SESAR JU CONSOLIDATED ANNUAL ACTIVITY REPORT 2020

founding members

EUROPEAN UNION

EUROCONTROL

SESAR JOINT UNDERTAKING

Abstract

This Consolidated Annual Activity Report, established on the guidelines set forth in Communication from the Commission ref. 2020/2297, provides comprehensive information on the implementation of the agency work programme, budget, staff policy plan, and management and internal control systems in 2020.

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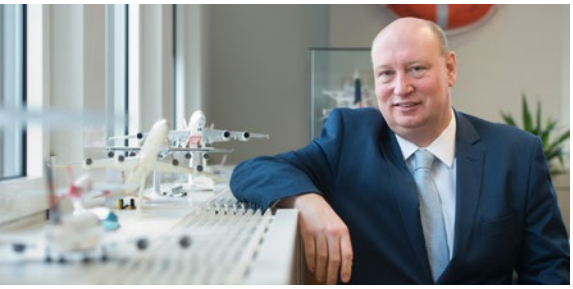
Foreword

Innovating air traffic management in times of unprecedented uncertainty



Henrik Hololei,
Director-General of the European Commission's Directorate-General for Mobility and Transport (DG MOVE) and Chair of the SESAR JU Administrative Board

For more than a year now, aviation and air traffic management have been faced with challenges that are unprecedented in the history of commercial air travel. The current crisis has equally put a lot of pressure on the European air traffic management system, reminding us again how critical it is for aviation to have an operating environment that is scalable as well as more robust, efficient and sustainable.

Against the current challenges, I am proud to see the resilience shown by the SESAR community in adapting its research and innovation activities within the current programme, while continuing to look towards Europe's future needs. The outcomes of these efforts are part of this annual activity report.

It has been an important year for SESAR research and innovation activities, as the community jointly developed the Strategic Research and Innovation Agenda that will be the basis for the work programme of the future SESAR 3 Joint Undertaking. In doing so, they have shown renewed commitment to achieving the Digital European Sky, and delivering on the 'European Green Deal' and the 'Sustainable and Smart Mobility Strategy'. It is testament to the success of the current SESAR JU and it is a real pleasure to observe that the industry and EUROCONTROL are showing such strong support for the establishment of the future partnership.

I would like to take this opportunity to thank the SESAR JU team and all project partners for their continued efforts to deliver tangible solutions through the ongoing Horizon 2020 programme. I am convinced that it is only through close and effective collaboration that we will succeed in overcoming the challenges facing our society and build an air traffic management system fit for the digital age and future challenges.

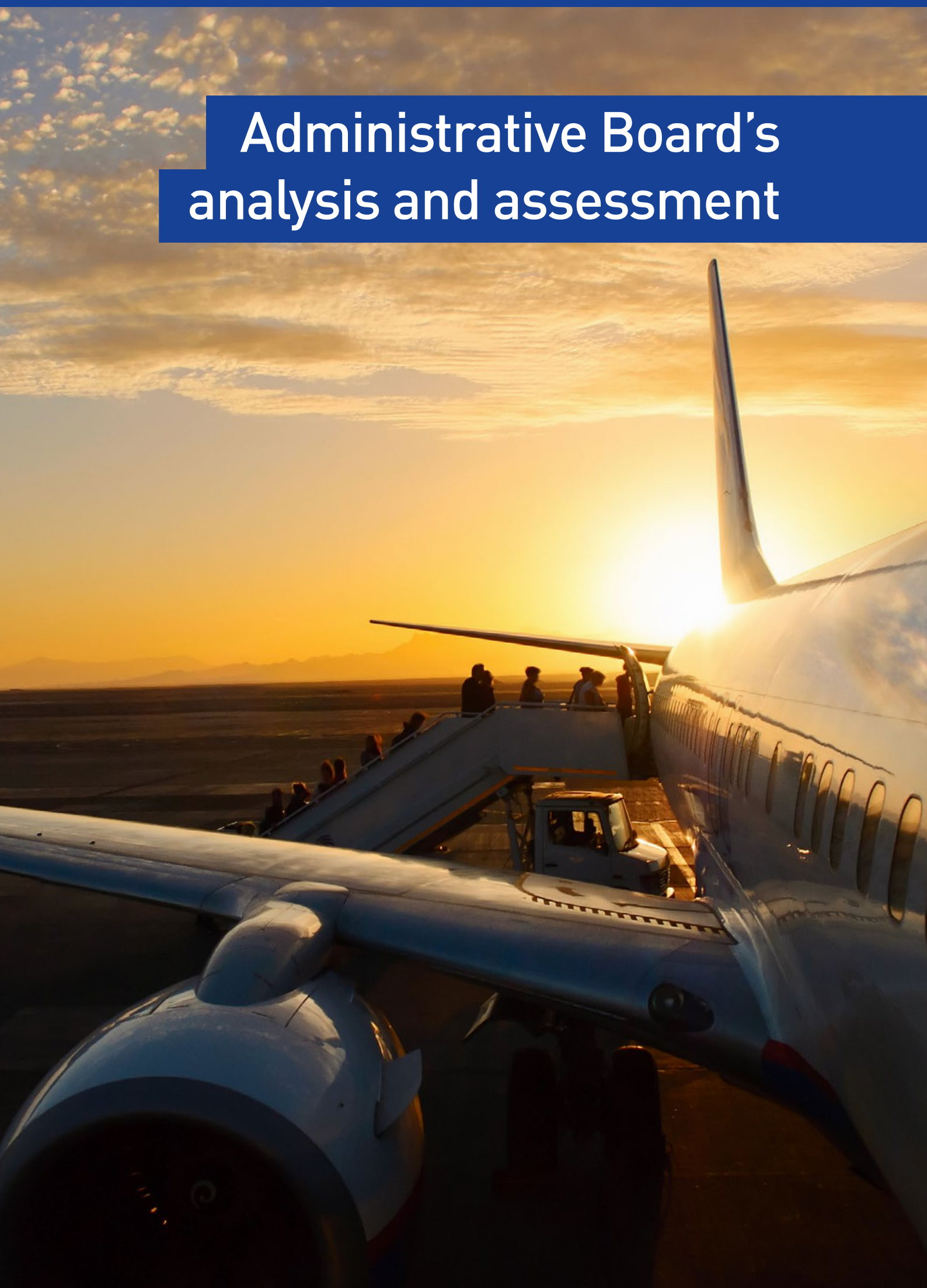
Florian Guillermet,
Executive Director,
SESAR Joint Undertaking

2020 is a year that no one is likely to forget any time soon, not least in the aviation industry. The hiatus in air travel has seen a dramatic drop in revenues of airports, airlines and air navigation service providers, and recovery remains slow and uneven.

Unsurprisingly, the crisis has had a knock-on effect on the SESAR Joint Undertaking and its research and innovation programme. With reduced operations and staff, our members and partners had to scale back or adapt their research activities, shifting deadlines, adjusting plans, and testing systems and solutions remotely. Yet, despite these challenging circumstances, our members and partners were determined to move forward with our common goal of developing the solutions necessary to build an air traffic management system fit for the digital age. The SESAR JU took measures to support them in this renewed effort.

Rather than shy away from adversity, our partnership showed renewed momentum to build a more resilient business model and streamlined infrastructure to enable aviation to become smarter and more sustainable now and for the generations to come. The pages of this report pay testament to that resolve and commitment.

Administrative Board's analysis and assessment



The Administrative Board has assessed the Consolidated Annual Activity Report (CAAR) for 2020 of the Single European Sky ATM Research Joint Undertaking (SESAR JU) and, having reviewed the document, notes the following:

- The SESAR JU met all its key policy and operational objectives in 2020 as outlined in the Single Programming Document for 2020 to 2022 (2020–2022 SPD);
- The SESAR JU's key achievements in 2020 were the following:
  - the completion of Release 9 (by September 2020), in line with the Release Plan published in 2018, the initiation of Release 10 and the start of the planning and preparation of Release 11, to be conducted in 2021;
  - the closure of the last projects under IR-VLD (industrial research and validation very large-scale demonstration) Wave 1 and of the U-space VLD calls for proposals;
  - the launch and management of ongoing projects under the IR-VLD Wave 2 restricted call for proposals;
  - the preparation and signature of grant agreements and subsequent management of ongoing projects under the ER4 open call for proposals;
  - the launch of the last two calls for proposals, the evaluation of the proposals received, award and grant agreement signature for the second VLD open call for proposals and the IR-VLD Wave 3 restricted call for proposals;
  - the organisation of and/or participation in major European and global events related to air traffic management and aviation, including the SESAR Innovation Days and several International Civil Aviation Organization (ICAO) events;
  - the communication of programme results and the promotion of scientific excellence through the SESAR Digital Academy, the Young Scientist Award, U-space consolidated report[1] and the exploratory research results brochure (second edition)[2];
  - the repayment of excess SESAR 1 financial contributions to SESAR JU members;
  - further preparation for the future of SESAR according to two non-exclusive scenarios: the repeal and replace scenario and the termination of the SESAR JU;
  - the delivery of corporate tools and initiatives to secure the efficiency of the SESAR JU operations' full continuity despite the context of the coronavirus disease 2019 (COVID-19) crisis.
- With these achievements, the SESAR JU completed its work programme for 2020 fully; the performance indicators show that all targets were met.
- While achieving its annual objectives, the SESAR JU defined and implemented budgetary measures that mitigated the adverse effects of the COVID-19 crisis on the aviation sector:
  - by increasing pre-financing rates applicable to grant agreements signed in 2020, to support the cash flow of beneficiaries of SESAR 2020 calls for proposals;
  - by implementing an exceptional reduction in the financial contribution instalment due by all SESAR JU members other than the EU by 1 July 2020, with the aim of supporting the cash flow of members other than the EU;
  - by increasing the budget available for new projects under the ER4 call for proposals by up to EUR 15.4 million, thus allowing an increase in the number of awarded projects and optimising the use of available funds;
  - by reducing its staff, infrastructure and operating expenditure.
- The required building blocks of assurance remained in place throughout 2020 and continued to work adequately: management assessment, registration of exceptions and non-compliance events, audits, internal control and management systems, etc.
- The main risks to the delivery of the SESAR JU's key objectives were identified and the relevant mitigating measures taken, keeping overall risks under control and at an acceptable level of criticality.

Consequently, the Administrative Board concludes that the 2020 CAAR accurately and adequately describes the work performed by the SESAR JU in 2020.

[1] *Consolidated report on SESAR U-space research and innovation results*

[2] *Exploring the boundaries of ATM (2016-2020)*

Executive summary

This chapter provides a short description of the SESAR JU and its key achievements and main outcomes across its strategic areas of operation in 2020.

The SESAR JU in a nutshell

Table 1 provides a short description of the agency's mission, objectives and conditions under which the SESAR JU operates:

TABLE 1 THE SESAR JOINT UNDERTAKING IN 2020 IN BRIEF

Name	SESAR Joint Undertaking (SESAR JU)
Objectives	The SESAR JU is responsible for coordinating, rationalising and concentrating all relevant air traffic management (ATM) research and innovation (R & I) efforts in the EU, with the aim of contributing to the modernisation and harmonisation of ATM in Europe.
Founding Legal Act	Established under Council Regulation (EC) No 219/2007 of 27 February 2007 [3] Modified by Council Regulation (EC) No 1361/2008 (SESAR JU Regulation) [4] Last amended by Council Regulation (EU) No 721/2014 [5]
Executive Director	Florian Guillermet (mandate runs until March 2022)
Administrative Board [6]	Members with voting rights: 1) SESAR JU members • EU (founding member) • EUROCONTROL (founding member) • Airbus • AT-One Consortium • B4 Consortium • COOPANS Consortium • Dassault Aviation • DFS • DSNA • ENAIRE • ENAV • Frequentis consortium • Honeywell • INDRA • Leonardo • NATMIG • NATS • SEAC2020 Consortium • Skyguide • Thales LAS France SAS • Thales AVS France SAS 2) Representatives at European level of civil users of airspace: Members without voting rights: • the military • air navigation service providers (ANSPs) • equipment manufacturers • airports • staff in the ATM sector • the scientific community.
Other governance bodies	The Programme Committee The Scientific Committee The Master Planning Committee (MPC)
Strategic research agenda	SESAR 2020 Multiannual Work Programme, adopted by the SESAR JU Administrative Board in 2015 [7]: http://www.sesarju.eu/newsroom/brochures-publications/sesar-2020-multi-annual-work-programme

[3] Council Regulation (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR).

[4] Council Regulation (EC) No 1361/2008 of 16 December 2008 amending Regulation (EC) No 219/2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR).

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

[6] Composition as at 31 December 2020.

[7] Decision ADB(D)05-2015: '2020 SESAR Multiannual Work Programme adopted'.

The year in brief

Since early 2020, the aviation community has been dealing with a crisis on a scale never seen before, with significant consequences for every member of the SESAR JU. Despite this extremely challenging context, the SESAR JU made considerable progress in delivering the R & I activities of the SESAR 2020 programme, while at the same time preparing for the future and the transition towards the Digital European Sky. Thanks to its agile structure, the partnership was able to adapt its operations to the evolving situation and, in doing so, meet all its corporate objectives. The activities highlighted in this report emphasise the SESAR JU's support for several of the European Commission's strategic priorities, including the Green Deal, the goal of building a Europe fit for the Digital Age, and a stronger Europe in the world.

MAINTAINING ACTIVITIES 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 were facing, and continue to face, unprecedented economic challenges due to the coronavirus pandemic. The measures helped to preserve the overall scope and level of ambition of the SESAR R & I 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.

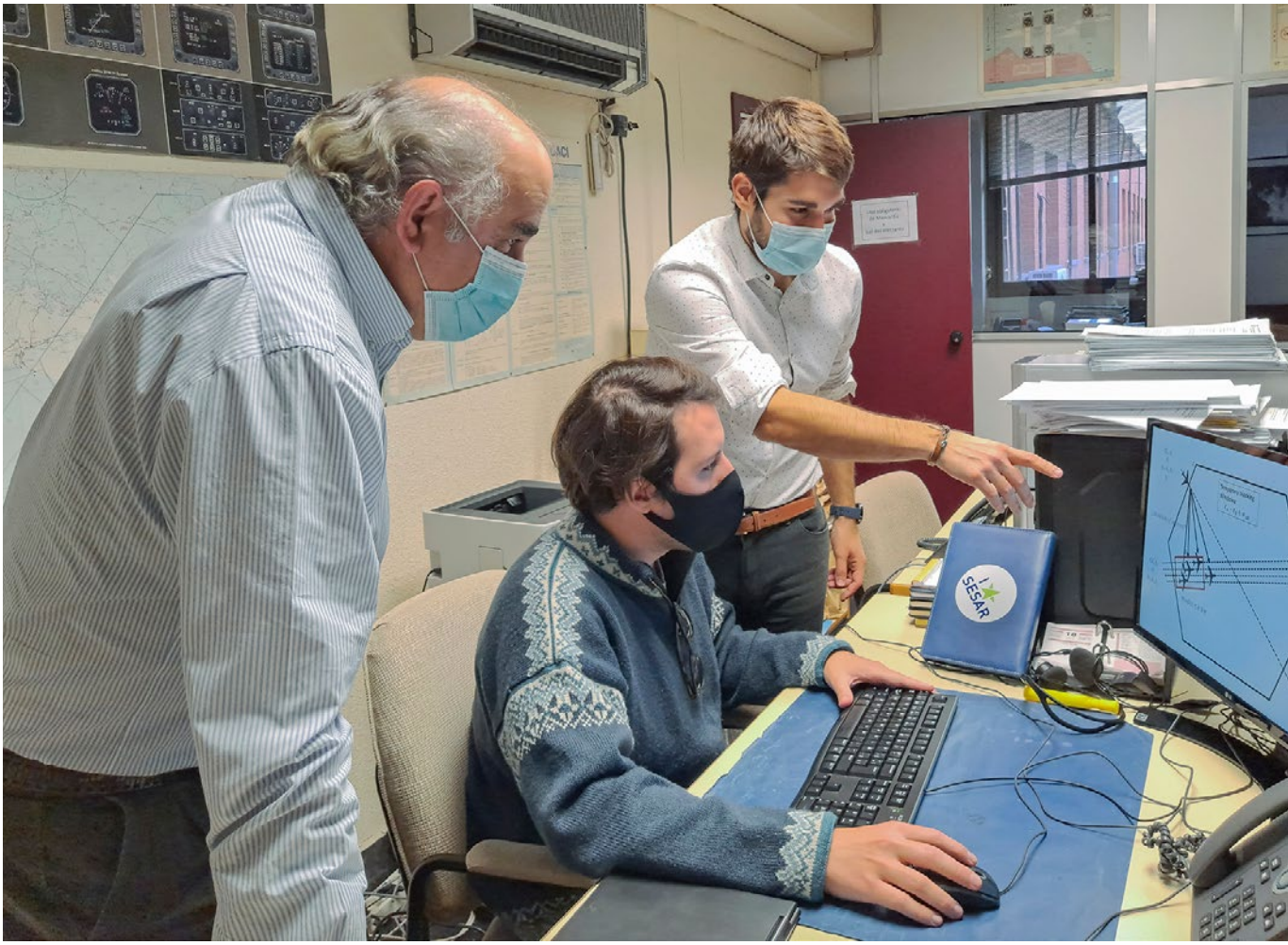
The measures included giving flexibility to projects, many of which involve operational stakeholders whose operations were severely curtailed throughout the year. Deadlines for published open calls were extended to allow stakeholders additional time to prepare their proposals. In addition, the SESAR JU made use of budget remaining from previous calls, reinjecting the funding into the programme and increasing pre-financing support to projects. At the same time, the partnership succeeded in reducing the financial contributions of members other than the EU and EUROCONTROL for a limited period, facilitated by cutting the running costs of the SESAR JU to the minimum.

In parallel with these practical measures of support, the SESAR JU also sought to steer discussions within the aviation community on the COVID-19 crisis and the relevance of SESAR innovation for the recovery of the sector. Passing the message through multiple channels and to a broad audience, the existing SESAR Digital Academy provided a suitable starting point. Over the course of the year, the partnership also organised Digital Sky Vodcasts, a series of live sessions with industry thought leaders to discuss the impact of the pandemic and how to build back better.

DELIVERING SOLUTIONS AND RESULTS AGAINST THE ODDS

Despite the challenging circumstances, SESAR JU members and partners were successful in advancing new technologies and procedures through the SESAR innovation pipeline, in accordance with the timeline set by the European ATM Master Plan – Europe's roadmap for the digital transformation of ATM. This resulted in the delivery of a batch of new digital solutions, 32 in total, ready for implementation. The delivery of these solutions is particularly timely, as they offer proven benefits in many key performance areas (KPAs), such as the environment, resilience, scalability, safety and cost efficiency.

