and new technology. Remote towers will make aviation safer and more robust through utilising advanced technology. We already have two towers operating from the Remote Towers Centre and will roll out a further 13 airport towers within the next two years."

The solution brings together in one place a number of modules to cover several different airports. At a remote tower centre, an air traffic controller can provide air traffic services to up to three low traffic volume airports at the same time. Thanks to the pooling of resources, controllers can assist each other in cases where the traffic at one of the airports becomes too complex to handle alone. Automatic planning tools support the remote tower centre supervisor for the most efficient allocation of airports and controllers to each working position. Such a centre is

being established at Arlanda to provide remote air traffic control to airports in Malmö, Östersund, Umeå and Kiruna, with one controller assigned to one

**“ This is the beginning of a new era of aviation. Our goal is to develop a more effective and sustainable aviation infrastructure through digitalisation and new technology. ”**

*Dag Falk-Petersen,  
CEO Avinor*



airport. Norway is among the countries taking forward the 'remote tower centre' (RTC) – intensive work is also underway in Germany, Hungary, Italy, Lithuania, Norway, Sweden, as part of SESAR 2020.

The SESAR JU and its members have been working on remote towers for many years. First on single remote tower operations and more recently on multiple remote tower solutions. In 2015, the first multiple remote tower SESAR Solution, 'remote tower for two low density aerodromes' was delivered., while further are under development. In 2019, the multiple remote tower module was finalised, which provides advanced features necessary for controllers to maintain situational awareness for two or three airports simultaneously. The solution can be used to pair airports of different sizes, with indicative figures showing that two airports with 15,000 to 40,000 annual movements or three airports with less than 15,000 annual movements can be handled by one air traffic controller simultaneously. In cases of traffic overload, airports can be split between several modules.

More on remote towers:  
[www.sesarju.eu/remotetowers](http://www.sesarju.eu/remotetowers)

## Automating complex clearances in support of free-route airspace operations

In 2020, SESAR JU members completed research into a capability which facilitates the generation of route changes and clearances, reducing the chances of mistyped instructions and paving the way for more complex free route operations in Europe.

Today, controllers create a controller-pilot data-link communications (CPDLC) route change instruction by typing waypoint names or selecting them from a route menu. A bespoke, non-published waypoint is more complex in its definition, requiring up to 15 digits to define a point by latitude/longitude. Manual entry of such a complex clearance is judged not feasible due to



© SESAR Joint Undertaking

high workload and the possibility of input errors. Controllers therefore currently limit route amendments to published waypoints.

In the future, flights in en-route airspace will largely be free route, with very few published waypoints in their flight plan. Flight plans will instead consist of user-defined, bespoke waypoints defined as lat/long pairs, and which may be widely-spaced. In this environment, the use of lateral interventions to resolve separation conflicts may require an instruction to resume own navigation to a latitude/longitude non-published waypoint.

The project investigated the capability to create route changes through interaction with a graphical interface on the controller workstation, and system-generated corresponding complex clearance with no typing required. Specifically the SESAR members prototyped a flight data processor (FDP) system functionality to auto-generate a clearance based on a graphically-defined route amendment. The operational concept, which can use both ATN baseline 1 and baseline 2 CPDLC message sets, requires that the aircraft is equipped with the capability to auto-load a CPDLC message into its flight management system/computer to reduce the possibility of transcription errors on the flight deck.

Put simply, the solution will help controllers manage more efficiently traffic in a free route environment. More specifically, the solution is expected to help maintain the separation management flexibility of heading instructions that exists in today's operations as we move to free route operations, and the ability to keep aircraft on closed-loop clearances, increasing the value of planning trajectories. The concept was positively assessed by controllers, who confirmed that the use of latitude/longitude would be particularly valuable within a free-route environment.

The solution is part of work undertaken within the SESAR solution on trajectory-based operations (PJ.18-02a). It is envisaged that this ATN B1 or B2 CPDLC capability would be used in conjunction with ADS-C downlink (namely, the extended projected profile or EPP in ATN B2), to provide confirmation of correct route entries on the flight-deck and support conformance monitoring tools. The use of EPP in ATC systems was demonstrated in SESAR PJ31 DIGITS VLD project (see page 41 for more details about this demonstration).

*This work received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 734161.*

## Predicting conflict-free trajectories using supervised machine learning

The 4DSkyways project (PJ.18W2 – Solution 53) is investigating how supervised machine learning can improve the generation of conflict-free trajectories. Researchers carried out a case study using historical data to predict conflict-free trajectories with a 5-minute look-ahead time. The historical data was used to learn a mapping between the traffic situation to the future conflict free positions (supervised learning phase) - this results in the “mimicking” of controller resolution patterns from similar traffic situations.