At the same time, the SESAR JU completed a significant body of work related to U-space, the European Commission's initiative for the safe and secure integration of drones. With the support of its members, the partnership assessed the findings from recently closed projects, analysing the coverage and level of maturity of each U-space service. The analysis clearly showed that progress has been made on the building blocks of U-space, with project partners reporting plans to start implementation in their countries. The analysis also identified important gaps in terms of the performance of certain



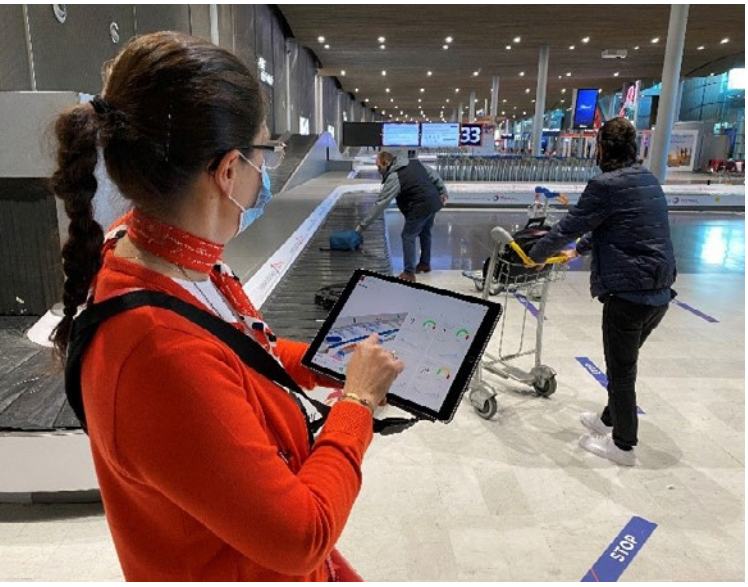
technologies or where more research is needed, especially in the area of urban air mobility (UAM) operations and the interface with manned aviation.

Another important output was the publication of results from the third wave of exploratory research. Taking place between 2016 and 2019, the projects brought together over 100 academic and industry partners, such as universities, small and medium-sized enterprises (SMEs), research centres, airlines, manufacturers and ANSPs from across the EU and EU-associated countries. The projects explored innovations and new technologies not just in aviation and ATM, but also in other sectors, such as the automotive, robotics and system engineering sectors, as well as in other safety-critical industries, such as the nuclear and space industries. The most promising and mature technologies are being fed back into the pipeline for further work (see below).

Altogether, these innovative concepts and solutions are contributing to the drive to futureproof Europe's aviation infrastructure, in line with building a Europe fit for a digital age.

FEEDING THE SESAR INNOVATION PIPELINE

To continue to deliver solutions and make progress on the digital transformation of ATM, the SESAR JU launched 67 projects across its three strands of research in 2020, namely exploratory research (ER) (41 projects), industrial research and validation (IR) (15 projects) and very large-scale demonstrations (VLDs) (11 projects).



The selected projects address a wide variety of topics that are key to increasing the resilience of the system, enabling scalability and enhancing safety. These include artificial intelligence (AI) tools to enable greater levels of automation, solutions to support intermodality, dynamic airspace configuration, flight-centric operations, virtual centres (e.g. delegation of air traffic services (ATS)), collision avoidance, and future satellite technologies, including 5G. Considering the urgency of the climate impact of aviation, many of the newly launched projects are focused on leveraging digital technology in order to support a swift transition to greener aviation, in line with Europe's Green Deal. These include projects investigating climate mitigation solutions and a large-scale demonstration aimed at accelerating the implementation of existing fuel-efficient solutions across all phases of flight.

The launch of these projects has led to an increase in the number and diversity of organisations participating in the programme. There are now close to 500 different beneficiaries, of which 24 % are SMEs, 16.4 % are higher education organisations or universities, and 8 % are research organisations.

ADVANCING LEARNING, SCIENTIFIC EXCELLENCE AND INNOVATION IN ATM

In 2020, the SESAR JU ran a series of webinars under the banner of the SESAR Digital Academy, providing participants with an in-depth view of the broad range of research that is under way across the SESAR 2020 programme. A total of 18 webinars, with an average of 400 participants, were held throughout the course of 2020, reaching a total global audience of over 3 700 participants. The webinar format has made the content of the SESAR 2020 programme accessible to the European public in a way that had never been possible before. All the material, including presentations, webinar replay link and full live questions and answers (Q & A) file, are available online, constituting an invaluable educational online resource for researchers, operational stakeholders and the interested general public.

PREPARING FOR THE FUTURE

In 2020, the European Commission requested the support of the SESAR JU to prepare the draft Strategic Research and Innovation Agenda (SRIA) for the Digital European Sky. Prepared within the framework of the SESAR

JU's Master Plan project, it details the R & I roadmaps to achieve the Digital European Sky including the integration of drones, and for achieving the ambitions of the 'European Green Deal' and the 'Europe Fit for the Digital Age' initiative.

The priority actions required to build a digitalised infrastructure that are outlined in the SRIA 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, 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). 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 (AUs), including new entrants.

ENSURING SMOOTH OPERATIONS

Underlying all this work are the corporate, financial and administrative activities of the SESAR JU. The crisis required the SESAR JU to trigger its own business continuity measures, and to make significant budgetary adaptations to alleviate the financial pressure facing its members. At the same time, grant management, legal and finance staff successfully ensured the smooth and timely launch and execution of calls, grants and projects. The drive for efficiency gains continued in 2020 with the establishment of an internal control strategy, in line with the European Commission internal control framework (ICF). In addition, 2020 saw the roll-out in all EU agencies, including the SESAR JU, of SYSPER, the Commission's human resources (HR) management platform, and accompanying tools to support staff in using the system.

Finally, 2020 also saw the conclusion of SESAR 1, with excess cash contributions being reimbursed to members.

Part I.
Achievements of 2020

The SESAR JU established this Consolidated Annual Activity Report (CAAR) in accordance with Article 74(9) of the EU financial regulation ([8]) and Article 48 of the framework financial regulation ([9]), Article 16 of the statutes of the SESAR JU ([10]) and Article 47 of the financial rules ([11]) of the SESAR JU.

This CAAR has several purposes.

- It provides evidence of progress towards achieving the SESAR JU's key objectives as defined in the 2020–2022 SPD implementing the SESAR 2020 Multiannual Work Programme (MAWP) ([12]), taking into account resources used during the reporting period.
- It outlines the management and oversight systems in place at the SESAR JU, including reference to the European Commission's ICF.
- It includes a declaration of assurance in which the Executive Director, in his role as authorising officer, provides reasonable assurance regarding the true and fair view given by the report and pertaining to the legality and regularity and the sound financial management of all transactions under his responsibility, and provides reasonable assurance that resources assigned to the activities reported upon in the CAAR have been used for their intended purpose and in accordance with the principle of sound financial management.

The SESAR JU has developed this CAAR in accordance with the guidelines set out in the Commission communication on the guidelines for programming documents for decentralised agencies and the template for the CAAR for decentralised agencies ([13]).

The SESAR JU was created under Article 171 of the treaty establishing the European Community and confirmed under Article 187 of the treaty on the functioning of the EU to provide an effective coordination role for all relevant research and development efforts within the EU. Its mandate and mission are coherent with the high-level goals of the single European sky (SES) initiative.

Founded by the EU and EUROCONTROL, the SESAR JU was established in 2007 as a joint undertaking ([14]), and became an EU body in 2009. It was subsequently augmented by 15 stakeholder members and then, in 2016, by a further four members, all committed to achieving the mission of the agency by 2024. Together with their partners and affiliates, the SESAR JU members other than the EU represent over 120 organisations from across the ATM community, including civil and military ANSPs, airports, civil and military AUs, staff associations, academic institutions and research centres. Through these partnerships and further collaboration with staff associations, regulators and the larger scientific community, the SESAR JU unites the skills of some 3 000+ experts to fast-track and focus research leading to change in European ATM.

([8]) Regulation (EU, Euratom) No 2018/1046 of 18 July 2018 of the European Parliament and of the Council on the Financial Rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014 and (EU) No 283/2014 and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012 (OJ L 193, 30.7.2018, p. 1).

([9]) Commission Delegated Regulation (EU) No 2019/715 of 18 December 2018 on the framework financial regulation for the bodies referred to in Article 70 of Regulation (EU, Euratom) No 2018/1046 of the European Parliament and of the Council (OJ L 122, 10.5.2019, p. 1).

([10]) Annex to Council Regulation (EC) No 19/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR).

([11]) Administrative Board decision ADB(D)21-2019.

([12]) The MAWP, which was approved by the Administrative Board in 2015, is updated through Single Programming Documents established each year; it can be consulted on the SESAR JU website: http://www.sesarju.eu/newsroom/brochures-publications/sesar-2020-multi-annual-work-programme

([13]) Commission communication COM (2020) 2297 final, 'on the strengthening of the governance of Union Bodies under Article 70 of the Financial Regulation 2018/1046 and on the guidelines for the Single Programming Document and the Consolidated Annual Activity Report'.

([14]) The SESAR Joint Undertaking (SESAR JU) was established under Council Regulation (EC) 219/2007 of 27 February 2007 (as modified by Council Regulation (EC) 1361/2008 (SESAR JU Regulation) and last amended by Council Regulation (EU) 721/2014).

The publication, in December 2015, of the European Commission document *An Aviation Strategy for Europe* [15] placed renewed focus on the SES initiative and increased the momentum to bring it to completion and achieve its goals of generating growth for European businesses, fostering innovation and enabling passengers to profit from safer, cleaner and cheaper flights, as well as from more connections. The strategy contributes directly to the achievement of the Commission's priorities of jobs and growth, a digital single market, energy union and the EU as a global actor, and the SESAR project and the SESAR JU are key to the implementation of the strategy's objectives.

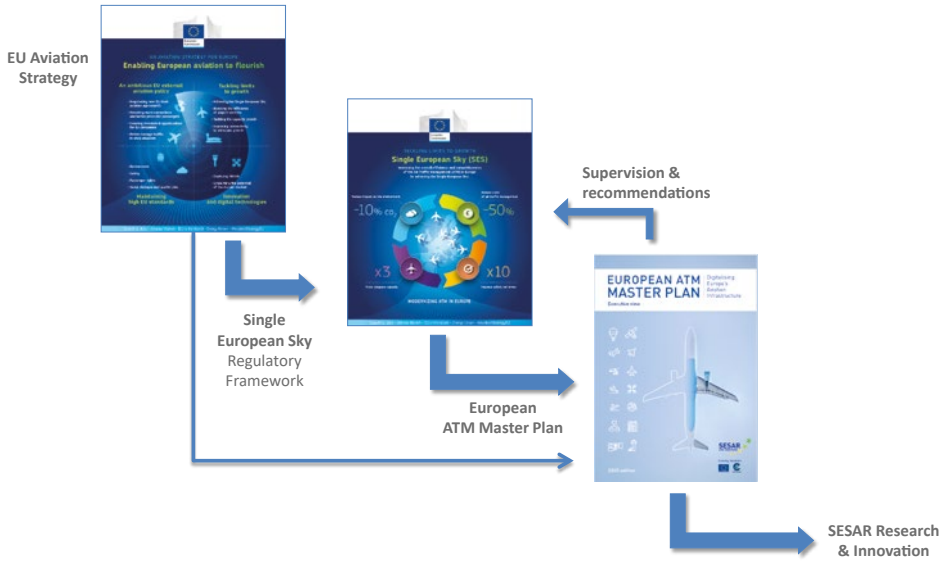
The SES legislative framework aims to achieve the following high-level goals:

- a threefold increase in capacity (this, it is hoped, will also reduce delays both on the ground and in the air),
- an improvement in safety by a factor of 10,
- a 10 % reduction in the environmental impact of flights,
- a 50 % reduction in the cost of ATM per flight.

The SESAR project, through its three phases (definition; development; and deployment), aims to deliver the operational procedures and technologies necessary for a new and global interoperable concept of ATM, built around a continuous sharing of data between aircraft, ANSPs and airports.

The challenges for ATM are captured by the SESAR JU in the European ATM Master Plan, which is the main planning tool for ATM modernisation in Europe. The role of the SESAR JU in coordinating and concentrating the SESAR research and innovation (R & I) is to define and develop solutions for building a more connected, greener, safer ATM system this is standardised and globally interoperable. Much of this work has been undertaken since 2008 through the SESAR R & I programme (called SESAR 1 for the period covering 2008 to 2016, and SESAR 2020 with a maximum period for award of grants ending in December 2020). Figure 1 shows the central role of the SESAR JU in driving and coordinating ATM R & I in relation to EU policy:

FIGURE 1 THE CENTRAL ROLE OF THE SESAR JU IN DRIVING AND COORDINATING ATM INNOVATION IN THE EU

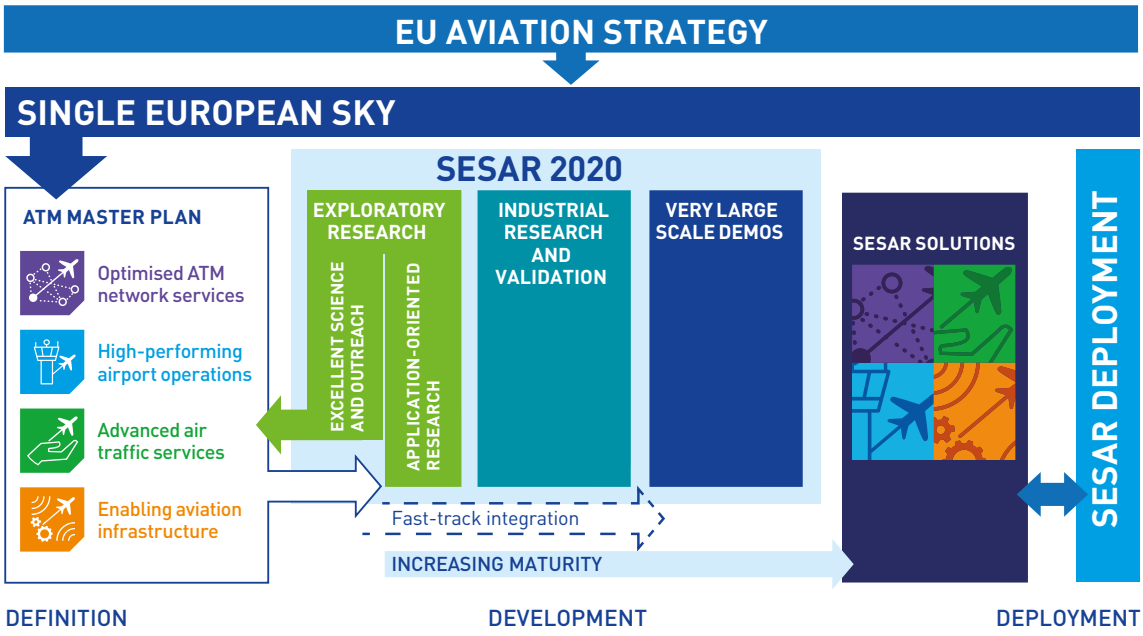


[15] http://ec.europa.eu/transport/modes/air/aviation-strategy

SESAR 2020 activities are funded through four different funding instruments. The Horizon 2020 Framework Programme for R & I (H2020) provided EUR 585 million, and the Connecting Europe Facility (CEF) provided EUR 10 million specifically for drone U-space demonstration activities. In addition, two initiatives were funded by assigned revenue (revenue used to finance specific items of expenditure), one to the value of EUR 500 000 and another to the value of EUR 800 000. This amounts to total funding from the EU of EUR 596.3 million. The SESAR JU maintains full compliance with these frameworks.

The SESAR JU transfers the results of its ATM R & I activities in the form of SESAR Solutions ([16]), making them available for deployment, and thereby offering making a positive contribution towards the achievement of the SES. The EU aviation strategy, the SES objectives, the ATM Master Plan (setting out how medium- and long-term objectives can be achieved) and the R & I activities that ultimately deliver SESAR Solutions transferred to deployment together make up the SESAR innovation pipeline (Figure 2).

FIGURE 2 THE SESAR INNOVATION PIPELINE – FROM EU AVIATION STRATEGY TO SESAR SOLUTIONS



As shown in Figure 2, the SESAR innovation pipeline starts with the European ATM Master Plan, which classifies ATM modernisation activities into four key areas: optimised ATM network services, high-performing airport operations, advanced ATS and enabling aviation infrastructure. Operational and technology solutions then pass through three R & I phases, maturing as they pass along the pipeline. The level of maturity of research outcomes is assessed using the European Operational Concept Validation Methodology (EOCVM), a well-established control and monitoring process linked to technology readiness level (TRL).

- ER addresses relevant fundamental scientific subjects that represent transversal topics for future ATM evolution ('excellent science and outreach') and investigates their potential application to the ATM sector ('application-oriented research'). ER covers research activities up

to TRL-2 ([16]). This phase of research also includes the work of SESAR's Knowledge Transfer Network (KTN), whose aim is to facilitate the development of ATM research in Europe in support of the SESAR JU. Exploratory research is wholly funded by the EU and is fully compliant with H2020 and its rules for participation ([17]). Calls for funding are open to all, thus attracting proposals from stakeholders beyond the membership of the SESAR JU, including from universities and research centres.

- IR includes applied research, pre-industrial development and validation projects, results in the development of SESAR Solutions. Annual releases of these technologies are assessed for maturity and potential benefit. IR covers research activities up to maturity levelV3/TRL-6.
- Very large-scale demonstration (VLD) activities are demonstrations of SESAR Solutions or of particular elements of a programme concept. These demonstration activities act as a bridge between the development and deployment phases of SESAR. They are funded by H2020 or the CEF (drone U-space demonstration activities) or, in the case of work undertaken by SESAR JU members other than the EU, by assigned revenue (through restricted calls), but also by open calls to ensure participation by a range of stakeholders beyond SESAR JU members, including SMEs and new entrants.

Provided a cost–benefit analysis returns a positive result, SESAR Solutions whose level of maturity is assessed to be V3/TRL-6 pass to the stage of deployment, in the form of either common projects or other types of deployment activities (e.g. at the national level).

The SESAR JU, as part of its remit as the technological pillar of the SES, also assists its stakeholders by providing independent support and advice on topics relevant to SESAR deliverables or on initiatives that demonstrate a high level of interdependency with SESAR project objectives.

The EU aviation strategy not only addresses the role of technology and innovation but recognises the need to secure Europe's leading role in international aviation. To this end, the SESAR JU also works closely with the European Commission, EUROCONTROL and European Union Aviation Safety Agency (EASA) on building and executing a coordinated plan of action involving third countries and the ICAO.

Part I of the CAAR first highlights progress and presents the cumulative achievements of the SESAR JU since 2014, then presents the achievements of 2020 in relation to the annual objectives for the SESAR JU's six strategic areas of operation, namely:

1. provide strategic steering to the SESAR programme,
2. deliver ER,
3. deliver IR,
4. deliver VLD activities,
5. deliver SESAR outreach,
6. deliver effective financial, administrative and corporate management.

All the objectives related to the abovementioned strategic areas of operation were achieved in 2020.

([16]) As required by H2020, the maturity of research outcomes is assessed using the TRL model, combined with the EOVCM model for the assessment of technological and operational concept developments.

([17]) Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in 'Horizon 2020 – the Framework Programme for research and Innovation (2014-2020)' and repealing Regulation (EC) No 1906/2006 (OJ L 347, 20.12.2013, p. 81).