They compared the performance of both models to a baseline to ensure a learning has been achieved. For the best model (sector based), the median deviations between the prediction and the true future locations represented 0.4NM and 23ft “with no change”, and 1.3NM and 500ft “with change”. These results show that relevant information has been extracted and a mapping between inputs and outputs achieved. However, the prediction error remains quite significant compared to separation standards (5NM, 1000ft).

Future work will investigate further both models as well as a novel approach relying on attention mechanisms. The project will seek to improve the performance by adding other parameters (e.g. military areas, meteo).

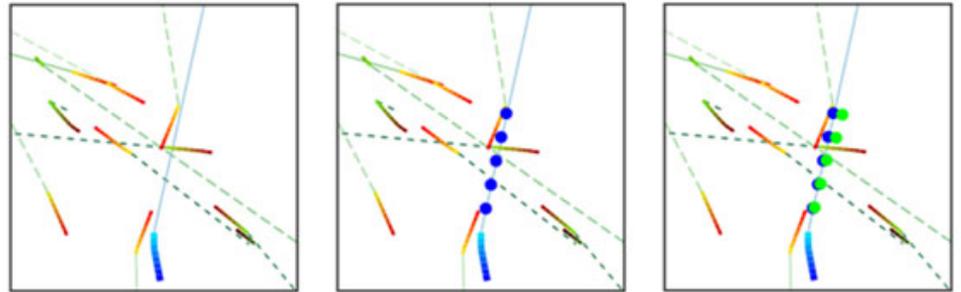


Figure 1: relative model, subject aircraft currently heading up and exit point slightly heading right (left, in blue: past and current positions; middle, blue dots: true future positions; right, green dots: predicted future position) and surrounding traffic (altitude colour coded).

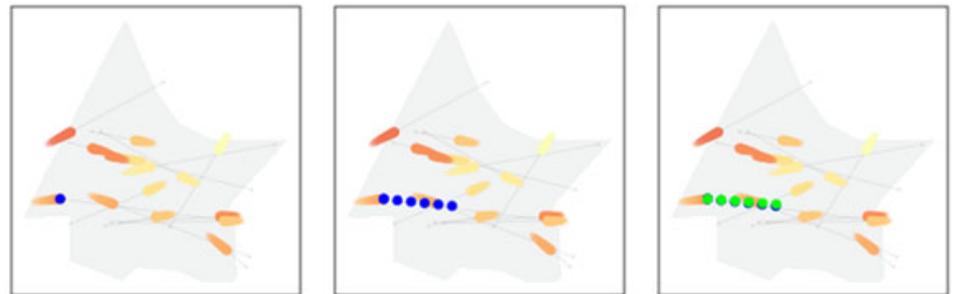


Figure 2: controller / absolute model, subject aircraft currently heading East (left, in blue: current positions; middle, blue dots: true future positions; right, green dots: predicted future position) and surrounding traffic (altitude colour coded).

Solution 53 aims to bring improvements to the ground trajectory prediction and separation management/ monitoring tools by using aircraft trajectory data, more precise meteo data, improved algorithms and machine learning techniques. The final results of the validation on supervised machine learning are planned for 2022.

Web: [www.sesarju.eu/projects/4DSkyways](http://www.sesarju.eu/projects/4DSkyways)

This project has received funding from the SESAR Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 872320



© 4DSkyways

[1] The study was presented by Integrated Communications Navigation and Surveillance (ICNS) conference in September 2020.

# Demonstrating SESAR

## *Very large-scale demonstrations*

**V**ery-large scale demonstrations offer a critical mass of proof of the performance benefits that SESAR Solutions can deliver to the aviation community. The demonstrations include trials involving live traffic and so typically take place in close-to-operational environments. The fact that so many stakeholders are eager to participate is proving invaluable for accelerating the operational acceptance and the subsequent industrialisation of SESAR Solutions. In other words: "seeing is believing."

### **Sustainability and resilience - focus of latest very large-scale demonstrations**

In 2020, a number of demonstrations came to a close while new very-large scale projects got underway (wave 2 and 3) to showcase the operational benefits offered by SESAR Solutions in several critical areas:

#### Airspace resilience

The aim is to demonstrate solutions that support optimised air traffic flows in a free route environment, as well as other uses of airspace (e.g. military). The demonstrations in this category seek to support the Airspace Architecture Study Transition Plan and its measure of "Launching an airspace re-configuration programme supported by an operational excellence programme to achieve quick win".

#### Integrated trajectory management

The aim is to showcase solutions that enable airports, airlines and air navigation service providers (ANSPs) to access to up-to-date flight, meteorological, airspace and aerodrome information, and that provide a coordinated and synchronised view of the trajectory throughout the operations, from the planning through the flight operations phase. The demonstrations in this category seek to support the Airspace Architecture Study Transition Plan and its measure of "Realising planned implementation related to mature SESAR Solutions supporting the implementation of cross-border free route, air-ground and ground-ground connectivity".

#### Environmental sustainability

The European Green Deal launched by the European Commission in December 2019 aims to create the world's first climate-neutral bloc by 2050. The demonstrations will aim to showcase solutions that can enable fuel efficient trajectories and can protect "perfect" flights from unnecessary deviations or constraints.

Get an overview of new and ongoing projects in 2020 and some highlights about these projects on the following pages.



© Shutterstock



**NEW!**

**STAIRS** - Airport surface management, airport safety nets and ATSAW

[VLD02]

While safety has improved thanks to airport surface management systems, these systems do not fully resolve the risk of runway incursions and are not envisaged to be deployed at smaller airports. And although traffic collision avoidance systems (TCAS) has been in use since 1981, there is currently no aircraft system to prevent runway collisions. SESAR JU members and partners have developed a solution making use of ADS-B technology to provide on-board surface alerts (SURF-A & SURF-IA). This demonstration aims to assess the performance of this solution in real operational environments, in particular the absence of nuisance alerts. This will be the largest ground ADS-B IN trial worldwide, paving the way towards the deployment of SURF-A/IA or future ADS-B applications and standards.

Web: [www.sesarju.eu/projects/STAIRS](http://www.sesarju.eu/projects/STAIRS)



**NEW!**

**ITARO** - Integrated TMA, airport & runway operations

[PJ.37 W3]

The project plans to demonstrate on a larger scale several solutions in the airport environment, which research has shown can bring efficiencies, both operationally and environmentally. These include procedures to enable more efficient and integrated runway throughput and terminal operations; a collaborative framework for managing delay constraints on arrivals; and improved arrival and departure operations.

Web: [www.sesarju.eu/projects/itaro](http://www.sesarju.eu/projects/itaro)



**NEW!**

**SORT** - Improving runway throughput in one airport

[VLD03]

The expected rapid growth in air traffic will lead to an increasing number of capacity constrained airports. Therefore airports have to improve significantly the runway and airport throughput while maintaining or increasing runway safety levels. This demonstration will put to the test four solutions delivered by SESAR JU partners: PJ.02-01: Wake turbulence separation optimisation PJ.02-02: Enhanced arrival procedures PJ.02-03: minimum pair separations based on required surveillance performance PJ.02-08: Traffic optimisation on single and multiple runway airports.



**NEW!**

**DREAMS**- Demonstration of runway enhancements made with satellite navigation

[VLD01 W2]

This project aims to mitigate the climate impact of aviation through the development of meaningful and sustainable activities including efficient airport operations using GNSS technology and improved aircraft noise assessments.



**ONGOING!**

**AUDIO** - Airport operations, the airspace user demonstration (VLD01 W2)

The demonstration project aims to improve safety, efficiency and predictability of flights by increasing the flight crew's situational awareness while the aircraft is taxiing. The project is demonstrating solutions, such as innovative advanced and connected moving map applications, to provide the cockpit with local airport data such as the on-ground traffic situation and planned taxi routes.

See page 42 for more details about the project results

Web: [www.audio-project.eu/](http://www.audio-project.eu/)



**CLOSED  
IN 2020!**

**AAL2** - Augmented approaches to land

Building on results of the AAL demonstration, this project has showcased how technologies, such as ground-based augmentation systems and enhanced flight vision systems can increase access to airports of all sizes in low-visibility mixed fleet operations.

Web: [www.sesarju.eu/projects/aal2](http://www.sesarju.eu/projects/aal2)



**CLOSED  
IN 2020!**

**DIGITS AU** -Initial trajectory information sharing  
(PJ.31 W1)

The project demonstrated the ATM benefits that can be realised through the use of downlinked 4D trajectory data in ground systems. The project conducted, in a close to operational environment and in fully representative operational conditions, a set of coordinated development and demonstration actions of key airborne and ground stakeholders in Europe.

See page 41 for more details about the project results.