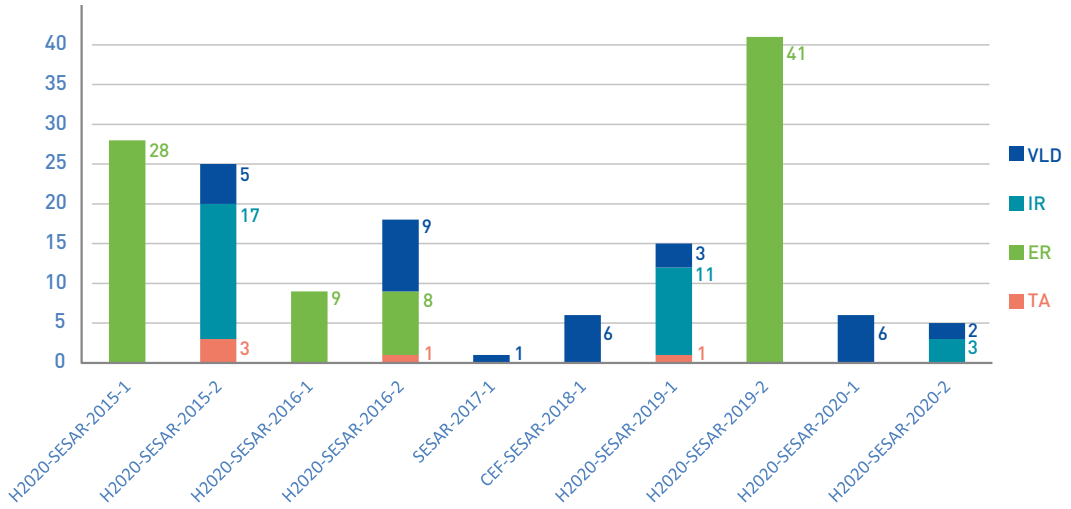
1.1. Context and reference for the overall achievements of the year

1.1.1. Overview of calls and grants up to 2020

A programme set up gradually from 2015 until 2020 ...

By the end of 2020, the SESAR 2020 programme had funded projects in each phase of the SESAR innovation pipeline through 10 calls for proposals under three different legal frameworks (Figure 3).

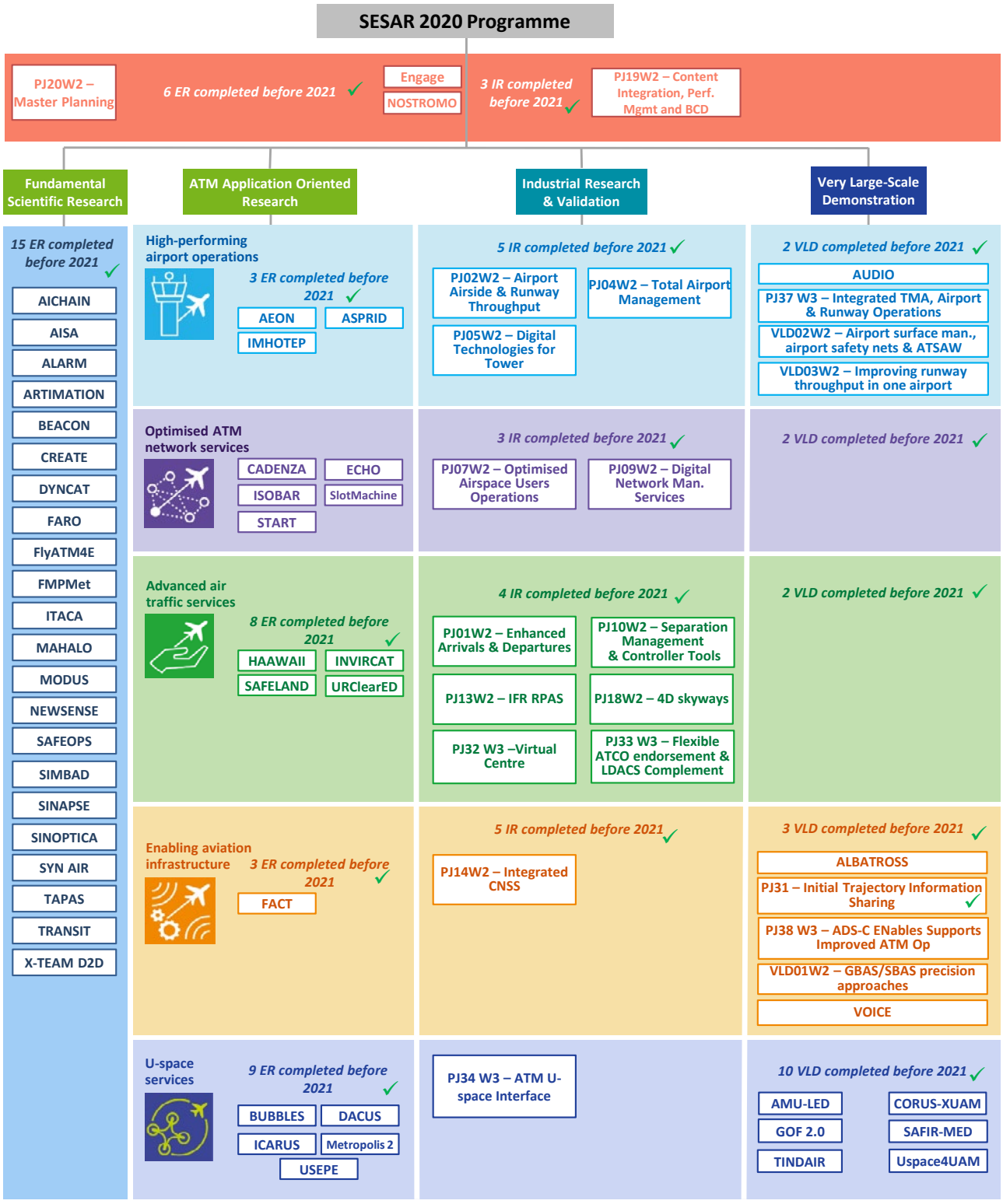
FIGURE 3 NUMBER OF PROJECTS IN EACH PHASE OF THE SESAR INNOVATION PIPELINE IN EACH CALL FOR PROPOSALS (TO END-2020)



... composed of a large variety of projects addressing the topics of the SESAR 2020 Multiannual Work Programme

The portfolio of projects resulting from these calls is structured in accordance with the topics defined in the SESAR 2020 MAWP, as shown in Figure 4.

FIGURE 4 PORTFOLIO OF PROJECTS RELATING TO EACH RESEARCH TOPIC OF THE SESAR 2020 PROGRAMME AT THE END OF 2020 [18]



[18] Figure 4 shows 153 projects in progress or closed, as two projects (Tindair and USpace4UAM) resulting from call for proposal VLD 2 Open with reference H2020-SESAR-2020-1 were still in the grant agreement preparation phase at the end of 2020.

FIGURE 5 EVOLUTION OF SESAR 2020 CALL-RELATED COMMITMENTS (EUR) UNTIL 2020

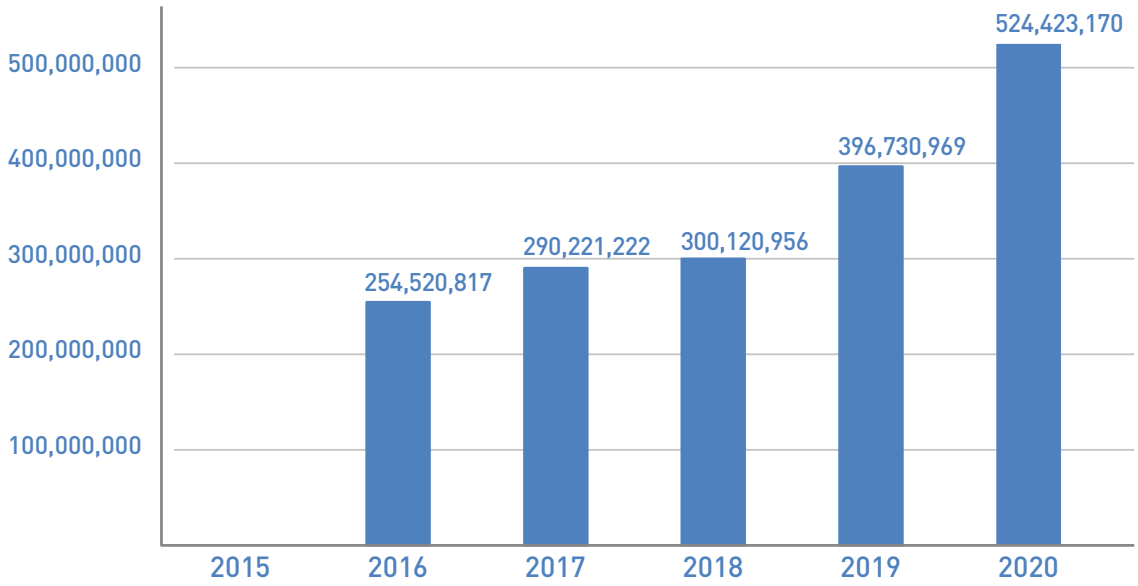


Figure 5 shows that the SESAR JU invests 90 % of its total budget from the EU (EUR 596.3 million) in R & I projects resulting from calls for proposals under H2020, the CEF and other frameworks [19], the rest being allocated to the procurement of services and studies in relation to core operations (covered from a budgetary perspective in Title 3, Operational expenditure) and to running costs (covered from a budgetary perspective in Title 1, Staff expenditure, and Title 2, Infrastructure and operating expenditure).

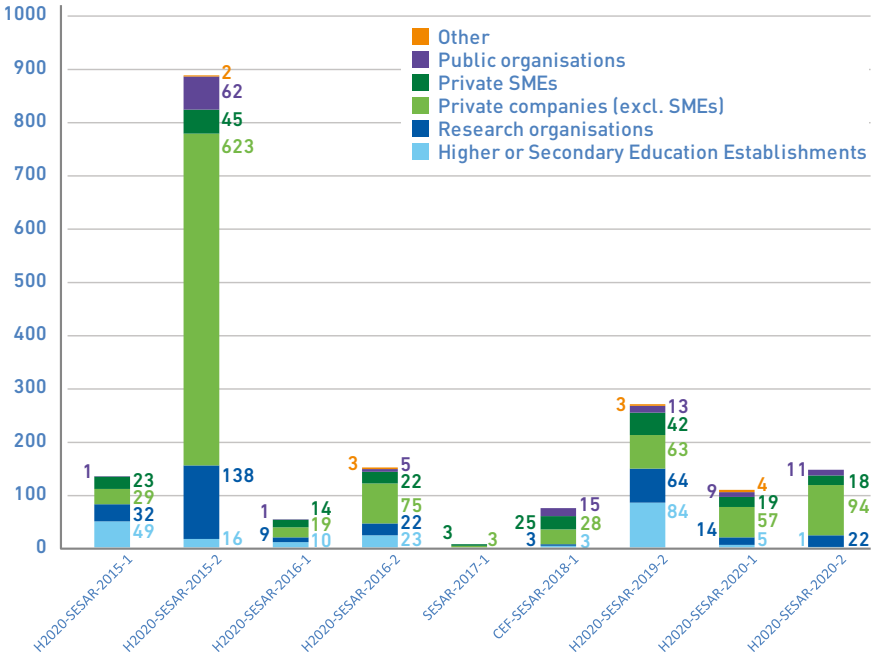
Further information on the calls for proposals, their outcomes and the resulting projects is provided in chapters 1.2 to 1.5 below.

A programme benefiting a broad range of stakeholders

All types of organisations targeted by H2020 are beneficiaries of the SESAR 2020 calls for proposals or linked third parties (Figure 6).

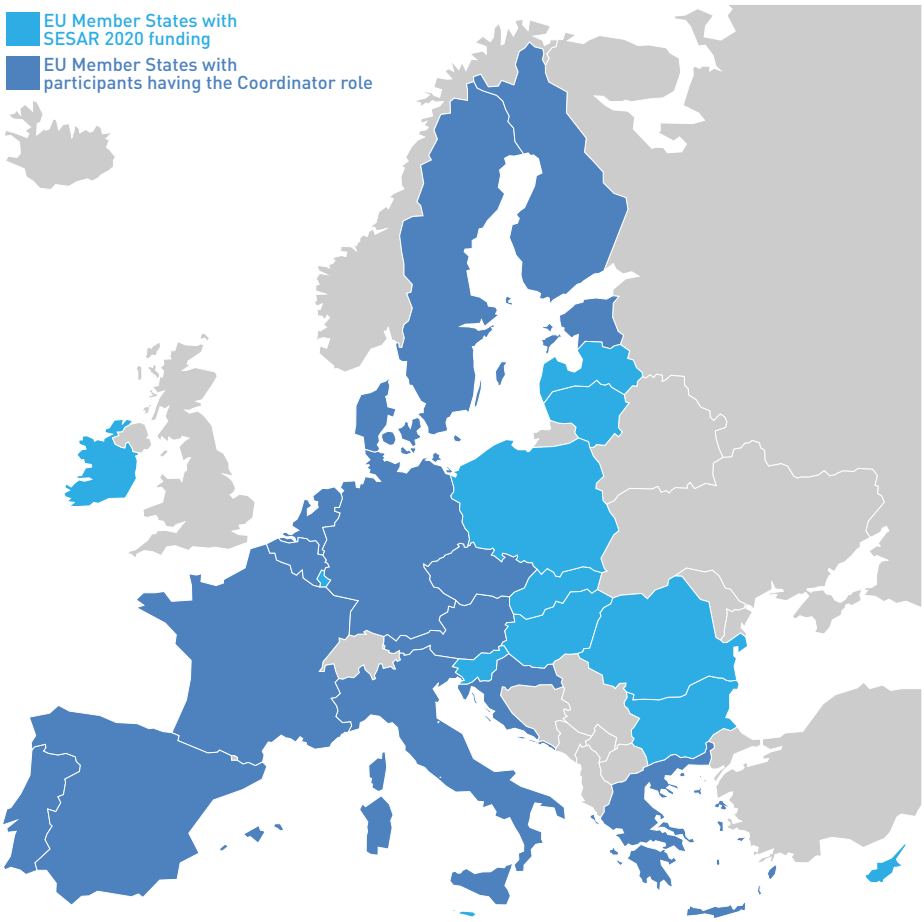
[19] In addition to the EU contribution of EUR 585 million established under the H2020 programme, the SESAR JU received a further EUR 11.3 million from the European Commission under three delegation agreements that mandate the SESAR JU to carry out additional activities in the area of air traffic management:
- delegation agreement EC/SESAR JU ref. MOVE/E3/DA/2016-669/SI2.743803, signed on 6 December 2016, with a delegated budget of EUR 500 000 in assigned revenue to organise a call for proposals for a geofencing demonstration, in accordance with Articles 54(2)(a) and 58(1)(c)(iv) of Regulation (EU, Euratom) No 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union (EU Financial Regulation) (OJ L 193, 30.7.2018, p. 1),
- delegation agreement EC/SESAR JU ref. MOVE/E3/DA/2017-477/SI2.766828, signed on 10 November 2017, with a delegated budget of EUR 800 000 in assigned revenue to procure a study to develop a proposal for the future architecture of European airspace,
- delegation agreement EC/SESAR JU ref. MOVE/E3/DA/2017-564/si2.771010, signed on 13 December 2016, with a delegated budget of EUR 10 million in assigned revenue from the CEF to organise a call for proposals on U-space demonstrations.

FIGURE 6 BENEFICIARIES OF SESAR 2020 FUNDING, BY TYPE OF ORGANISATION



This funding is distributed across 27 EU Member States (Figure 7).

FIGURE 7 SESAR 2020 FUNDING FOR EU MEMBER STATES AT THE END OF 2020



1.1.2. The innovation pipeline in practice (2015–2020)

As shown in Figure 2, SESAR 2020 programme activities form the SESAR innovation pipeline, which comprises three successive phases of R & I: ER, IR and VLDs. The paragraphs below provide an overview of the cumulative achievements in each of these three phases since the beginning of the SESAR 2020 programme.

1.1.2.1. Delivery of exploratory research

To meet the objectives set in the European aviation strategy, the innovation pipeline first delivers outputs in the form of scientific results through a portfolio of ER projects. The SESAR JU has delivered 45 ER projects resulting from three open calls for proposals funded by a total EU contribution of EUR 38.6 million:

- H2020-SESAR-2015-1 exploratory research call 1 (ER1) on ATM excellent science & outreach and ATM application-oriented research,
- H2020-SESAR-2016-1 exploratory research call 2 (ER2) on remotely piloted aircraft systems (RPAS),
- H2020-SESAR-2016-2 exploratory research call 3 (ER3) on transversal ER and ATM application-oriented research.

The first call for proposals for ER projects [20] to be carried out under the SESAR 2020 programme (ER1) was launched in 2015, and 28 projects aiming to produce tangible results in the fields of ATM excellent science and outreach and ATM application-oriented research were fully funded under H2020. In 2018, all 28 ER1 projects completed their activities and delivered promising results on automation and science applied to ATM. The outcomes of 11 of these projects were incorporated into the specifications of the call for proposals for the next wave of projects in the second R & I phase, IR projects (referred to as the Wave 2 call; see below), showing the effectiveness of the SESAR innovation pipeline.

In addition, under the second call for proposals (ER2), in 2016, which focused on RPAS, nine projects received funding, enabling new RPAS actors to embark on the SESAR journey. These projects, which are since closed, addressed a wide variety of topics, including the concept of operations (ConOps) for drone operations, critical communications, surveillance and tracking, information management, aircraft systems, ground-based technologies, cyber-resilience and geofencing.

The third call for proposals, ER3, was launched at the end of 2016. Funding was awarded to eight projects addressing new metrics to capture network effects; a new methodology and guided approach for fast-time simulation; advanced prediction models for flexible trajectory-based operations;

[20] For more details, see *Exploring the boundaries of air traffic management: a summary of SESAR exploratory research results 2016–2020* (available at. https://op.europa.eu/en/publication-detail/-/publication/04378ccb-dab0-11ea-adf7-01aa75ed71a1).

or measures to manage global navigation satellite system (GNSS) threats (e.g. jamming, spoofing). One project (Engage) assumed the role of the SESAR 2020 KTN. The rationale of ER3 in which projects to fund was twofold: to inspire new researchers and to help to align SESAR ER and IR through a wide range of activities and financial support actions. Further details can be found in paragraph 1.3.2, 'Status of exploratory research 3 call (H2020-SESAR-2016-2), below.

A final call for proposals on ER, referred to as ER4, was launched in 2020, and the call management procedure resulted in the funding of 41 new projects. A summary of the call management procedure and of these projects can be found in paragraph 1.3.3, 'Status of exploratory research 4 call (H2020-SESAR-2019-2', below.

Other activities related to ER carried out during 2020 were intended to foster innovation and advanced technology in ATM. In particular, SESAR Innovation Days were held in various EU Member States to support dissemination of project results throughout the research community while the Young Scientist Award, which again took place in 2020, recognises young scientists with the potential to contribute to scientific research in the field of ATM. Finally, 2020 saw the ramp-up of the SESAR Digital Academy, launched in 2019 to bring together, under one umbrella, access to SESAR ER activities and outreach relating to education and training, as well as professional learning opportunities offered by research centres, universities, industry partners and other entities within the ATM/aviation domain. More information on these events can be found in subparagraph 1.6.3.1, 'Events and conferences', below.

Taken together, ER projects funded by the SESAR 2020 programme benefited 226 different organisations, of which 44 % were higher education organisations or research centres from all over Europe.

1.1.2.2. Delivery of industrial research

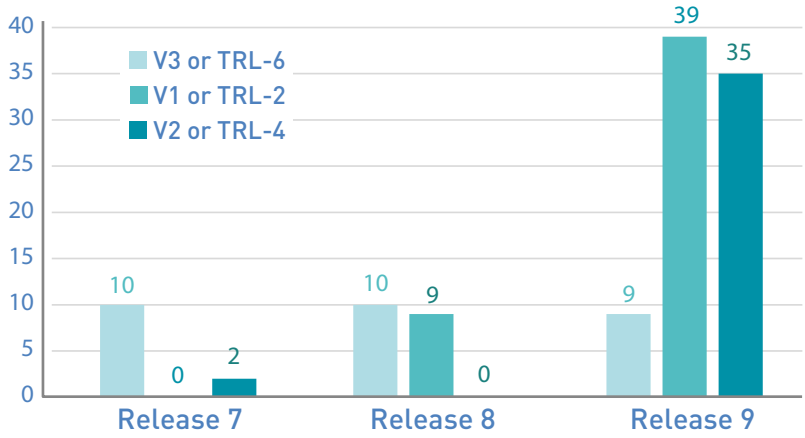
A robust delivery process ...