Web: [www.sesarju.eu/projects/DIGITS](http://www.sesarju.eu/projects/DIGITS)



**NEW!**

**ADSCENSIO ADS-C** enables and supports improved ATM operations  
(PJ.38 W3)

Building on the results of DIGITS, this project aims to demonstrate the efficiency and robustness of a technological infrastructure to support datalink communications between the aircraft and various ground consumers for real-time transmission of four-dimensional trajectory data. The aim is to support the industrial implementation of the use of automatic dependent surveillance-contract extended projected profile (ADS-C-EPP) data downlinked from aircraft – the target is for 45% of all flights in Europe to have the capacity to share trajectory.

See page 41 for more details about the project.

Web: [www.sesarju.eu/projects/ADSCENSIO](http://www.sesarju.eu/projects/ADSCENSIO)



**NEW!**

**ALBATROSS** -The most energy efficient flying bird (VLD02)

ALBATROSS aims to support the transition towards greener and more sustainable aviation. Taking holistic approach, the project will address all flight phases and demonstrate the complementary between airborne and ground solutions, such as alternative aircraft fuel, technologies for better air-ground connectivity, artificial intelligence and big data, and highly collaborative ATM procedures.

Web: [www.sesarju.eu/projects/ALBATROSS](http://www.sesarju.eu/projects/ALBATROSS)



**NEW!**

**VOICE** - Reduced separations and improved efficiency based on Vhf cOmmunICations over LEO satEllites (VLD02)

The project will demonstrate the benefits of using satellite-based VHF systems for voice and datalink air traffic services in remote portions of airspace, especially in reducing separation without compromising on safety. Project partners will perform cross-border operations to illustrate the feasibility of using these technologies across national borders.

Web: [www.sesarju.eu/projects/voice](http://www.sesarju.eu/projects/voice)



## Four-dimensional trajectory data: a pathway to decarbonisation

After two years of experimental entry-into-service programmes and more than 20,000 flights carried out by about 90 A320 aircraft from six airlines (Air France, British Airways, EasyJet, Iberia, Novair and Wizzair), the DIGITS project led by Airbus alongside more than 15 partners came to an end in 2020. The project focused on analysing the real-time transmission of four-dimensional trajectory data (Latitude, longitude, altitude, time) as a solution to better inform ATM operations. And the findings are very encouraging.

Jean-Brice Dumont, Airbus Executive Vice-President, Engineering: *“Thanks to the transmission of four-dimensional trajectory data, ATM will be able to improve, optimise and better predict an aircraft’s trajectory, thereby enabling us to immediately and concretely reduce our environmental footprint.”*

For example, during periods of heavy airport traffic, such as summer holidays, air traffic controllers often divert some aircraft to holding patterns to better organise arrivals queuing in the terminal area. In another example, ground control often requests an aircraft begin its descent before its optimum top of descent (TOD) due to a lack of accurate visibility of an aircraft’s optimum trajectory.

In these scenarios, the aircraft must either fly additional time or must withdraw from its optimal trajectory, which requires more fuel consumption and CO<sub>2</sub> emissions. In fact, if flying in a holding pattern at 10,000 feet and at 220 knots, an A320 Neo consumes 25 kg of fuel per minute, or 100 kg for a four-minute holding. In addition, these scenarios could result in delayed arrivals, disrupt the departure flow, and increase workload for both controllers and pilots.

However, by transmitting complete, up-to-date information about its trajectory, an aircraft can send air traffic control invaluable data that is essential for

© Shutterstock



better decision-making. The result is more efficient and better coordinated management of optimised aircraft trajectories, which will lead to increased safety of air traffic operations in general.

Assisted by a system fed with this knowledge, the controller in the previous two scenarios will thus be able to request a precise adjustment in the aircraft’s cruise speed to avoid diversion to a holding pattern in the airport terminal area and to enable optimum TOD—an action that will lead to reduced CO<sub>2</sub> emissions. Specifically, fuel savings could be up to 10 kg, or the equivalent of approximately 32 kg of CO<sub>2</sub>, if an aircraft descends from its optimum TOD. When calculated over an entire year for a European jet fleet of about 5,500 aircraft, the savings could be as high as 65,000 tons of fuel.

In 2021, the solution is expected to gradually enter into service across several European countries (i.e. France, Switzerland, Hungary, Bulgaria, Poland, Spain) thanks to further demonstrations done through SESAR PJ.38 ADSCENSIO project. This will involve the development of a centralised shared trajectory data platform.

More information:  
[www.sesarju.eu/projects/DIGITS](http://www.sesarju.eu/projects/DIGITS)

**“Thanks to the transmission of four-dimensional trajectory data, ATM will be able to improve, optimise and better predict an aircraft’s trajectory, thereby enabling us to immediately and concretely reduce our environmental footprint.”**

*Jean-Brice Dumont,  
Executive Vice-President,  
Engineering, Airbus*

*These projects have received funding from the SESAR Joint Undertaking within the framework of the European Union’s Horizon 2020 research and innovation programme under grant agreements No 731818 (DIGITS) and No 101017626 (ADSCENSIO).*

**Ask the flight crew: how SESAR project keeps pilots in the loop in digital map design**

Partners in the Airspace User supporting Demonstration of Integrated Airport Operations (AUDIO) demonstration are developing a moving map display for pilots to increase their situational awareness while the aircraft is taxiing. In 2020 the project worked with Lufthansa pilots to ensure the design of the map fits the needs of the end users.

A “connected” moving map means adding real time traffic information and taxi route to the existing airport moving map application in the electronic flight bag. Airports providing this local data to the pilots would further support flight crews in navigating safely and efficiently on the ground. This capability builds on solutions developed in SESAR 1.

In a dedicated workshop with pilots, the consortium mapped the taxi-in and taxi-out procedures and the critical steps which could benefit from the additional data in a visual display. The pilots could imagine some advantages, such as being able to adjust taxi speed and power settings based on the traffic situation, or with a more predictable taxi route, using single engine taxi procedures more often. They brainstormed on what visual display elements are useful in other routing applications, and with this in mind, each

pilot designed their ideal display of real time traffic situation and routing. Then, they voted on the best design ideas, identifying which could be the most useful to implement. This exercise helped the AUDIO partners to really understand pilots’ needs in order to design a well-adapted display. Pilots made it clear that having this connected moving map would help them anticipate, making ground movements more manageable.

More information:  
<https://www.audio-project.eu/>

*This project has received funding from the SESAR Joint Undertaking within the framework of the European Union’s Horizon 2020 research and innovation programme under grant agreement No 783161.*



© AUDIO



© AUDIO





© Shutterstock

# Enabling the safe and secure integration of drones

## U-space

### Report published with consolidated U-space research findings

In 2020, the SESAR JU published a report on the state-of-play of the technological capabilities and services required to ensure the safe and secure integration of drones into the airspace. The report consolidates the findings from 19 SESAR research and demonstrations projects (2017-2019), including an analysis of the coverage and level of maturity of each service, and identifies areas requiring further research.



Since 2017, the SESAR JU has been active in researching drone traffic management within the framework of U-space, an initiative by the European Commission to ensure the safe and secure integration of new air vehicles, including drones, in Europe. The aim of U-space is to put in place a set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for a large numbers of drones, with an initial look at very low-level (VLL) operations.

The central outcome of the research is the U-space Concept of Operations (CONOPS), providing an initial U-space architecture and description of airspace types and U-space services to enable safe and efficient very low-level drone (VLL) operations. In parallel, the projects researched, developed and demonstrated U-space services from U1-U3 in a variety of geographical environments and airspace classes, while taking into account several types of flight mode and operational environment. The projects also looked at the density of drone traffic, as well as the complexity of the traffic and service provision, including multiple simultaneous service providers. An analysis of the activities shows that collectively the projects addressed all U1 services and almost all U2 services. Meanwhile only limited coverage was achieved for U3. U4 was not covered by the research activities.

In terms of the level of readiness, the projects demonstrated U1 and U2 services were ready for use in environments with low levels of complexity (rural areas, segregated airspace) and a low density of traffic. In these environments, the projects were able to show the feasibility of multiple service provision, strategic deconfliction, as well as the possibility of increasing situational awareness through information sharing. They also demonstrated the importance of reliable tracking and monitoring and addressed

the interface with manned aviation. Many technologies were successfully tested and demonstrated, but there is a strong need for performance requirements and system standardisation. At the same time, the analysis underlined the need to further develop and validate U-space to cater for high complexity/ high density operating environments (urban operations, mixed traffic). This will require further research and innovation, in particular in relation to conflict management, emergency management and monitoring services – It is these services that will make U-space scalable and robust to support dense and complex operations in U2 and to ensure a transition to U3 and U4.

The consolidated findings from SESAR JU research activities supports the definition of required standards, protocols and regulation. The findings from these 19 projects take Europe several steps closer to implementing a safe, initial drone operating environment, and provide the necessary building blocks for more advanced U-space services leading to full integration with manned aviation. Nevertheless, the findings make clear that more work is needed on developing and validating drone capabilities. In addition, more data will need to be collected to elaborate the necessary minimum operational performance standards (MOPS) for U-space services, equipment/systems and capabilities and the enabling infrastructure to be set to support U-space operations. Based on

this data, industry, regulatory, research and standardisation bodies need to work together to complete the full implementation of U-space.

Download the publication!