The SESAR JU release process enables members and partners to carry out research in stages and at each stage to validate SESAR candidate solutions in real-life operational environments. Thus, the SESAR JU, with validation sites across Europe, has taken R & I out of the lab and connected it to the real world. A total of 114 SESAR candidate solutions were developed and validated as part of the IR activities carried out under the 17 Wave 1 projects that resulted from the restricted call for proposals with the reference H2020-SESAR-2015-2 (W1).

Activities carried out in these projects covered the four key features of the ATM Master Plan, namely optimised ATM network services, high-performing airport operations, advanced ATS and enabling aviation infrastructure. Three additional projects focused on transversal steering activities, namely the maintenance of the ATM Master Plan, the management of system engineering requirements and content integration (e.g. consolidation of the performance results).

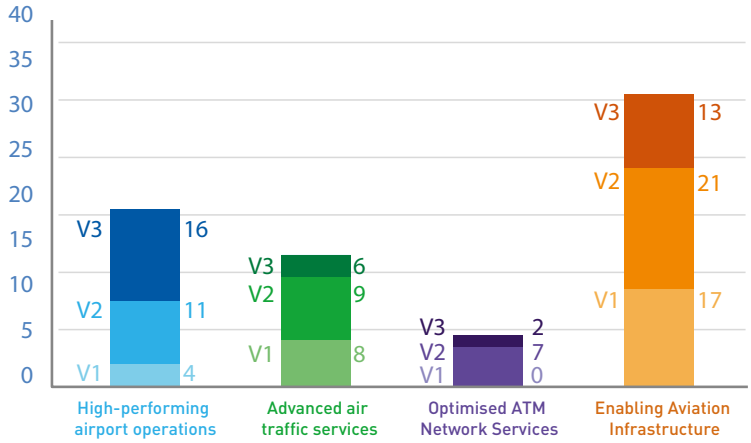
Through the release process, SESAR candidate solutions are validated at a certain maturity level, V1 (or TRL-2), V2 (or TRL-4) or V3 (or TRL-6), the last corresponding to readiness for industrialisation and further deployment. Releases are delivered every year. Figure 8 shows the number of (candidate) SESAR Solutions delivered through releases since the launch of the SESAR 2020 programme: Release 7, during the ramp-up of the programme; Release 8 (which concluded in April 2019) and Release 9 (starting in 2019 and concluding in April 2020).

FIGURE 8 NUMBER OF (CANDIDATE) SESAR SOLUTIONS DELIVERED IN RELEASES 7, 8 AND 9 (AT THE END OF 2020)



Some, but not all, SESAR Solutions increase in maturity across the different releases. Figure 9 summarises the numbers of SESAR Solutions delivered in Releases 7–9 of Wave 1 that reached each maturity level, categorised by the key feature of the ATM Master Plan addressed by the projects.

FIGURE 9 TOTAL NUMBER OF (CANDIDATE) SESAR SOLUTIONS DELIVERED THROUGH RELEASES 7, 8 AND 9 ACHIEVING EACH LEVEL OF MATURITY, BY KEY FEATURE (AT THE END OF 2020)



In Wave 1, total funding of EUR 202.7 million was awarded to 125 beneficiary organisations, of which 39 were SESAR JU members, either in their own right or as part of a consortium ([21]), 80 were linked third-parties and nine were SMEs.

In 2020, the SESAR JU identified, from responses to the IR-VLD Wave 2 call for proposals, which was launched in early 2019, candidate solutions that warrant further development as well as the next set of candidate solutions that it is hoped, by the end

([21]) In addition to EUROCONTROL (Founding Member), there are a further 19 stakeholder organisations, some of which are consortia.

of 2022, will complement the performance gains already provided by the SESAR 2020 programme. The Wave 2 call resulted in the award of funding to 12 IR projects. In addition, in 2020, the SESAR JU prepared and launched a final call for proposals for IR projects, IR-VLD Wave 3, using funds remaining from the amount set aside for Wave 1 projects. As a result, three additional IR projects were funded. All the projects resulting from these calls were launched in execution during 2020 and will allow further development of some of the 45 candidate solutions that reached early levels of maturity at the end of Wave 1, as well as others that were identified in the Wave 2 preparation process. For instance, some candidate solutions at the V2 or TRL-4 level of maturity will be further developed and delivered through the subsequent releases up to 2022 under Wave 2 and Wave 3.

More information on the Wave 2 and Wave 3 projects can be found in paragraphs 1.4.2, 'Status of IR projects under the Wave 2 call (H2020-SESAR-2019-1)', and 1.4.3, 'Status of the Wave 3 call (H2020-SESAR-2020-2)', below.

... accelerating the development pace ...

The release system and validation process, which are run in close coordination with SESAR JU members, have also demonstrated that it is possible to accelerate development. Candidate solutions arising from SESAR 1 took, on average, 10 years to reach the maturity level 'ready for industrialisation'; in the case of SESAR 2020 projects, the average development time has fallen to six years. Furthermore, the total development time can be broken down into the time required for technologies to transition from V1 to V2 and from V2 to V3. A comparison of these times for SESAR 1 and SESAR 2020 Wave 1 projects shows that, although the average time required for completion of V1 is similar, the time required to reach V2 is 33 % lower for SESAR 2020 projects than for SESASR 1 projects, while the time required to transition from V2 to V3 is 46 % lower. Table 2 presents the time, in years, taken to move from each maturity level to the next as well as the cumulative number of years required to reach the V3 level.

TABLE 2 **PACE OF DEVELOPMENT OF CANDIDATE SOLUTIONS**

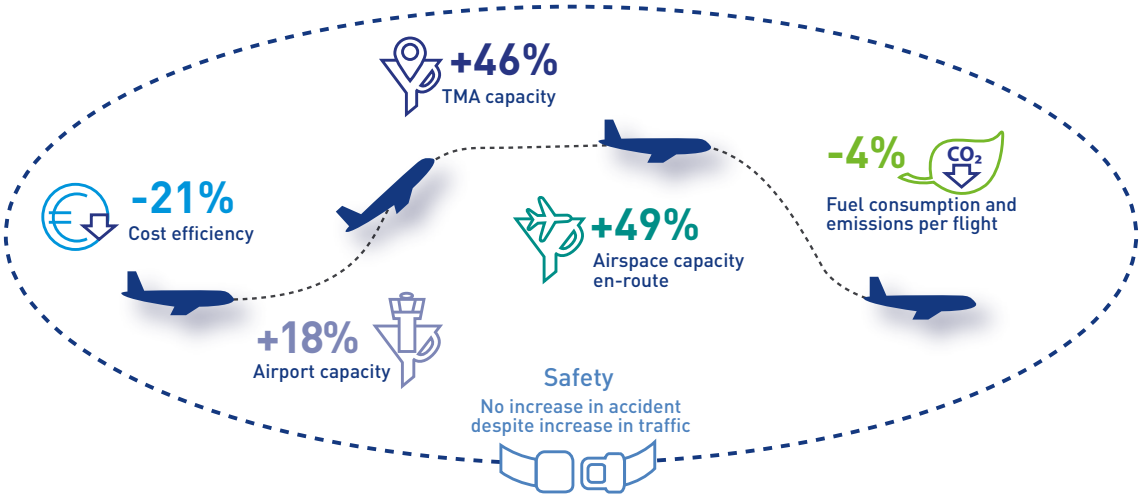
		SESAR 1	SESAR 2020	Acceleration
V0 to V1		**2,00**	**1,96**	
	V0 to V1	3,41	2,29	33%
V0 to V2		**5,41**	**4,25**	**21%**
	V2 to V3	4,4	2,38	46%
V0 to V1		**9,81**	**6,63**	**32%**

... answering to the performance ambition established in the European ATM Master Plan ...

The SESAR JU, in addition to implementing a development and validation process for SESAR candidate solutions, has designed a performance management process to measure the performance of validation activities against the ambitions recorded in the European ATM Master Plan, which are translated into KPAs and related measurable indicators – key performance indicators (KPIs).

The SESAR 2020 programme has already made an effective contribution to the performance targets set out in the 2015 edition of the European ATM Master Plan. Figure 10 depicts diagrammatically the overall targets for SESAR 1 and the SESAR 2020 Wave 1 solutions in each of the six KPAs of the ATM Master Plan. Achieving these targets will require solutions to be deployed in an optimal and timely manner. It shows the expected performance contribution to the six ATM Key Performance Areas (KPAs) of the SESAR Performance Framework, which represent the part of the SES performance ambitions that the SESAR Programme is expected to achieve:

FIGURE 10 CONTRIBUTION OF SESAR 1 AND SESAR 2020 WAVE 1 CANDIDATE SOLUTIONS TO THE ACHIEVEMENT OF THE PERFORMANCE AMBITIONS SET OUT IN THE EUROPEAN ATM MASTER PLAN (TMA, TERMINAL MANOEUVRING AREA)



... enabling to cover the Master Plan 2015 ...

Since 2012, significant progress has been made on completing the R & I activities of the first SESAR JU work programme (SESAR 1), leading to the delivery of SESAR Solutions, many of which are currently being implemented.

Building on the 2012 edition of the Master Plan, the vision outlined in the 2015 Master Plan is to achieve 'high-performing aviation for Europe' by 2035. This vision reflects the goals captured in the SES II initiative, which calls for 'more sustainable and better performing aviation' (2), and in *Flightpath 2050 – Europe's Vision for Aviation* (3), which envisages that, in 2050, 'The European aviation community leads the world in sustainable aviation products and services, meeting the needs of EU citizens and society'.

Fulfilment of the vision requires the implementation of trajectory-based operations (TBOs) such that aircraft can fly their preferred trajectories without being constrained by airspace configurations, which in turn relies on the provision of air navigation services (ANS) to support the execution of the business or mission trajectory. Achievement of the vision will be enabled by a progressive increase in the level of automation support, the implementation of virtualisation technologies and the use of standardised and interoperable systems. It is envisaged that, as a result of the expansion of digitalisation technology, the infrastructure will progressively evolve, allowing ANSPs, irrespective of national borders, to plug in their operations where they are needed, supported by a range of information services. Airports would be fully integrated into the ATM network, which would facilitate and optimise AUs' operations.

To achieve this vision, the SESAR JU identified a set of 'key R & I activities' relating to each of the four ATM key features. A 'key R & I activity' can be defined as an ATM operational change that provides significant network performance improvements to the operational stakeholders.

Thus, the 2015 Master Plan was used to define the SESAR 2020 programme to ensure that the programme would develop, validate and deliver the SESAR Solutions needed to meet the objectives set out in Master Plan.

Most of the key R & I activities were addressed by the Wave 1 projects through the development of the related SESAR Solutions. Indeed, only four out of 44 key R & I activities were not covered by the Wave 1 proposals.

- One such activity related to ad-hoc delegation of separation to flight deck. This refers to changes to in-trail flying procedures to allow a reduction in

procedural separation minima between two aircraft by delegating the responsibility for ensuring separation to the pilots. The concept was first addressed as part of the SESAR 1 programme. The R & I results identified in 2017, at the end of the SESAR 1 programme, showed that this initiative did not provide the expected operational benefits. As a result, it was decided that further work on this research topic was not required.

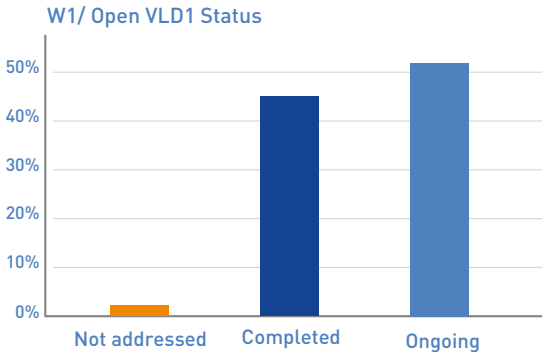
- The other three activities not covered by the Wave 1 proposals related to general aviation (GA) and rotorcraft (R) -specific communications, navigation and surveillance (CNS) systems. These three R & I activities were referring to the development of future CNS enablers very specific to GA/R operations allowing them to benefit from GNSS applications and data exchange. The proposals received in the Wave 1 call did not address them.

As a corrective action, GA/R CNS solutions were covered in the VLD Open 1 call through the GAINS and GRADE projects.

- The General Aviation Improved Navigation and Surveillance (GAINS) project validated, through live flying activities, the CNS concepts enabled by GNSS and the European Geostationary Overlay Service (EGNOS). The validation activities included in particular an electronic conspicuity solution to improve traffic situational awareness for both pilots and ground ATS staff and the execution of instrument approach procedures incorporating advanced performance-based navigation (PBN) features (e.g. varying-diameter radius-to-fix (RF) legs with localiser performance with vertical guidance (LPV) and instrument landing system (ILS) final approaches).
- The GNSS Solutions for Increased GA and Rotorcraft Airport Accessibility Demonstration (GRADE) project focused on the applicability to GA/RC of terminal approach flying LPV procedures and CAT II/III ground-based augmentation system (GBAS) approaches.

As a result of the Wave 1 validation activities and the VLD Open 1 call, 20 out of 44 key R & I activities have been completed and a further 23 are undergoing development and validation. As previously mentioned, the R & I activity 'Ad-hoc delegation of separation to flight deck' is no longer under consideration. Figure 11 shows the status of the 44 key R & I activities.

FIGURE 11 **KEY R & I NEEDS COVERAGE AND COMPLETION BY THE SESAR 2020 WAVE 1 AND VLD OPEN 1 PROJECTS**



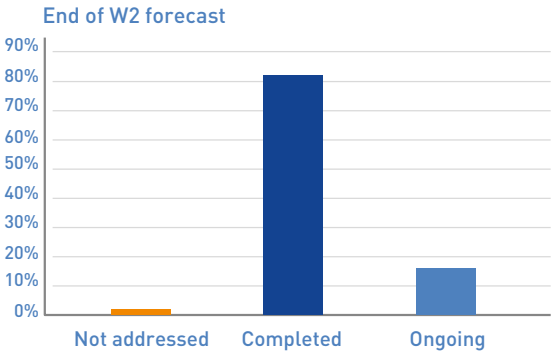
The remaining key R & I activities still to be further validated have been included in the technical specifications of the Wave 2 and Wave 3 restricted calls for proposals (see above). Based on the proposals submitted by SESAR JU members and the content of the grants it is envisaged that 16 additional key R & I activities will be completed by the end of the SESAR 2020 programme (scheduled for December 2022) and that seven activities will still require further work (the related candidate solutions will be delivered at the V2/TRL-4 maturity level).

- Collaborative control refers to coordination by exception rather than coordination by procedure and is facilitated by advanced controller tools, supporting reduced need for coordination agreements, fewer boundary constraints and the ability to combine sectors into multisector planner teams.
- Advanced separation management aims to further improve the quality of services of separation management in the en-route and TMA operational environments by introducing automation mechanisms.

- Dynamic and enhanced PBN routes and airspace bring together vertical and lateral profile issues in both the en-route and TMA phases of flight, with a view to creating an end-to-end optimised profile and ensuring transition between free-route and fixed-route airspace.
- Generic (non-geographical) controller validations are advanced tools and concepts that will help to remove the qualification constraints imposed on air traffic control officers (ATCOs) for controlling a single volume of airspace. This approach would allow ATCOs to operate in any airspace classified as a particular type.
- The development of multiconstellation/multifrequency (MC/MF) receivers for GNSS will enable standardisation of multiconstellation GNSS.
- Traffic alerts for pilots for airport operations are enhanced on-board systems that allow pilots to detect potential and actual risks of collision with other traffic during runway operations, non-compliance with airport configuration (e.g. closed runway, non-compliant taxiway, restricted areas), as well as non-conformance with procedures or air traffic control (ATC) clearances. In all cases the flight crew are provided with appropriate alerts. Pilots are provided with the appropriate alerts when there is a risk of runway excursion (during take-off and landing).
- Surface operations by RPAS facilitate the operation of RPAS at airports and their integration into an environment that is dominated by manned aviation. To the maximum extent possible, RPAS will have to comply with the existing rules and regulations.

The expected coverage at the end of SESAR 2020 programme is shown in Figure 12.

FIGURE 12 KEY R & I NEEDS COVERAGE AND COMPLETION BY THE SESAR 2020 WAVE 1 AND VLD OPEN 1 PROJECTS



In summary, all key R & I activities defined in the 2015 Master Plan have been covered by the SESAR 2020 programme, with more than 80 % fully completed and the remaining candidate solutions reaching the V2/TRL-4 maturity level.

... and allowing the transition to the Master Plan 2020

Work on the 2020 edition of the European Master Plan was launched at the end of 2017. The Master Plan update campaign had also to consider the recommendations from the Airspace Architecture Study carried out in parallel and delivered to the European Commission at the beginning of 2019. The convergence between the two activities allowed the SESAR JU to deliver a first complete update of the Master Plan to the European Commission and the SESAR JU Administrative Board in April 2019. Following a consultation period managed by the European Commission, the 2020 edition of the Master Plan (referred to as the '2020 Master Plan') was adopted by the SESAR JU Administrative Board on 17 December 2019.

The vision set out in the 2020 Master Plan is largely focused on the SESAR programme's goal of a 'Digital European Sky', which relies on interoperable and more automated systems that allow smooth data exchange and 'capacity-on-demand' and will support the integration of all air vehicles, manned and unmanned, civil and military, in all airspaces, controlled or not.

To achieve the aforementioned improvements and maximise performance gains it will be necessary to change the way in which solutions are deployed and services are provided. It is envisaged that this change will be achieved through a four-phase approach that sees the high-level architecture gradually moving from a country-specific architecture to one that is interoperable and enables flexible service provision. The four-phase approach to a stable target architecture was set out in the 2015 Master Plan. However, the 2020 Master Plan envisages the delivery of phase C of the SESAR vision, while also identifying the R & I activities not covered by the current SESAR programme that will be required to complete phase C and deliver phase D of the SESAR vision, the Digital European Sky.

Nine essential operational changes (EOCs), so-called game changers, have been identified as crucial to the structural evolution of European ATM, and for each key R & I activities have been defined.

The Master Plan update campaign, which took place in parallel with the preparation of the Wave 2 and Wave 3 calls for proposals, gave the SESAR JU the opportunity for the first time to consider mapping key R & I activities (remaining work from the 2015 Master Plan as well as new activities) to the EOCs and the phased evolution of the high-level architecture. The campaign also acted as a bridge between the final outputs of the SESAR 2020 programme and the programme of the future SESAR 3 Joint Undertaking.

This approach has enabled the SESAR 2020 programme to anticipate what will be included in the programme of the future SESAR 3 Joint Undertaking, for which the reference will be the 2020 Master Plan, and to report on its coverage accordingly. Figures 13 and 14 show the current status of the nine EOCs (Figure 13)and their expected status at the end of SESAR 2020 programme (Figure 14). The figures show, for each EOC, the percentage of identified R & I activity that has been achieved by SESAR Solutions that have already been validated and are ready for industrialisation (i.e. have reached the V3 maturity level), the percentage of R & I activity covered by candidate solutions under development in Waves 2 and 3 ('ongoing') and the R & I needs that remain to be met by the future by the programme of the future SESAR 3 Joint Undertaking.