[www.sesarju.eu/publications](http://www.sesarju.eu/publications)

### New U-space research projects take off!

Building on the results from the 2017-2019 project portfolio, in 2020 the SESAR JU made provisions for a new set of projects in all three strands of research. These address several key areas, including urban air mobility (UAM), air traffic

management (ATM)/U-space convergence, and advanced U-space services and technologies (U3 and U4), including the development of miniaturisation, automated detect and avoid functionalities, and reliable means of communication. Get an overview of new projects in 2020 and some highlights about these projects on the following pages.





## NEW EXPLORATORY RESEARCH PROJECTS (ER 4)

**BUBBLES** - Defining the building basic blocks for a U-space separation management service

BUBBLES aims to formulate and validate the concept of a U-space advanced (U3) 'separation management service'. It will develop algorithms to compute the collision risk of UAS (Unmanned aircraft systems), allowing to define separation minima and methods, so that a safety level stated in terms of overall probability of collision can be defined and maintained.

Web: <https://bubbles-project.eu/>

See page 49 for more details about this project.

**DACUS** - Demand and capacity optimisation in U-space

DACUS aims to develop a service-oriented demand and capacity balancing (DCB) process for drone traffic management. This overall objective responds to an operational and technical need in European drone operations for a tangible solution integrating the functionalities of the SESAR U-space services for drone traffic management (DTM) to produce timely, efficient and safe decisions.

Web: <https://dacus-research.eu/>

**ICARUS** - Integrated common altitude reference system for U-space

ICARUS aims to propose an innovative solution to the challenge of the common altitude reference inside very low-level (VLL) airspace with the definition of a new U-space service and its validation in a real operational environment.

Web: [www.u-spaceicarus.eu/](http://www.u-spaceicarus.eu/)

See page 50 for more details about this project.

**Metropolis 2** - A unified approach to airspace design and separation management for U-space

Metropolis 2 aims to provide the fundamentals for concrete solutions for U-space U3/U4 services that are needed to enable high density urban aerial operations, with a unified approach to the following U-space services: strategic deconfliction, tactical deconfliction, and dynamic capacity management.

Web: [www.sesarju.eu/projects/Metropolis2](http://www.sesarju.eu/projects/Metropolis2)

**USEPE** - U-space separation in Europe

USEPE aims to research drones' separation methods in high demanding environments, such as cities, and on the use of machine learning algorithms to automate the safe separation and deconfliction of drones, while maintaining airspace capacity in different environments. The research will take into account both the strategic and tactical flight phases.

Web: [www.sesarju.eu/projects/USEPE](http://www.sesarju.eu/projects/USEPE)

## INDUSTRIAL RESEARCH (W3)

### **AURA** - ATM U-space interface (PJ.34 W3)

The project aims to identify the requirements for U-space information exchange with ATM through system-wide information management and will validate a set of selected U-space services, developing the service definition for the SWIM candidate services. It will also provide inputs for the current regulatory and standardisation initiatives regarding U-space with a high involvement of external stakeholders.

Web: [www.sesarju.eu/projects/aura](http://www.sesarju.eu/projects/aura)

## VERY LARGE-SCALE DEMONSTRATIONS

### **AMU-LED** - Air mobility urban large experimental demonstrations

The project aims to develop a detailed concept of operations and define urban air missions followed by simulations and a large-scale real flight demonstration campaign to verify and validate the concepts. The project will allow UAM stakeholders to specify various use cases applicable to logistics and urban transport of passengers, design or integrate UAM environment, test the UAS ground and airborne platforms and finally, assess safety, security, sustainability and public acceptance.

Web: [www.sesarju.eu/projects/AMU-LED](http://www.sesarju.eu/projects/AMU-LED)

### **CORUS-XUAM** – Concept of operations for European U-space service – extension for urban air mobility

CORUS-XUAM will demonstrate how U-space services and solutions could support integrated urban air mobility (UAM) flight operations, allowing eVTOLs/UAS and other airspace users (unmanned and manned) to operate safely, securely, sustainably and efficiently in a controlled and fully integrated airspace, without undue impact on operations currently managed by ATM. The project is proposed by the consortium that delivered the CORUS U-space ConOps in 2019, extended by the addition of UAM expertise.

Web: [www.sesarju.eu/projects/CORUSUXAM](http://www.sesarju.eu/projects/CORUSUXAM)

### **GOF 2.0** - Integrated urban airspace very large-scale demonstration

The project will demonstrate operational validity of serving combined UAS, eVTOL and manned operations in a unified, dense urban airspace using current ATM and U-space services and systems. Both ATM and U-space communities depend extensively on the provision of timely, relevant, accurate and quality-assured digital information to collaborate and make informed decisions.