FIGURE 13 CURRENT EOC COVERAGE

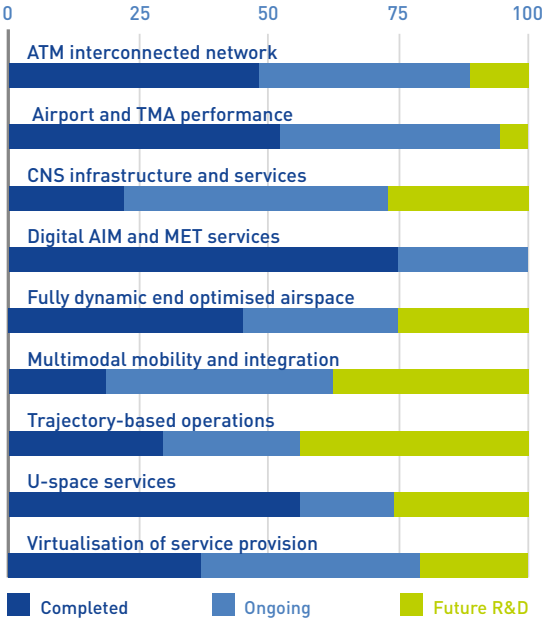
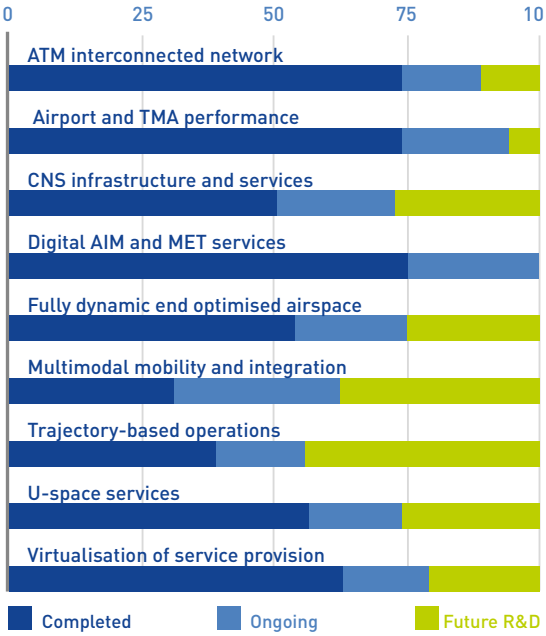


FIGURE 14 EOC COVERAGE FORECAST AT THE END OF THE SESAR 2020 PROGRAMME



Similarly, Figures 15 and 16 show the current status (Figure 15) and status forecast at the end of the SESAR 2020 programme (Figure 16) of each of the four phases (A, B, C and D) of the SESAR vision.

FIGURE 15 CURRENT COVERAGE OF THE PHASES OF THE SESAR VISION

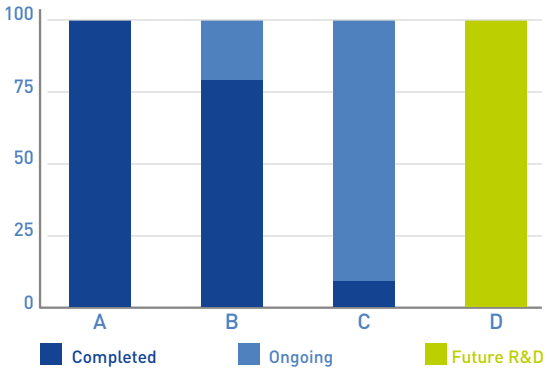
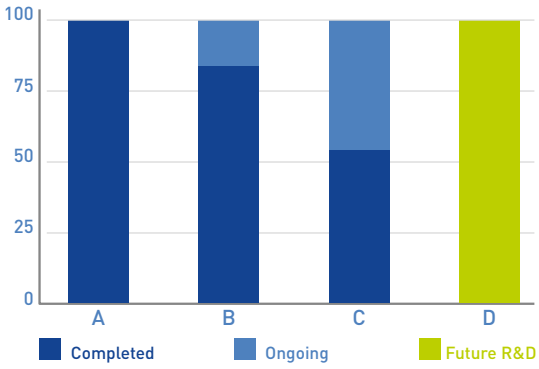


FIGURE 16 COVERAGE OF THE SESAR 2020 VISION PHASES (A, B, C AND D) FORECAST AT THE END OF THE SESAR 2020 PROGRAMME



Through the outputs already delivered up to the end of 2020 and the ongoing development and validation of the candidate SESAR Solutions, the SESAR 2020 programme will address most of the R & I activities defined in the 2020 edition of the European ATM Master Plan. The SESAR JU is confident that the R & I contribution provided by any future extension of the programme will be sufficient to achieve the desired improvement in the European ATM system, supporting the EU's renewed ambition and high-level objectives on the environment (in particular, the European Green Deal), digitalisation and smart mobility, as defined in the 2020 ATM Master Plan.

1.1.2.3. Delivery of very large-scale demonstration activities

Through VLDs, the SESAR JU assesses its solutions in wider, more complex, real-life environments involving a broad range of ATM stakeholders. Such activities enable the acceleration of operational acceptance and uptake of SESAR Solutions.

In 2017, SESAR JU members and partners continued to bridge the gap between R & I and deployment, through the delivery of the four VLDs (VLD Wave 1, included in the Wave 1 restricted call H2020-SESAR-2015-2), covering the four key features of the ATM Master Plan. The demonstration activities focused mainly on the flight trajectory profile generated by the flight management system (FMS) downlinked to and used by the ATM ground systems, the integration of airport solutions for optimising the platform operations, cross-border application of the extended TMA operations and extended network collaborative management.

In addition, the SESAR JU evaluated proposals received in response to VLD Open Call H2020-SESAR-2016-2 (launched at the end of 2016), covering solutions enabling high-performing aviation in Europe, global interoperability, and the safe integration of all air vehicles. This evaluation resulted in the award and signature of 10 grants with a focus on demonstrating SESAR Solutions for high-performing aviation in Europe, global interoperability and safe Integration of all air vehicles. More information can be found in subparagraph 1.5.1.2, 'Status of the VLD Open 1 call (H2020-SESAR-2016-2)', below.

Furthermore, the SESAR JU was asked by the European Commission (the Directorate-General for Mobility and Transport) to organise a call for proposals for the demonstration of an active geofencing service with the aim of funding a single project (call SESAR-2017-1). The funded project demonstrated a web-based geofencing solution that uses location signals to prevent drones from flying in no-fly zones and that zones can be generated, monitored and controlled by the responsible authorities.

Moreover, in response to a new mandate from the European Commission and with funds from the CEF, the SESAR JU launched a third open call (CEF-SESAR-2018-1) leading to the selection of six U-space projects. Their focus was on showing the readiness of U-space services to manage a broad range of drone operations and related applications, and their interaction with manned aviation. Further details are provided in paragraph 1.5.2, 'Activities carried out over other financial frameworks: status of the U-space call (CEF-SESAR-2018-1)', below.

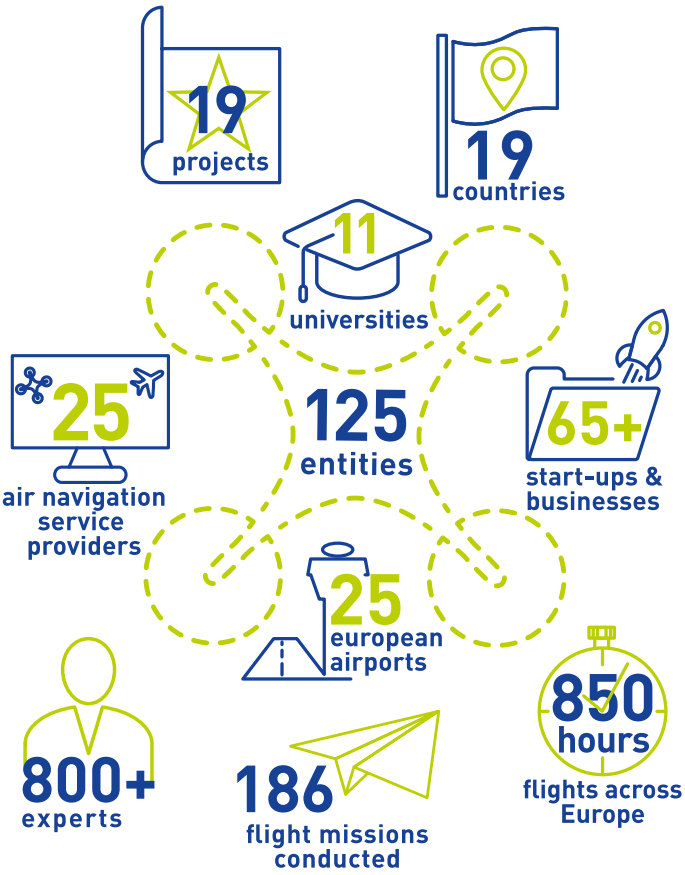
Finally, the IR-VLD Wave 2 call for proposals resulted in the award of funding to three VLD projects. In addition, in 2020, the SESAR JU prepared and launched two last calls for proposals covering VLDs, namely the IR-VLD Wave 3, using funds made available from the final amount of the Wave 1 projects, and the VLD Open 2 call for proposals. These calls resulted in eight additional VLD projects (two carried out by SESAR JU Members and their partners and six carried out by other beneficiaries). All the projects resulting from these calls were launched in execution during 2020.

More information on the Wave 2 and Wave 3 VLD projects and on the VLD Open 2 projects can be found in subparagraphs 1.5.1.3, 'Status of the VLD projects under the Wave 2 call (H2020-SESAR-2019-1)', 1.5.1.4, 'Status of the VLD Open 2 call (H2020-SESAR-2020-1)', and 1.5.1.5, 'Status of Wave 3 call (H2020-SESAR-2020-2)', below.

1.1.2.4. Delivery of U-space services

The Vilnius and Helsinki Conferences highlighted that unlocking drone operations in Europe is an urgent priority for Europe, with a deadline of 2019 for implementation of U1 services. The SESAR JU was entrusted by the European Commission to manage U-space-related activities at EU level. The different calls previously mentioned funded a total of 19 ER or VLD projects relating to the services and technological capabilities needed to make U-space a reality. The projects brought together 25 European airports, 25 ANSPs, 11 universities and more than 65 start-ups and businesses, as well as 800 experts, working in close cooperation with standardisation and regulatory bodies, including the European Organisation for Civil Aviation Equipment (Eurocae) and EASA (Figure 17).

FIGURE 17 FACTS AND FIGURES ON THE SESAR 2020 U-SPACE PROJECTS



The principal goal of the research is to develop a U-space ConOps, which it is intended will provide an initial U-space architecture and description of airspace types and U-space services to enable safe and efficient very low-level (VLL) drone operations. In parallel, the projects researched, developed and demonstrated U-space services from U1 to 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. However, only limited coverage of U3 services was achieved. U4 services were not covered by the research activities. In terms of the level of readiness, the projects demonstrated that 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.

The projects were able to show, in these environments, the feasibility of multiple service provision and 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 emphasised 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 R & I, 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 next chapters present the specific achievements of the SESAR JU within each of its strategic areas of operation in 2020, which have built on the achievements of the past years.

1.2. Strategic area of operation 1: provision of strategic steering to the SESAR programme

The SESAR JU met all its objectives related to strategic steering of the SESAR programme in 2020, as set out in paragraph III of the 2020–2022 SPD. This includes the following achievements and results.

- Call for proposals with reference H2020-SESAR-2019-1 (IR-VLD Wave 2 call for proposals) – launch of Wave 2 transversal activities. Projects PJ.19-W2 and PJ.20-W2 were launched in execution at the end of December 2019, were in full execution over the course of 2020 and are expected to be closed by the end of 2022 (see paragraph 1.2.2, 'Preparing for the future of air traffic management research: the Strategic Research and Innovation Agenda', below).
- Secure alignment of levels 1 and 2 of the ATM Master Plan: cancelled. Instead focus has been placed on the SRIA in 2020, as agreed by the Master Planning Committee in April 2020.
- Strengthen the annual reporting on Master Plan level 3 yearly implementation, including the deployment: cancelled. The update of levels 2 and 3 of the Master Plan has been postponed to 2022.
- Revise the process for future updates of the Master Plan as well as its scope and relations with other strategic plans. The main areas of improvement were discussed and agreed at the Master Planning Committee meeting on 4 December and the related action plan will be delivered in 2021.
- Ensure effective and efficient SESAR 2020 programme governance meetings. The SESAR JU held three meetings with the Scientific Committee, four meetings with the Programme Committee and two meetings with the Master Planning Committee. These three advisory bodies provided support to the SESAR JU Executive Director in steering the operational activities of the SESAR JU, through a number of contributions in the form of strategic document reviews, participation in evaluation activities, etc. (see paragraph 1.2.3, 'Outcomes from the governance bodies', below).

In 2020, Strategic Area of Operation 1 consisted in three types of activities:

- supervising the contributions of transversal activities and steering projects,
- preparing for the future of ATM research through the development of an SRIA for the next phase of research,
- coordinating with governance and support bodies.

1.2.1. Contributions of transversal steering projects

Two projects carried out within the IR strand of the SESAR 2020 programme address transversal topics, with a view to ensuring a coherent and consistent development of candidate solutions: PJ.19-W2, 'Content integration, performance management and business case development', and PJ.20-W2, 'Master planning and maintenance'. The achievements of these projects in 2020 are outlined below.

PJ.19-W2, 'Content integration, performance management and business case development (PJ.19-W2 'CI')

Launched in December 2019, the mission of PJ.19-W2 is to ensure that candidate solutions provide a coherent, consistent and validated view of how ATM performance can be improved and information integrated. In addition, the project enables and supports the

process of capturing SESAR requirements to ensure the traceability between the technical and operational requirements. It also enables the overall performance of SESAR Solutions to be assessed against the performance improvements expected for the European ATM system and set by the European ATM Master Plan.

In 2020, the first year of the newly launched SESAR 2020 Waves 2 and 3, PJ.19-W2 focused on the following main activities.

- Some outstanding SESAR 2020 Wave 1 activities were completed.
- SESAR 2020 Wave 2 transversal activities focusing on set-up (i.e. tools, repositories, method, guidance, training, management) were initiated, and a cross check with the SESAR 2020 W2 projects devoted to the development of candidate solutions (see chapter 1.4, 'Strategic Area of Operation 3: delivery of industrial research and validation', below).
- SESAR 2020 Wave 2 solutions were provided with support to enable them to start their validation activities, for example by setting defined validation performance targets, providing training in architecture and system engineering as well as general coaching, and enabling knowledge sharing through the European ATM architecture (EATMA) community, as well as support in the areas of performance and cybersecurity.
- The first annual content integration cycle was arranged and completed, the first SESAR architecture baseline (EATMA V13 and Dataset 20) was released and the following outputs of the annual content integration were delivered.
  - High-level operational requirements 2020. These translate the future European ATM operational concept into detailed but still high-level requirements which will be further refined in the detailed operational concept produced by the relevant SESAR Solution (i.e. the operational services and environment description (OSED)).
  - SESAR architecture release note 2020 (EATMA V13/DS20). Architecture release notes are issued annually and outline the status and evolution of the SESAR architecture content and maturity following the integration and consolidation of the SESAR Solution material available by July of any year, in this case July 2020.
  - eATM Portal release note 2020. eATM Portal release notes report on the evolution of the eATM Portal content and new changes introduced as part of DS20/EATMA V13, detailing connections between Master Plan level 2 and Master Plan level 3, and highlighting the possible impact on level 1.
  - The Report on Service, Information and Terminology 2020. This provides information about the 86 services that are already part of the SESAR architecture.

The COVID-19 crisis had some impact on resource availability and made collaboration among projects and partners more difficult. This did not prevent PJ.19-W2 from delivering on time all but two of its expected outputs (i.e. Operation Content Description, 2020 edition, and Architecture Definition Description, 2020 edition). It is planned that both will be delivered at the beginning of 2021.

PJ.20-W2, 'Master Planning' (PJ.20-W2, 'AMPLE')

Launched in December 2019, the overall objective of the Master Planning project is to support the SESAR JU in its activities related to Master Plan evolutions. Essentially, it consists in maintaining, updating and publishing as and when necessary the European ATM Master Plan at all of its three levels (executive, planning and implementation). This work is monitored and reported upon through transparent

and collaborative processes and involves all stakeholder categories and the key institutions involved in European ATM: the European Commission, EUROCONTROL, EASA, the Network Manager (NM), the SESAR deployment manager (SDM), the European Defence Agency (EDA) and Eurocae.

The work of project PJ.20-W2 is broken down into several work packages (WPs).

- WP1 deals with administration and management-related activities and delivered project, ethics and risk plans as well as regular progress reports. In 2020, activities carried out as part of the other three WPs achieved the following.
- WP2 covers activities related to level 1 of the Master Plan. While awaiting a decision on whether or a not a Master Plan level 1 campaign would be launched during Wave 2 of SESAR 2020, the main work emphasis was on the delivery of WP2.04, 'Standardisation and regulatory needs'.
- WP3 covers activities related to level 2 of the Master Plan. An analysis of the differences between the original and updated versions of the Master Plan identified significant changes to Master Plan level 2 in terms of timescales, performance, investment and scope. The resulting report feeds further expert judgement analysis carried out by the SESAR JU and aims ultimately to report to the SESAR JU management and governance levels including the Administrative Board.
- WP4 covers activities related to Master Plan level 3. Activity in 2020 focused on two areas.
  - Work on the Master Plan level 3 comprised the following.
    - Operational views were brought in alignment with the EOC structure set out in the 2020 edition of the Master Plan level 1 (see subparagraph 1.1.2.2, 'Delivery of industrial research'). In addition, elements of performance previously found under deployment

views were incorporated into operational views, and the overall layout of deployment views was improved, including by highlighting links to relevant solutions and clearly identifying their status (as 'regulated', 'committed' or 'voluntary').

  - One new implementation objective was fully developed and included in the Master Plan. In addition, some changes to existing implementation objectives were made as part of the normal maintenance programme and to further align the Master Plan with the SESAR Deployment Programme.
  - This resulted into a deliverable entitled 'European ATM Master Plan level 3 – Implementation Plan (2020)'.

- Work on the Master Plan level 3 report comprised the following.
  - The report was brought into alignment with the EOC structure set out in the 2020 edition of the Master Plan level 1 and, in the area of performance, qualitative indication of the KPAs benefiting from the deployment of the objectives was added (as also identified in the 2019 Master Plan).
  - Covering both implementation objectives related to SESAR Solutions, and included solutions for which commitment has not been expressed yet through an implementation objective. For this last category, the information is at a high level.
  - The resulted in a deliverable entitled 'European ATM Master Plan level 3 – Implementation Report (2020)'.

- WP5 covers ad-hoc activities. In May 2020, the SESAR JU tasked WP5 team to carry out the SRIA development work in close cooperation with stakeholders and seeking their support through a stakeholder consultation. The final version of the SRIA was delivered on time and in accordance with the brief, and was followed by a public survey. Respondents to the were broadly supportive of the SRIA document. The final version was tabled to EUROCONTROL 's Civil–Military Stakeholder Committee (CMSC) prior to its handover to the European Commission. Further information on the outcome of this major activity in 2020 can be found in paragraph 1.2.3, 'Outcomes from the governance bodies', below.

In addition to the two projects providing transversal steering to IR projects, coordination in the field of ER is ensured through two projects: Engage and Nostromo.