Web: [www.sesarju.eu/projects/GOF2](http://www.sesarju.eu/projects/GOF2)

**SAFIR-MED** – Safe and flexible integration in advanced U-space and flexible services focusing on medical air mobility

The project will combine five unmanned UAV platforms (passenger eVTOL, hydrogen fuel cell VTOL, AED medical drone, X8 medical transport) with manned aviation in real-life demonstrations validating technology and the maximum number of U-space services in real urban environments. The results are expected to help refine the current U-space architecture principles and create measurable indicators for the inclusion on UAM smart city transport roadmaps, supporting standardisation and safety.

Web: <https://www.safir-med.eu>

**\*TINDAIR** - Tactical instrumental deconfliction and in flight resolution

The project aims to demonstrate and refine the safety, performance, standardisation and regulatory requirements to enable UAM with specific focus on U-space U3 services identified in the U-space Blueprint and refined by CORUS, and, unlock new and enhanced applications and mission types in high density and high complexity areas.

**\*Uospace4UAM** - U-space for UAM

The project will carry out a series of multi-national demonstrations, both with drones and UAM, covering different use cases, including mixed operations, to derive critical enablers for a wide set of UAM service applications that can be applied all over Europe.

\* Grant agreements were signed in February 2021





## Taking safely to the skies

Keeping aircraft safely separated is one of, if not, the core function of air traffic management today. Research partners in the BUBBLES project are now working on developing this same function to manage the forecasted high numbers of drones that are expected to access the airspace in the coming years. The European consortium will develop and validate a concept of operations (CONOPs) for separation management in U-space.

Although some separation minima have been developed in the context of SESAR for example for detect and avoid (DAA) systems, they cannot be easily extended to ground-based tactical conflict resolution systems. To this end, BUBBLES will use an innovative performance-based approach not yet applied to the U-space. This approach is inspired by the methodology used by EUROCAE to develop the ED 261 (GEN-SUR-SPR) standard, which the consortium will adapt to the unique features of the U-space. The BUBBLES

consortium will apply the methodology to a generic very low level (VLL) airspace and will start by identifying the set of possible UAS missions that can take place therein. BUBBLES will conduct pre-defined risk assessments (PDRA) for each generic UAS CONOPs, as well as pair-wise PDRA for all the possible combinations of UAS CONOPs.

A generic operation services and environment description (OSED) will be defined by the aggregation of the expected CONOPs and the available U-space services. The consortium will develop new intelligence (AI) techniques to determine the separation minima needed to guarantee a particular target level of safety (TLS) stated in terms of frequency of collision taking into account the results of the PDRA.

The outcomes will support the competent authorities designated by the Member States in performing risk assessments and identifying the required U-space services and systems performance prior to designate a particular VLL volume as a U-space airspace. They will also

“ Keeping aircraft safely separated is one of, if not, the core function of air traffic management today. ”

support U-space service providers (USSP) in maintaining the required levels of safety performance. European citizens will access to new services thanks to the ability to fly drones safely and securely in the airspace.

More information at:  
[www.bubbles-project.eu](http://www.bubbles-project.eu)

*This project has received funding from the SESAR Joint Undertaking within the framework of the European Union's Horizon 2020 research and innovation programme under grant agreement No 893206.*

## A universal approach to altitude measurement

Currently there is no common altitude reference for manned and unmanned aviation, or between different drone manufacturers. Traditional methods to determine altitude, and ensure vertical separation, are based on pressure altitude.

Partners in the ICARUS project are developing a universal flight altitude reference system based on a geodetic approach as opposed to the traditional barometric based system used in manned aviation.

Altitude information is critical for traditional aviation since it is needed to avoid collisions with ground obstacles and maintain vertical separation between aircraft. That's why pilots measure and transmit their altitude continuously.

Currently, drones use both barometric and satellite systems to measure their altitude. However, barometric altitude measurements are affected by local environmental conditions, for example temperature gradients in built up areas. Also, drones can take off and land almost

everywhere, not only from designated airfields, ruling out the local barometric altitude system as a common reference.

This is where satellite systems come in. The geodetic altitude computed using global navigation satellite systems (GNSS) using multi constellation configurations introduce significant improvements as the basis for common altitude reference for drones, especially in very low-level airspace. The accuracy of the altitude estimation is enhanced, i.e. altitude measured in centimetres rather than in tens of feet, while augmentation techniques (such as the European EGNOS system) ensure a high precision and error detection.

The ICARUS project will develop a solution and validate in real-life environment using a new U-space service that will provide, at the strategic (flight planning) and tactical (flight execution), phases:

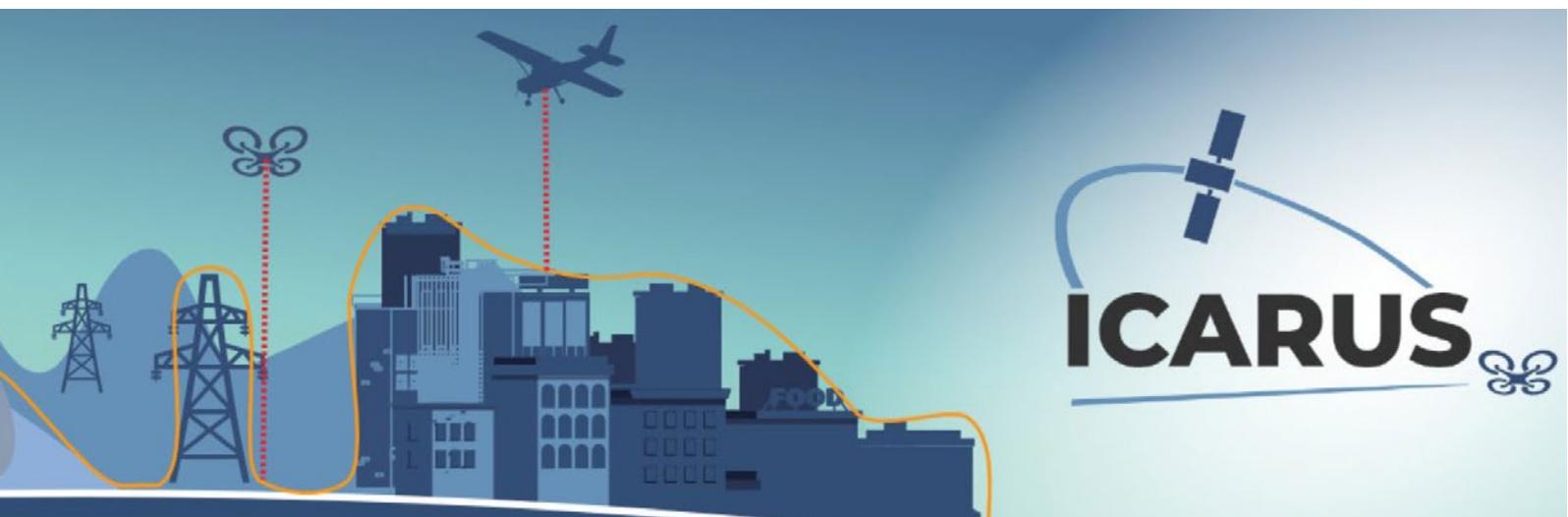
- Real-time information of vertical distance to the ground, to ensure collision avoidance, and
- Conversion of different altitude reference systems, to ensure vertical separation of traffic

Ultimately, the project aims to develop the safest possible system for a common altitude reference system to address the needs of manned and unmanned traffic.

More information:  
[www.u-spaceicarus.eu/](http://www.u-spaceicarus.eu/)

*This project has received funding from the SESAR Joint Undertaking within the framework of the European Union's Horizon 2020 research and innovation programme under grant agreement No 894593.*

**“ Altitude information is critical for traditional aviation since it is needed to avoid collisions with ground obstacles and maintain vertical separation between aircraft. That's why pilots measure and transmit their altitude continuously. ”**





## SESAR Digital Academy webinars

In 2020, in view of the situation, the SESAR JU took its events calendar online, hosting a wide range of webinars within the framework of the SESAR Digital Academy. These webinars provided participants with in-depth view of the broad range of research that is underway across the SESAR 2020 programme. All webinar material, including recordings and Q&As, are available on the SESAR JU website. Watch out for more webinars in 2021!

[www.sesarju.eu/webinars](http://www.sesarju.eu/webinars)

## SESAR Solution Catalogue – 4<sup>th</sup> edition

A fourth edition of the SESAR Solution Catalogue will be published in 2021, providing readers with an update on the solutions now ready and available for industrialisation, as well as ongoing work on candidate solutions. Recognising the changing landscape of aviation and the challenges facing our sector, this latest edition will shine a light on some of the solutions (delivered and candidate) that have been identified as essential enablers for making ATM more scalable, sustainable and resilient.





founding members



For more information, visit [sesarju.eu](http://sesarju.eu)



[www.sesarju.eu](http://www.sesarju.eu)



@SESAR\_JU



SESAREuropeanunion



Publications Office  
of the European Union