The Engage project was launched in January 2018 in the context of the ER3 call for proposals to perform the role of SESAR 2020 KTN in support of the SESAR JU and is managed by a consortium of organisations from academia and industry. Its focus is twofold: to inspire new researchers and to help to align SESAR ER and IR through a wide range of activities and financial support actions. The network aims, in particular, to stimulate the transfer of the results of fundamental research to ATM application-oriented research, and of application-oriented research to IR. The successful implementation of the innovation pipeline in SESAR 2020 will rely largely on the effectiveness of the KTN initiatives organised by Engage.

At the core of the network are four thematic challenges (TCs), proposed by the ATM community: TC1, vulnerabilities and global security of the CNS/ATM system; TC2, data-driven trajectory prediction; TC3, efficient provision and use of meteorological (MET) information in ATM; and TC4, novel and more effective allocation markets in ATM. These are supported by dedicated workshops, with the second series of four workshops completed in 2020.

The 10 projects that received the first wave of catalyst funding (total budget of EUR 600 000), each lasting 12 months, are now complete. Representatives of each project participated in the workshop relating to the TC that their project aimed to address. Funding was open for three months until April 2020, with eight of the 21 proposals selected for funding (total budget of EUR 480 000). The second wave of funding was launched in July 2020, and projects that received funding in the second

wave have now reached the intermediate reporting stage.

During 2020, the 10 Engage-funded (total budget of EUR 830 000) PhD students reached the end of their first year. Eight of the PhD topics are aligned with the thematic challenges; however, all PhD students have been active in the workshop programme, the SESAR Innovation Days and Engage summer schools. The second summer school was held virtually over five days in September, with 86 people registering for a mixture of PhD sessions, research tutorials and presentations from industry experts.

Engage also supported the SESAR JU in the organisation of the 10th SIDs (held virtually) in December 2020. The closing keynote session included a presentation summarising forthcoming network activities and how to get involved. This was also the platform for the official launch of the EngageWiki (wikiengagektn.com), the one-stop European knowledge hub developed by the Engage consortium.

Key wiki features include an interactive research map that allows users to explore the results of a bottom-up clustering from unsupervised machine learning applied to SESAR 1 and SESAR 2020 projects and papers; an ATM concepts roadmap showing how previous SESAR research connects with the flagship activities of the 2020 SRIA, identifying future challenges; and an interactive database of undergraduate and postgraduate programmes offered in Europe.

The second project is Nostromo, which stands for 'Next-generation Open-Source Tools for ATM Performance Modelling and Optimisation'. One of the most challenging modelling problems facing the ATM research community is the assessment of the performance impact of new SESAR Solutions at a system level, something that has been a long-time objective. The Nostromo project aims to develop new approaches to ATM performance modelling that can combine model transparency, computational tractability and ease of use with the sophistication necessary for a realistic representation of the ATM system. It does this by:

- developing a methodology for the construction of ATM performance metamodels,
- implementing the macro-methodology by developing open-source metamodels of different state-of-the-art microsimulation tools and a set of visualisation and visual analytics tools that facilitate the analysis, interpretation and communication of the results and
- demonstrating and evaluating the maturity of the approach and the capabilities of the newly developed toolset through a set of case studies addressing the performance assessment of SESAR Solutions at European Civil Aviation Conference (ECAC) level.

As a result of the ER4 call for proposals with reference H2020-SESAR-2019-2 (further information on this call for proposals and its results is provided in paragraph 1.3.3, 'Status of the Exploratory Research 4 call (with reference H2020-SESAR-2019-2)', below), the project was ramped up in May 2020 and delivered, in addition to a project management plan, a data management plan and a dissemination, exploitation and communication plan:

- requirements specifications,
- a data repository,
- a preliminary specification of case studies subject to demonstration and evaluation.

The Nostromo project follows a three-stage iterative and incremental approach: implementation of case studies, followed by evaluation and correction. As a result of the COVID-19 crisis, which necessarily constrained the collaboration environment, it took longer than anticipated to implement and ramp up this approach among all project beneficiaries.

1.2.2. Preparing for the future of air traffic management research: the Strategic Research and Innovation Agenda

1.2.2.1. Setting the scene

The 11th meeting of the Master Planning Committee on 29 April 2020 agreed that the COVID-19 crisis shows that the long-term vision laid out in the 2020 edition of the European ATM Master Plan, a resilient and fully scalable ATM system in support of 'the Digital European Sky', is more relevant than ever. However, the committee concluded that short-term priorities should be reconsidered. In particular, if R & I is to support the set-up of SESAR 3, it will be necessary to develop an 'Integrated Air Traffic Management' SRIA to support the European Commission's proposal for a future regulation establishing a new EU partnership on integrated ATM.

The European Commission invited the SESAR JU to put in place the working arrangements necessary to ensure contributions from the aviation industry and from potential future partners. Because of the need for alignment with the 2020 Master Plan, the blueprint for SESAR 3 and the high-level partnership proposal (HLPP) and to ensure broad stakeholder visibility and support, the SESAR JU tasked the PJ.20-W2 project with carrying out the development work and consulting with European ATM and U-space stakeholders.

1.2.2.2. Development of the Strategic Research and Innovation Agenda

Three successive phases of work were organised by PJ.20-W2 project to develop the SRIA.

The development phase aimed at defining a first robust draft SRIA addressing mainly the description of the R & I roadmaps (i.e. the Digital European Sky portfolio) together with the performance and economic impacts. PJ.20-W2 members actively contributed to the drafting of the document, guaranteeing a close alignment with the 2020 edition of the Master Plan and with the HLPP. The development phase concluded at the end of July 2020 with the delivery of the first draft SRIA document ready for further consultation.

The consultation phase aimed to open up the review of the SRIA to any interested ATM actor, and in particular potential new partners of the future SESAR 3. To ensure involvement of the full spectrum of ATM stakeholders, a public survey was launched at the end of July 2020 and comprised a comprehensive list of questions covering all the SRIA content. The survey attracted more than 140 respondents, agreeing or disagreeing, and providing comments in some cases. All relevant ATM stakeholder groups contributed at expert or political level (e.g. aircraft/drone operators, airports, ANSPs, ground and airborne industry, research organisations, ATCOs, Air traffic safety electronics personnel (ATSEPS), MOT/MOD). The results of the survey demonstrated huge support from all participants for the proposed content of the SRIA. The comments received were taken into consideration and a revised version of the SRIA document was made available at the end of August 2020, ready for a final consultation.

The aim of the consultation closure workshop was to present the updates made to the SRIA document in response to the survey results and to obtain final agreement to deliver the SRIA. The consultation was held in early September using the EUROCONTROL 's advisory and consultative framework, in particular the CMSC. The CMSC helps ensure that the requirements of civil and military users are met in a balanced manner, while paying due regard to national security and defence interests and fully integrating industrial stakeholders in a joint EUROCONTROL –civil–military collaborative decision-making process. The CMSC is composed of representatives of all Member States (civil and military), together with EU and stakeholder representatives. As a conclusion to the consultation workshop, the CMSC supported the SRIA document and recommended that PJ.20-W2 deliver it to the SESAR JU.

As a follow up action, the PJ.20-W2 project delivered the final draft SRIA to the SESAR JU. After a last review and editorial/design polishing, the SESAR JU submitted the SRIA document to the European Commission on 19 September 2020.

1.2.2.3. Key content of the SRIA

This SRIA presents the strategic R & I roadmaps for 2021–2027 in order to deliver on the implementation of the Digital European Sky (i.e. fully scalable services supported by a digital ecosystem minimising the environmental footprint of aviation), including the integration of drones, matching the ambitions of the European Green Deal and the Europe Fit for the Digital Age initiatives.

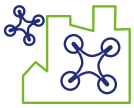
The priorities outlined in the SRIA that are necessary to build a digitalised infrastructure are also critical to recovery following the COVID crisis, enabling aviation to become more scalable, economically sustainable, environmentally efficient and predictable.

To achieve the Digital European Sky, nine R & I flagships (roadmaps) have been identified.

Connected and automated ATM. The Digital European Sky vision recognises that the future ATM environment will be increasingly complex, with new air vehicles flying at different speeds and altitudes from conventional aircraft. Moreover, there will be increasing pressure to reduce the costs of the ATM infrastructure while improving performance. Secure data-sharing between all the components of the ATM infrastructure and the relevant non-ATM stakeholders is a key part of the Digital European Sky, together with automation using the shared data to improve ATM performance. This flagship identifies the specific research needed to realise the automation and connectivity vision of the European ATM Master Plan for the future ATM ground system.

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

Capacity-on-demand and dynamic airspace. In recent decades, capacity has not always been available when and where needed, and has often been available when and where it is not needed. Air traffic, including new AUs such as RPAS or high-altitude operations (also referred to as HAO), will increase by 2030 and will require an increase in capacity as well as different types of airspace. Integrated ATM needs to be agile and flexible if capacity is to be provided where and when it is needed, and particularly if the use and performance of limited resources, for example airspace and ATCOs, are to be maximised. It will require the dynamic reconfiguration of resources and new capacity-on-demand services to maintain safe, resilient, smooth and efficient air transport operations while allowing for the optimisation of trajectories even at busy periods.



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

Virtualisation and cybersecure data-sharing. The Airspace Architecture Study clearly highlighted the lack of flexibility in the sector configuration capabilities at pan-European level. This is caused by the close coupling of ATM service provision to the ATS systems and operational procedures, preventing air traffic from making use of cloud-based data service provision. A more flexible use of external data services, considering data properties and access rights, would allow the infrastructure to be rationalised, reducing the related costs. It will enable data-sharing and foster a more dynamic airspace management and ATM service provision, allowing air traffic service units (ATSUs) to improve capacity in those portions of airspace where traffic demand exceeds the available capacity. Furthermore, it offers options for the contingency of operations and the resilience of ATM service provision.

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

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

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

Civil/military interoperability and coordination. The digital transformation of the European ATM network will have an impact on both civil and military aviation and ATM operations. Care must be taken to ensure a sufficient level of civil–military interoperability and coordination, especially concerning trajectory and airspace information exchange, as well as the use of interoperable CNS technologies. Therefore, a joint and cooperative civil–military approach to ATM modernisation would be the best choice to achieve the appropriate level of interoperability, while also maximising synergies between civil and military research and development activities.

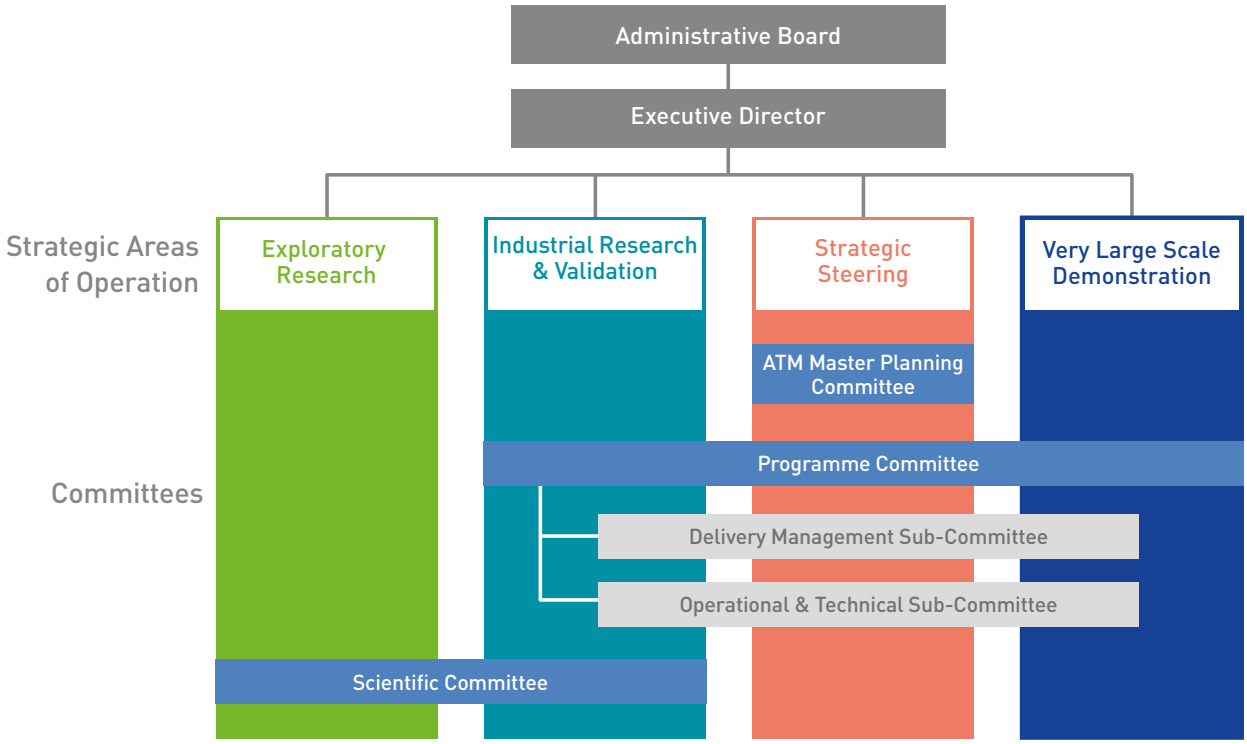
1.2.2.4. Conclusion

The SRIA was delivered by the SESAR JU, and secured a broad support from potential future partners in the SESAR 3 Joint Undertaking, which was confirmed through a public consultation.

1.2.3. Outcomes from the governance bodies

The governance of the SESAR 2020 programme is depicted in Figure 18.

FIGURE 18 GOVERNANCE OF THE SESAR 2020 PROGRAMME



The following subparagraphs summarise the contribution of the Administrative Board (SESAR JU governance) and of the advisory bodies (Scientific Committee, Programme Committee, ATM Master Planning Committee) to the SESAR JU activities in 2020.

1.2.3.1. Activities of the Administrative Board in 2020

Activities of the Administrative Board in 2020 are addressed in Part IIa, chapter 2.1, 'Administrative Board', below.

1.2.3.2. Contributions from the Scientific Committee in 2020

During 2020, the fourth year of its mandate, the SESAR 2020 Scientific Committee continued building on the experience of the previous three years; in addition, the establishment of new task forces provided opportunities to expand the mission and objectives of the Committee in different directions while remaining engaged.

The most important achievements and conclusions of the active task forces during 2020 are summarised below.

Regarding the SESAR Digital Academy, preparatory work by the former SESAR Scientific Research Agenda Task Force was taken up and continued to support the JU in building up, maintaining, evaluating and further developing the SESAR Digital Academy initiative in collaboration with external stakeholders. The task force analysed stakeholder interests and challenges related to the further evolution of the Academy. Relevant challenges were identified and potential solutions elaborated. It was recognised that the COVID-19 pandemic had a significant impact on the way in which stakeholders interacted with the Academy. In order to overcome these issues and to identify

important elements of further developing the Academy workshops with academia and industry are planned for 2021. In addition, lean evaluation schemes for quality assurance will be elaborated.

The Improved Scientific Methodology Task Force was created to facilitate dialogue with, and provide guidelines for, projects to encourage the application of sound scientific methods. After looking through the relevant background information, and creating a comprehensive list of potential areas of interest, the task force worked on facilitating the ER4 project kick-off processes. It provided a formal series of slides for use during the kick-off meetings, and, as a major task, created a 'checklist' (later endorsed at SESAR programme level as guidelines) to help structure experimental plans and to encourage dialogue between projects and project officers. Raising awareness of the need for adequate scientific methodologies remains a key focus of the task force in the upcoming period.

The Performance Measurement Task Force continued to identify ways to improve performance measurement in ATM. The focus in 2020, in collaboration with PJ.19.04, was the scoping of a further recommendations paper, intended for use in the R & I programme of the future SESAR 3 Joint Undertaking. It was important to consider the wider context of target setting and management in air transport and to establish action priorities for the task force regarding the production of this paper. This was partly supported through consideration of a number of IR case studies, and by generating a range of methodological and strategic improvements for the assessment of SESAR Solutions. A clear focus has emerged for activities in 2021.

The main goals of the Security Task Force in 2020 were to provide guidance on how to organise the security activities in the future SESAR programme; a focus on the multimember international collaborative development and programme requirements, drawing on the quality and quantity of security expertise; and to consider any necessary means of ensuring the security and thereby encouraging the exchange of cybersecurity requirements / best practices between partners in the SES initiative. The focus at the beginning of 2020 was on drafting the recommendation paper. The paper pointed to the need for a wider stakeholder consultation, in the form of a workshop series. The last part of 2020 was dedicated to the organisation of the workshop series (to be held in Q1 2021), with workshops consisting of presentations by keynote speakers and discussions on selected topics, with input from participants. The results will be summarised in the form of recommendation paper to be published in Q2 2021.

On top of the work performed by the different task forces, a number of transversal activities have been carried out. In fact, the Scientific Committee supported activities related to the SESAR programme, such as the evaluation of the applications for the Young Scientist Award, the evaluation of the papers for the annual SIDs event, which took place virtually owing to the COVID-19 pandemic (more information is available in subparagraph 1.3.4.1, 'SESAR Innovation Days', below), and the review of some key SESAR documents, such as the performance framework, in association with PJ.19.04.

The COVID-19 pandemic has not eased the usual working arrangements of the Scientific Committee, despite preventing face-to-face committee meetings and events, such as physical workshops, previously used to progress some task force topics. It did, however, provide the impetus to move online some of the usual activities carried out under the SESAR Digital Academy umbrella, in the form of virtual events (i.e. webinars). These have been widely recognised as extremely

engaging and useful by the programme members.

The fourth call for proposals on ER was also launched in 2020 (see paragraph 1.3.3, 'Status of Exploratory Research 4 call', below). Members of the Scientific Committee and the SESAR JU conducted, for each ER topic, a thorough review of the number of funded projects in comparison with the number of applications received. The outcome of this review, along with a study performed by the Engage KTN (expected to be delivered in early 2021), will provide the SESAR JU with an insight into how the ER programme should evolve the future .

The Engage KTN continued to report its ongoing activities and achievements to the members of the Scientific Committee. These updates, together with the close link established with the members of the SESAR Digital Academy Task Force, have paved the way for a smooth transition of ongoing projects and continuity of several tasks and initiatives in anticipation of the expected closure of the Engage project in December 2021.

Continued ongoing engagement with the SESAR JU communication media (e-news, LinkedIn, Twitter, as described in subparagraph 1.6.3.4, 'Online communications', below) and the attendance at meetings of external observers have contributed to boost the visibility of the Committee to all levels inside and outside the organisation and created greater awareness of its scope and ongoing work. An example is the poster session that the Improved Scientific Methodology Task Force set up during the virtual SIDs in 2020.

1.2.3.3. Contributions from the Programme Committee in 2020

Since its establishment in November 2016, the renewed Programme Committee has assisted the Executive Director in defining and putting in execution an effective programme management through strategic guidance and tactical steering of the SESAR JU's work programme, but with its remit limited to the higher maturity IR and VLD activities.

Four meetings were held in 2020, addressing the following topics.

- In close coordination with its members, the SESAR JU closely monitored the impact of the first wave of the COVID-19 crisis on its projects and members. An in-depth analysis of the impact of the crisis on the development of the SESAR Solutions was conducted by the Delivery Management Subcommittee (DMSC) in the first half of 2020, identifying potential issues and

potential mitigating actions. The overall situation reported to the Programme Committee was quite encouraging: it was expected that more than 90 % of solutions would be managed as planned, with the remaining 10 % requiring some adaptations such as the reallocation of the tasks among contributors or a review of the validation approach and schedule. The main reason for the positive outcome was that most projects were still in their ramp-up phase, the stage of organising the work, so that any delay could be addressed during the remainder of the project. However, a second wave of COVID-19 in the second half of the year led to the identification of additional issues. In fact, it was SESAR JU members who drew the Programme Committee's attention to the new issues, which included the withdrawal of some members from solutions development because of a lack of resources; greater than anticipated difficulty in implementing mitigation actions (e.g. allocation of tasks to another contributor); in the case of airports, a refocus on core business, with a knock-on impact on R & I activities; and difficulty in accessing validation platforms and preparing validating exercises. As a result, the Programme Committee supported the SESAR JU's proposal to run, in conjunction with the DMSC, a second analysis to get a revised picture of the impact of the crisis on the development of SESAR Solutions. This analysis will be performed in Q1 2021 with the consolidated view tabled at the first Programme Committee in March 2021.

- The SESAR 2020 programme delivery approach is based on the release process, which identifies on a yearly basis the solutions that will be delivered at a specific maturity level and the planned VLDs. The Programme Committee supported the SESAR JU in the context of three releases outlined in subparagraph 1.1.2.2, 'Deliver industrial research', and paragraph 1.4.4, 'SESAR solutions delivery: the release process in 2020', below. Release 9 (in execution in 2019 until April 2020) has delivered its results, and these were shared with the Programme Committee through the Release 9 report (more information on the Release 9 outcomes can be found in subparagraph 1.4.4.1, 'Release 9 outcomes', below). The Release 10 plan, based on the information on validation activities provided in the Wave 2 project schedules, was approved by the Programme Committee in mid-2020. The delay to the usual release process (the plan is usually approved in Q1 of a given year) was caused by the ramp-up of the Wave 2 projects that got underway in early 2020. Regular progress reports on the validation of Release 10 solutions were made to members to ensure that execution remained in line with the plan (more information on the Release 10 execution can be found in subparagraph 1.4.4.2, 'Release 10 execution', below). The Programme Committee also endorsed in December 2020 the Release 11 plan covering all validation and demonstration activities from January 2021 until April 2022.
- As specified in the MAWP, Wave 2 projects will close by the end of 2022. In order to address the elements of the Airspace Architecture Study that are not fully covered in Wave 2 and further address the ATM Master Plan, the SESAR JU launched a Wave 3 call for proposals restricted to the SESAR JU members and covering IR activities and VLDs. In accordance with the process defined in the 2018–2020 SPD (Paragraph III, paragraph 2.1.2), a shortlist of Wave 3 SESAR Solutions was drawn up in consultation with the Programme Committee. This list was finalised by the Programme Committee at the end of 2019, at which point, as set out in the consultation process, the consultation phase was considered closed. The subsequent steps of the procedure related to the management of that call for proposal are described in paragraph 1.4.3, 'Status of the Wave 3 call', below.
- The IOP solution (Interoperability between ATM ground systems) is critical if the European aviation infrastructure is to evolve towards greater interoperability and automation, the Programme Committee closely monitored the development through regular reports done by the SESAR JU. At the 17th meeting of the Programme Committee meeting in December 2020, the

SESAR JU informed the committee that the IOP solution was fully mature and had achieved TRL-6. The committee was notified that technical specifications were available and that the IOP solution could move to industrialisation. Revision of the first draft of Eurocae ED133, which was created in early 2020 based on the intermediate technical specifications, is already under way. The final technical specification has been validated at the maturity gate although revision of ED133 is still ongoing, and is expected to be delivered by Eurocae in 2021.

1.2.3.4. Contributions from the Master Planning Committee in 2020

Since its establishment in January 2017, the MPC has assisted the Executive Director with strategic advice on the maintenance, execution and update of the European ATM Master Plan (the Master Plan), and helped to maintain a strong connection between SESAR development and deployment activities.

The MPC held two meetings in 2020 (29 April and 4 December).

The meeting of 29 April 2020 was largely devoted to two issues.

- **The impact of the COVID-19 crisis on execution of the European ATM Master Plan.** MPC members confirmed that there is no need to amend the overall vision (the 2020 edition of ATM Master Plan was adopted only in December 2019) and stressed that the need for the ATM infrastructure to adapt to a more digital future and to be more resilient and scalable in response to fluctuations (up or down) in demand for air transport has never been greater. MPC members also confirmed that adjustments to the current 2020–2025 implementation priorities are needed to help the sector come out of the crisis. Finally, MPC members stressed that environmental sustainability is an absolute necessity for aviation and confirmed that, despite the scale of this sudden crisis, and the long shadow it will cast, establishing the European sky as the most environmentally

friendly sky in the world should remain a core objective.

- **The 2020 Master Plan: towards implementation.** MPC members took note of the progress achieved on the implementation of all three measures outlined in the Airspace Architecture Study transition plan presented by the NM, the SDM and Eurocae and the supporting enabling regulatory framework (reference period (RP) 3, ATM data service providers (ADSPs) and Common Project (CP) CP1) presented by the Commission. MPC members stressed that, in the light of the COVID-19 crisis, the overall vision and the objectives of the 2020 edition of the European ATM Master Plan (level 1), adopted only in December 2019, remain valid although adjustments to the shorter term (2020–2025) implementation milestones may be necessary. To that end, MPC members noted the request from the Commission to the SESAR JU to deliver an SRIA covering the time period of the next Multiannual Financial Framework and providing a more detailed implementation plan for the activities of the future partnership. Furthermore, MPC members recommended that the formal adoption of further updates to Master Plan implementation in the areas of R & I (level 2) and deployment (level 3) be postponed until 2021, when the industry is expected to have returned to more normal operations and when the ATM Master Plan will be better able to reflect the outcome of regulatory decisions reflecting the need to re-prioritise shorter term milestones such as those related to RP3, ADSPs and CP1, but also the future ATM partnership.

The meeting of 4 December 2020 was entirely devoted to a 'lessons learned' exercise focusing on how to improve master planning processes and updating MPC members on the set-up of the future partnership. The SESAR JU presented the high-level SWOT (strengths, weaknesses, opportunities and threats) analysis taking into account lessons learned as well as relevant audit findings. MPC members expressed their support for the analysis, which was performed on the understanding that the following areas of weakness needed to be acknowledged and addressed as part of the action plan: buy-in from Member States and the link to performance scheme and usability by decision-makers of levels 2 and 3, to enable better progress monitoring. The Commission emphasised the need to strengthen and simplify the ATM Master Plan process to safeguard the strategic value of this important and useful instrument. Consequently, it should be further improved if it is to meet the needs of its target audience of executives and policymakers. This should also help to address the need to generate more interest and commitment from Member States. It was agreed that the SESAR JU would develop an action plan addressing the outcome of the discussion for presentation at the next MPC meeting in Q2 2021.

1.3. Strategic area of operation 2: delivery of exploratory research

The SESAR JU met all its objectives related to ER in 2020, as set out in Paragraph III of the SPD 2020–2022. This includes the following achievements and results.

- Call with reference H2020-SESAR-2019-2 (ER4 call for proposals) – award of grants and supervision of projects. A list of grants initially awarded following evaluation of the responses to the call was published and the funded projects were subsequently launched, with project management plans approved by the end of 2020. Following the increase in the ER4 in budget in Q2 2020, a second round of grants were awarded by the end of 2020. Overall, 41 grants were awarded as a result of the ER4 call for proposals.
- Ensure commitment of the scientific community around the SESAR topics. The Young Scientist Award took place in December 2020 as part of the SIDs.
- Establish the SESAR Digital Academy into operation. The SESAR Digital Academy was launched at the beginning of April. During 2020, the Digital Academy was active in organising webinars to overcome the constraints imposed by the COVID-19 pandemic.

The SESAR JU delivers exploratory research results (both fundamental research and ATM application-oriented research) through 86 projects in execution or already closed resulting from the following calls for proposals under the H2020 framework.

- The first exploratory research call, ER1, with reference H2020-SESAR-2015-1, resulted in 28 projects, all closed and not addressed in this document ([22]).
- The second exploratory research call, ER2, focusing on RPAS, with reference H2020-SESAR-2016-1, resulted in nine projects, in execution until 2020.
- The third exploratory research call, coupled with the first open VLD call, with reference H2020-SESAR-2016-2, resulted in eight projects, in execution until 2020.
- The fourth exploratory research call, ER4, with reference H2020-SESAR-2019-2 (41 projects), was launched in 2019. After completion of the call procedure and successful awarding of grants, 29 ER projects entered the grant agreement preparation phase, which was completed at the beginning of 2020. As a second outcome of the call procedure, the SESAR JU established a reserve list of 12 proposals, which were then awarded a grant as a result of the allocation of additional budget. The preparation and signature of grant agreements were finalised during 2020. The delivery of outcomes is expected by 2022.

The following paragraphs outline the status of the ER projects. ER also encompasses other activities: SESAR Innovation Days, participation in relevant research events or fora and mechanisms set up by the KTN (e.g. PhD programmes), and workshops and open days arising from individual ER projects.

[22] Detailed information on these projects can be found in previous Consolidated Annual Activity Reports of the SESAR JU.

1.3.1. Status of exploratory research 2 call on RPAS (H2020-SESAR-2016-1)

The second open call for proposals for ER, ER2, was opened and closed in 2016 and aimed to address the domain of RPAS and unmanned aerial systems (UASs). The resulting projects were launched in execution in 2017. In 2020, the last four projects funded under ER2 completed their activities and were closed. These were Airpass, Impetus, PercEvite and TERRA. The following paragraphs describe the activities of each project carried out in 2020 until its closure.

The Airpass (Advanced Integrated RPAS Avionics Safety Suite) project reviewed existing CNS infrastructures and technologies, as well as existing on-board technologies for unmanned aircraft that can support VLL flights, dense airspace and possible U-space integration. Every U-space service was then mapped onto one the main avionics components of a drone (communication, navigation, automated flight control or database).

At the project closure meeting in February 2020, the SESAR JU measured the maturity of the technology against the ER/IR gate and concluded that the project had fully achieved its objectives.

- Airpass has delivered a set of 68 functional requirements relating to several on-board components and has defined an on-board system concept for participation in U-space, including functional flow diagrams of the overall system and its subsystems and identification of the required interfaces both between the subsystems and with the outside world. To verify the data flow through the system, various scenarios were developed for visual line of sight (VLOS) and beyond visual line of sight (BVLOS) flights at all U-space service levels, U1 through U4.
- A gap analysis of the on-board system concept was carried out, with particular emphasis on the gap between currently available technologies and the technologies required to support the concept. The analysis touched upon all subsystems. For communication systems, it was identified that the main gap is the lack of sufficient infrastructure to support the required bandwidth for U3 and U4 deployment.

In short, the project concluded that the technologies required for a large-scale integration of drones are available, but that the current infrastructure (e.g. mobile services for communication) and levels of qualification (e.g. hardware) might not be sufficient to support this.

The Impetus (Information Management Portal to Enable the integration of Unmanned Systems) project investigated the suitability of the 'micro-services' paradigm as a flexible and cost-efficient solution for life cycle support of the expected large variety of drones and missions. Impetus identified the information needs of drone users by reviewing the entire drone operational life cycle. A key takeaway of this review was that many of the 'apparently' big differences between ATM and U-space arise mainly from differences in scale. Drone information services will be significantly more detailed, diverse and dynamic. For example, the accuracy of safety-critical information will

need to be much greater than that provided by current solutions. This applies to geospatial information services, to ensure surface clearance; local weather information, which is required to calculate drone trajectory uncertainties; and non-conventional navigation sources (such as signals of opportunity and vision-based navigation), to allow for more precise navigation on a local scale.

The project closure meeting and assessment of maturity at the ER/IR gate took place in February 2020, and the SESAR JU concluded that the project had fully achieved its objectives.

- The project has produced a proposal for a technological solution for delivering the required services enabling scalable operations by multiple users with diverse business models. The proposal incorporates the mechanisms necessary to assure data quality and integrity, and is sufficiently flexible to facilitate the integration with manned ATM systems. The project has described, in detail, the related architecture from the functional and technical perspectives, such architecture being one of the main inputs of the U-space brochure.
- Impetus also prototyped U-space services, based on micro-service-based architectures, and tested them in four different experiments. These experiments addressed the requirements and challenges of the selected U-space services and also transversally explored the benefits of the U-space implementations based on micro-services. All exercises provided inputs to better quantify the benefits of this implementation by analysing whether or not the micro-service solution is safe, interoperable, scalable and sufficiently flexible and cost-adaptive to meet U-space operational requirements.

The PercEvite (sense and avoid technology for small drones) project has developed a multi-communication package with Wi-Fi, long-term evolution (LTE) and automatic dependent surveillance-broadcast-in (ADSB in). This package allows drones to communicate information on their position to other air users, to communicate with other drones and to receive messages from manned aircraft (using ADSB-in). Communication is necessary to ensure sufficient clearance between different air users. The project has implemented a solution for obstacle detection and avoidance; this uses two cameras and the processing power of S.L.A.M. dunk (simultaneous localisation and mapping) technology. In particular, the method uses both stereo vision (to see distances) and optical flow (to estimate the velocity of the drone). This allows the drone to fly both indoors, where the global positioning system (GPS) signal may be or poor or absent, and outdoors. The drone can fly autonomously and stop if it detects obstacles. The project has developed software to gauge distances in a single image. This way of gauging distances is complementary to stereo vision (triangulation with two cameras), and has the potential to improve distance estimation. Finally, an audio dataset has been collected with helicopter sounds for non-collaborative, audio-based detection of manned aircraft.

The project closure meeting and maturity assessment at the ER/IR gate took place in September 2020, and the SESAR JU concluded that the project had fully achieved its objectives.

- PercEvite has developed a sensor, communication and processing suite for small drones, enabling detection and avoidance of ground-based obstacles and flying air vehicles without the need for human intervention. One version of this suite has ADS-B in for avoiding general aviation aircraft equipped with ADS-B. While the mini-suite is completely based on

commercial off-the-shelf (COTS) products, the micro-suite includes a stereo vision system that was custom designed as part of the PercEvite project. The project consortium will release the schematics of this stereo vision system under an open hardware licence.

- PercEvite has also developed various algorithms for the avoidance of ground-based obstacles, communication-based cooperative avoidance and various types of non-cooperative avoidance. Many of these algorithms have been successfully tested in real-world environments.

The project investigation led to the following four conclusions.

- It is possible to create very lightweight suites that can stay well clear of both static obstacles and other flying air vehicles and that require only minimal adjustments to current hardware and software used by drone producers.
- Communication of position and velocity between different flying air vehicles is very mature and can be implemented with little effort at a very high gain.
- Ground-based obstacle avoidance is also rather mature, although limitations (flying in the dark, fog) and edge cases (reflections, transparent surfaces, etc.) exist. These limitations and edge cases can be tackled through by additional sensors if necessary.
- Although the project made important steps towards non-cooperative sense and avoid, it is the least mature technology.

The TERRA (Technological European Research for RPAS in ATM) project has identified functional service requirements for U-space ground systems based on the collection of operational needs and analysis of ConOps. Specific targets have been set for the performance of CNS services. Non-functional requirements have been defined for the drone traffic management system (design, security, monitoring and interfaces). The project analysed new candidate technologies that could be applied to U-space and, in particular, ML for trajectories prediction and conflict detection. A gap analysis was carried out to determine the extent to which existing and proposed technologies for U-space are able to meet functional requirements; this included tests of the applicability to drones of ADS-B and GPS in urban canyons. The results of the gap analysis allowed the project to define a basic systems architecture to deploy U-space services.

The project closure meeting and maturity assessment at the ER/IR gate took place in February 2020, and the SESAR JU concluded the project had fully achieved its objectives.

- TERRA has identified a set of operational and functional ground-based system requirements for three representative business cases, taking into consideration both operator requirements and the potential impact on stakeholders. This

is one of the key inputs of the U-space brochure.

- TERRA has analysed the applicability of existing CNS/ATM technologies which could be applied to U-space, the identification and development of new technologies and analysis of their applicability, considering in both cases the performance provided by these technologies and the requirements imposed for their use.
- Two ML methods to aid both monitoring of nominal VLL UAS operations and early detection of off-nominal (trajectory deviation) conditions were evaluated: deep learning for U-space conflict prediction and rule-based reinforcement learning for tactical deconfliction in U-space.
- After identifying the most appropriate technologies, comparing their performance and applicability with the user requirements and defining a technical architecture, the TERRA project team performed live trials to assess the performance of UAV-dedicated ADS-B devices in real flight conditions, as well as GNSS performance in simulated urban canyons.

1.3.2. Status of exploratory research 3 call (within call reference H2020-SESAR-2016-2)

The third open call for ER proposals, ER3, was opened in 2016 and closed in 2017. It consisted the first work area of the call also covering VLD Open 1 (see subparagraph 1.5.1.2, 'Status of the VLD Open 1 call projects', below). The resulting projects were launched in execution in 2018. Six projects funded under this call were closed in 2019 (as reported in the SESAR JU's 2019 CAAR) and one further project, Emphasis, completed its activities in 2020 and was closed. One project, Engage, was still in execution at the end of 2020 and will complete its activities by the end of 2021. The following paragraphs outline the outcomes of these projects in 2020.

The Emphasis (EMPowering Heterogeneous Aviation through cellular SIgnalS) project focused on increasing the safety, reliability and interoperability of GA/R operations involving both commercial aircraft and emerging drones, all of which are considered critical to securing and improving airspace access for GA/R users in the future and to improving operational safety.

The project closure meeting and maturity assessment in January 2020, and the SESAR JU concluded the project had fully achieved its objectives. The Emphasis project addressed four main technological elements and all achieved a maturity level of at least TRL-2:

Datalink over LTE/5G for aviation apps:

- technology concept and constraints in terms of GA formulated based both on the literature and on simulations,
- basic principles of 4G and 5G for GA communication links studied and their parameters for practical applications provided.

- Network-based navigation using 4G and 5G:
  - radiofrequency (RF) network-based navigation methods studied and reviewed and new concepts for integration with GNSS and INS navigation developed and implemented (prototype software level),
  - technology concepts tested and validated through simulations in relevant scenarios.
- Low-power ADS-B (concept considered to be at TRL-3):
  - concept and operational needs documented, system designed and prototyped including experimental hardware,
  - concept validated through simulations and flight testing in a real environment.
- Affordable obstacle detection:
  - concept and operational needs identified and documented,
  - concept assumption validated using COTS components and real data collected from external sources (maps/databases) or recorded in a real environment (millimetre wave (mmW_ radar), results and limitations documented.

The project also investigated an alternative approach to the certification of some avionics functions. Its aim is to support the use of COTS components and scalability. The possible application of the proposed approach has been demonstrated on the concept of affordable ADS-B.

The activities of the Engage project in 2020 are described in paragraph 1.2.1, 'Contributions of transversal steering projects'.

1.3.3. Status of exploratory research 4 call (with reference H2020-SESAR-2019-2)

The fourth open call for ER proposals, within call reference H2020-SESAR-2019-2 [23], was opened in April 2019 and closed in September 2019. The H2020-SESAR-2019-2 call for proposals covered two different work areas.

- Work area 1, ATM excellent science and outreach, aims to bridge the gap between ATM research and the wider research community and to provide the necessary scientific support to ATM change either directly or through connecting with research areas in other disciplines or sectors. Consequently, the purpose of this research area is to investigate, which new technologies, methodologies, concepts or validation methods developed in non-ATM sector could be introduced in the context of ATM and, in particular, serve the identified SESAR business needs and the Flightpath 2050 vision, or identify new ATM business opportunities. The scope of this work area is as follows:

[23] Call conditions were set out in the 2019 SESAR JU Annual Work Programme. Call documentation is available on the Funding and Tenders Portal.

- Work area 2, ATM application-oriented research, is intended to bring to the level of maturity required to feed the applied research conducted in the SESAR JU new concepts for ATM not already identified in the European ATM Master Plan as well as emerging technologies and methods. The scope of this work area is as follows:

HIGH-PERFORMING AIRPORT OPERATIONS

ADVANCED AIR TRAFFIC SERVICES

OPTIMISED ATM NETWORK SERVICES

ENABLING AVIATION INFRASTRUCTURE

ATM OPERATIONS, ARCHITECTURE, PERFORMANCE AND VALIDATIONS

RPAS

DRONES

The total budget of the call was EUR 38 564 361, of which EUR 15 500 000 was allocated to work area 1 and EUR 23 064 361 to work area 2. The evaluation of the proposals was completed at the end of 2019 and the evaluation report was submitted to the Executive Director of the SESAR JU in January 2020. It was proposed that 29 grants be awarded and that a reserve list of good-quality proposals beyond the maximum budget be drawn up. Subsequently, 16 projects in work area 1, with a total value of EUR 15.6 million, and 13 projects in work area 2, with a total value of EUR 22 million, proceeded to the grant agreement preparation phase. The grant agreement preparation phase was completed in June 2020. In September 2020, an additional amount of EUR 15.4 million was made available (see Paragraph III, subparagraph 2.6.1.4, in the 2020–2022 SPD), which allowed the SESAR JU to award 12 additional grants to projects on the reserve list (six in work area 1 and six in work area 2); the grant agreement preparation phase concluded in December 2020 with the signature of all grant agreements and the launching of the projects in execution. All projects are expected to complete their activities by the end of 2022.

The following paragraphs outline the outcomes of the 41 ER4 projects in 2020 (in alphabetical order).

The **AEON** project (Advanced Engine Off Navigation) kicked off in November 2020. The project aims to define a ConOps for engine-off taxiing techniques, making use of the following novel technologies that are coming onto the market.

- Non-autonomous taxiing technologies, such as TaxiBots. These are hybrid towing vehicles which, unlike normal pushback trucks, can tow full aircraft to near the start of the runway without the aircraft having to start their engines. This technology is expected to reduce fuel consumption during taxiing by 50–85 %.
- Autonomous taxiing technologies, such as the e-taxi system. These rely on electric motors embedded in landing gear, which allow planes to push back and taxi without their jet engines running – saving fuel, reducing emissions and ending last-minute delays while waiting for airport tugs.
- Single-engine taxiing technologies. By using only half the number of engines installed to generate the energy needed for taxiing, taxi fuel consumption can be reduced by 20 %.

Importantly, fuel savings translate into reductions in carbon dioxide (CO_2) and nitrogen oxide (NO_x) emissions, while minimising engine use results in reduced noise.

The project will work closely with airports, airlines and aircraft manufacturers on developing the following:

- an overall aircraft engine-off navigation ConOps, detailing how the three eco-friendly solutions can be combined in the airport surface management process at both strategical and tactical levels in order to minimise fuel consumption and emissions without affecting arrival and departure flight schedules,
- a business model to help airports and/or airlines evaluate the benefits of implementing these technologies,
- real-time evaluation of environmental indicators to support decision-making, conflict-free routing for all vehicles.
- The project aims to ensure that its approach can be integrated into airport collaborative decision-making tools.

The ultimate goal of the **AIchain** solution is to enhance (by enabling the secured exploitation of private data with relevant operational value) the performance of the AI and ML models that are researched and/or used today in the context of ATM system. It is expected that, if access to private data is unlocked, enabling the data to be exploited by current AI algorithms, then network operations and ATM performance could be significantly improved. In addition, it is hoped that the proposed AIchain solution will enable the design of SESAR operational improvements that can take advantage of the new capabilities to exploit private data that were previously unavailable.

The AIchain project kicked off in July 2020. Its objectives are to:

- define the AICHAIN solution architecture as a potential SESAR technology enabler for the exploitation of private data value, and to implement a functional small-scale prototype for user validation and operational value experimentation;
- develop an incentive mechanism that addresses the motivational aspects of data owners in order to facilitate the adoption and the effective utilisation of the AIchain concept;
- demonstrate and quantify the operational value of the AICHAIN concept with an ATM use case in the area of advanced demand-capacity balancing (A-DCB) services.

The aim of the **AISA** project (AI Situational Awareness Foundation for Advancing Automation) is to implement advanced automation, AI and human need to be able to share situational awareness. To this end, the 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 ML with a reasoning engine.

The project kicked off in June 2020. Its specific objectives are to:

- explore the effects of human–machine distributed situational awareness and opportunities for automation of monitoring tasks in en-route operations;
- identify the data needed by air ATCOs to ensure that the proposed solution is correct (transparency) and to develop the method to provide those data;
- investigate methods for adaptation of the automated system to changes in the environment, ensuring business continuity and safety.

The **ALARM** project (multi-hazard monitoring and early warning system) aims to develop a prototype global multi-hazard monitoring and early warning system. Global multi-hazard monitoring relies on near-real time and continuous global Earth observations from satellite. The objective is to generate prompt alerts of natural hazards affecting ATM and to provide information that will enhance situational awareness and provide resilience in a crisis.

The project kicked off in November 2020. The project aims to integrate the following phenomena into its prototyped multi-hazard monitoring and early warning system:

- Severe weather conditions. Flying through a thunderstorm entails multiple risks (strong

turbulence, wind shear, downbursts, icing, lightning and hail).

- Aerosols/gases from natural hazards, for example fire smoke, desert dust, volcanic ash and sulphur dioxide (SO_2) plumes. These hazards are less frequent than severe weather; however, their effects can be extremely disruptive. The use of space-based instruments enables the continuous global monitoring of natural airborne hazard in an effective, economical and risk-free way.
- Space weather. This is understudied as aviation hazard. The effects on aviation include the disruption of radio/satellite communication (jeopardising very high-frequency (VHF)), high-frequency (H and datalink communications, as well as those of RPAS); the degradation of navigation systems, for example GNSS-based procedures and magnetic compasses; and increased radiation exposure of crew and passengers and a higher risk of radiation-induced failures of on-board systems.
- Aviation-induced climate change due to emissions of greenhouse gases or their precursors. This is not currently considered in ATM decision-making. ALARM will integrate existing assessments obtained by previous studies to mitigate the climatic impact of aviation.

The **ARTIMATION** project aims to investigate the use of AI methods to predict air traffic and to optimise traffic flows based on explainable artificial intelligence (XAI) to address the challenge related to transparency of automated systems in the ATM domain. Artimation will provide a proof-of-concept of a transparent AI model that uses visualisation, explanation and generalisation to ensure safe and reliable decision support.

The project kicked off on January 2021.

- Artimation aims to provide transparency and explainability to the AI algorithms based on data-driven storytelling, immersive analytics and visualisation in order to predict air transportation traffic and optimise traffic flows in the ATM domain.
- A further objective is to develop a conceptual framework for building human-centric XAI based on an extensive review of the fields of ATM, in other words to identify how specific explanations can be useful, why certain reasoning methods fail and how to apply the different elements of XAI to mitigate these failures. The new transparent and explainable models developed are intended to be acceptable to the ATM operators in their decision-making tasks as they are developed based on closed loop of operational procedure and user test.
- A new generalised and optimised AI model will be able to predict air traffic and optimise traffic flows in ATM based on machine lifelong learning and integration of causality.
- User guidelines will enable the further development and application of AI algorithms that provide transparency in the ATM domain with the goals of predicting air traffic and optimising traffic flows.
- The project will develop a human-centric AI model that will be readily accepted by ATM operators.

The **ASPRID** project (Airport System Protection from Intruding Drones) kicked off in November 2020. The project will explore the definition and initial validation of a service-oriented operational concept and system architecture to protect airports from intruding drones, either by mistake or through malicious intent. The project will analyse aircraft and airport (runway and surface) operations, exploiting all their related attributes to assess if and in what way they are vulnerable to different identified use cases of intruder attacks and how non-nominal scenarios can evolve. This analysis will result in the definition of a solution that, tuned to a specific situation, should bring the airport back to nominal conditions within acceptable time constraints.

The project specific objectives are to:

- determine how critical aircraft and airport operations might be adversely affected by drone intrusions;
- define a complete concept of an innovative single-platform system architecture,

supported by procedures and regulation issues, to manage both airport intrusion and airport operations efficiently;

- validate the system architecture according to safety and security performance objectives.

The main benefits expected from the development of such a solution are improvements in safety, security and resilience to disruptions from the operational and the economic perspectives.

The **BEACON** project (Behavioural Economics for ATM Concepts) aims to study the feasibility of extending the 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 capture the agents' behaviours properly, Beacon will make use of behavioural economics.

The project kicked off in July 2020. Its specific objectives are to:

- propose a set of improved flight prioritisation mechanisms that expand current UDPP capabilities;
- define new metrics to evaluate the fairness and equity of flight prioritisation mechanisms and validate their appropriateness with AUs;
- quantify the impact of 'non-rational' behaviours of AUs on the outcome of the proposed mechanisms, taking advantage of the methods and tools developed in the field of behavioural economics;
- integrate the insights gained from behavioural economics into an agent-based microsimulation model of the full ECAC network able to capture network effects (the model shall be able to compute a set of KPIs, including the newly developed fairness and equity KPIs, allowing a comprehensive assessment of the new UDPP mechanisms);
- run a set of simulation experiments to evaluate the impact of the new UDPP mechanisms on the selected KPIs, taking into account behavioural effects, in order to analyse the advantages and the risks with respect to current UDPP capabilities;
- derive guidelines and methodological recommendations on the further development, validation and deployment of the new UDPP mechanisms that pave the way to a more harmonised and efficient flight prioritisation process across Europe.

The **BUBBLES** project (Defining the Building Basic Blocks for a U-space Separation Management Service) targets the definition and the validation of a U-space advanced (U3) 'separation management service' at TRL-3. The SESAR JU kicked off the project in May 2020. In brief, the project will:

- develop algorithms and define separation minima and methods (procedural, tactical self-separated or tactical ground-based) to maintain current safety levels;
- develop operational uses cases, a set of generic OSEDs from which safety and performance requirements for the CNS systems will be derived.
- investigate the use of AI to support separation management, for both centralised and distributed systems.
- contribute to standardisation activities by drafting the performance specifications required for the CNS and AI-based systems involved in the provision of the separation management service.

Since the kick-off meeting, the project management plan, the communication and dissemination plan and other documents, such as ethics requirements, necessary to ramp up the project have been written. The project team has delivered its first technical outcomes to the SESAR JU, which include:

- a risk-based method for determining separation minima,
- a method for calculating conflict frequencies,
- a method for calculating the collision risk in a conflict,
- a methodology for generating and simulating UAS representative trajectories based on basic trajectory patterns.

The **CADENZA** project (Advanced Capacity and Demand Management for European Network Performance Optimization), which kicked off in 2020, aims to develop a detailed trajectory broker concept for the European network, incorporating advanced demand–capacity balancing (DCB) 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).

CADENZA covers all areas of capacity provision (en route, terminal area and airport) as well as all temporal levels (strategic, pre-tactical and tactical). The project is expected to achieve significant improvements in cost efficiency as well as positive impacts on other KPIs, in particular a reduction in delays. The CADENZA concept will be thoroughly validated, using mathematical models and comprehensive real-world data.

The project team has defined five specific objectives for the project, which are to:

- explore several variants of a trajectory broker concept with a range of options for A-DCB, along with supporting organisational and regulatory changes and, with stakeholder input, select and develop the most promising ones;
- in the case of the selected options, develop suitable A-DCB processes in temporal (strategic, pre-tactical and tactical levels) and spatial (en route, terminal airspace, airport) dimensions, including technical aspects thereof;
- develop mathematical models to support decision-making at all three temporal levels mentioned in the second objective, with the aim of improving overall network performance;
- evaluate the network performance of the selected trajectory broker concept and ADCB options (including carrying out extensive sensitivity analyses) and compare the selected solutions against a baseline to identify key performance-improving drivers, as well as potential showstoppers;
- increase stakeholder buy-in by actively involving key stakeholder representatives in all phases of the project, as well as through targeted communication and dissemination activities.

The **CREATE** project (Climate and weather models to improve ATM resilience and reduce its impact) aims to develop innovative procedures in ATM to reduce the climate and environmental impact of aviation, while increasing the resilience of air operations to weather phenomena. To address this challenge, the project will look at the ATM system primarily from the perspective of en-route operations, with a focus on minimum environmental and climate impact, and secondarily from the perspective of TMA operations, which include approach/departure operations near airports, with a focus on local air quality and noise load.

CREATE kicked off in July 2020. The project will:

- study the vulnerability of the ATM system with respect to weather phenomena, in order to improve ATM procedures so that vulnerability can be reduced;
- study the impact of aviation on the environment, both short and long term (climate), in order to propose ATM operational changes able to reduce such impact;
- study possible new meteo tools and methodologies, in order to integrate their use into ATM;
- validate proposed ATM operational changes in order to reduce ATM environmental impact and improve ATM resilience with respect to weather.

The **DACUS** project (demand and capacity for U-space optimisation) aims to develop a service-oriented DCB process for drone traffic management. The SESAR JU kicked off the project in July 2020. The project intends to integrate in a consistent DCB solution the relevant factors influencing demand and capacity (such as CNS performance availability), definitions (such as airspace structure), processes (such as separation management) and services (such as strategic and tactical conflict resolution).

Five specific objectives are set:

- develop a drone DCB process, from the strategic phase to the tactical phase, integrating uncertainty and U-space performance metrics for airspace capacity;
- develop innovative services algorithms, models and technologies to support a large number of simultaneous operations and to design and manage efficient and safe drone trajectories;

- define a structure for VLL airspace and a set of airspace rules that optimise the trade-off between capacity and safety;
- find the optimal balance between on-board and ground intelligence in tactical separation;
- refine CNS requirements in support of tactical and procedural separation, with a focus on the urban environment.

Since the kick-off meeting, the project management plan, the communication and dissemination plan and other documents, such as ethics requirements, necessary to ramp up the project have been written. The project team has also started to work on the technical part by developing a first deliverable that is a description of an environment adapted to a set of uniform, risk-based, mission-aware airspace structures and rules. All rules, structures and measures need to be compliant with the boundary conditions found in complex aeronautical environments, such as urban areas with a dense population or high traffic volumes. The deliverable also includes the identification of these potential limiting conditions.

The **DYNCAT** project (Dynamic Configuration Adjustment in the TMA) aims to enable more environmentally friendly and more predictable flight profiles in the TMAs, namely on approach, by supporting pilots in configuration management.

DYNCAT aims, in particular, to demonstrate the potential for 4D trajectories to be optimised by taking into account environmental considerations, specifically CO_2 and noise levels, and to make the changes needed for safer, more cost-effective and more environmentally sustainable operations in TMAs.

DYNCAT kicked off in July 2020. Its objectives are to:

- highlight the impact of current (approach) ATM operations in the TMA on environmental pollution, cost-effectiveness and safety, based on actual flight data;
- quantify the potential to reduce CO_2 emissions and noise in real-life (through aircraft source noise models available at the DYNCAT consortium);
- measure the improvements in flight predictability and flyability (pilot workload, safety) achieved by the implementation of novel pilot support functions, with a focus on optimisation of high-lift system actuation for low-noise approaches within the extended TMA (E-TMA);
- derive measures to be implemented in the short term (mainly on-board procedures) and mid-term (mainly new on-board system functionalities) and identify the necessary enablers, such as new technological functions (supportive tools, data exchange) and regulatory changes, to allow improved airborne procedures.

The **ECHO** project (European Concept of Higher airspace Operations), which kicked off in 2020, will deliver a comprehensive demand analysis and a comprehensive, innovative and feasible ConOps enabling near-term and future higher airspace operations in a safe and orderly manner.

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.

The work of ECHO 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).

The **FACT** project (Future All Aviation CNS Technology) started in July 2020. The overall objective of the project is to take a fresh look at the validated technical CNS/ATM building blocks that can support today's and tomorrow's air traffic challenges in the most cost-effective way. It will do so by focusing on safety, security, performance, efficiency and robustness, through the development of an integrated CNS (iCNS) functional architecture.

By addressing both existing and new AUs, such as drone or UAM operators, the project aims to build a bridge between future U-space (expected to be fully digital and highly automated) and conventional ATM systems, considering both technological and users' perspectives.

The project adopts the following, more specific, iCNS design objectives:

- to enable advanced services, extensive operational data collection and efficient information sharing among different service providers and AUs;
- to improve access of GA to airports and airspace through their smooth integration within commercial aircraft operations, which will be achieved primarily through interoperable surveillance, increased navigation performance and flight information service/weather information (FIS/MET) provision;
- to enable access to airports for new users such as UAM vehicles and drones – typically today within segregated airspace, but with the option for gradually supporting their full integration into airspace;
- to enable evolution of autonomous operations for drones and UAM vehicles;
- to improve the resilience of GNSSs within the proposed iCNS;
- to enhance the resilience of nominal and non-nominal operations to emergency situations affecting operational safety and security.

The iCNS capabilities will be validated for selected operational use cases. This will be done in real environments, using experimental demonstrators developed in the project.

The **FARO** project (Safety and resilience guidelines for aviation) 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.

FARO kicked off in May 2020. The objectives of the project are to:

- define a conceptual framework that enables the evaluation of safety and resilience performance in terms of the technical, organisational, human and procedural characteristics of the ATM system;
- generate predictive models of safety events as a function of the technological, organisational, human and procedural dimensions associated with an automation solution to quantify the likelihood of safety events as a measure of the safety level;
- to analyse the impact of higher levels of automation on ATM resilience;
- to research system resilience performance (absorptive, restorative and adaptive capacity) by characterising it as a function of performance variability, brittleness and adaptive capacity;
- to develop a set of guidelines to facilitate the definition and evaluation of the safety and resilience criteria associated with a new automation solution;
- to find research gaps by evaluating the impact on safety and resilience of the selected automation and thereby identify research and development (R & I) needs in the field of safety and resilience in ATM.

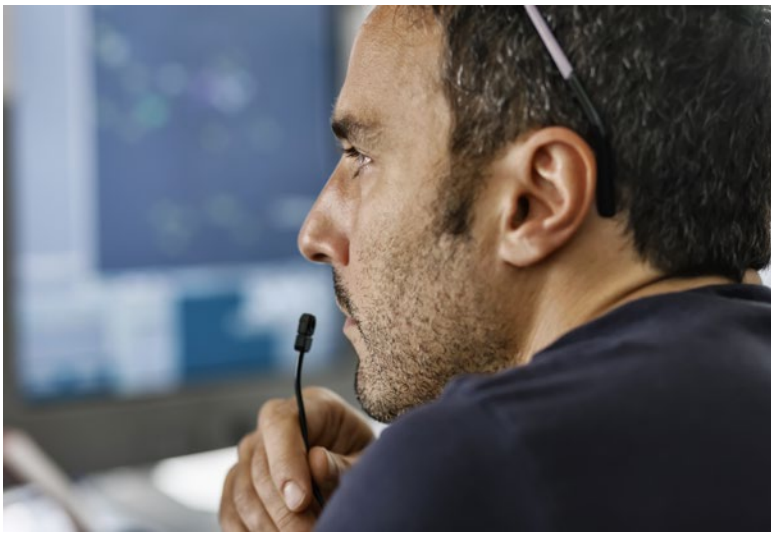
The **FlyATM4E** project (Flying Air Traffic Management for the benefit of environment and climate) kicked off in June 2020. The project has the following objectives:

- to advance concepts to assess the climate impact of ATM operations that incorporate adequate representation of uncertainties, including CO_2 emissions, contrails, the effects on climate of ozone, methane and water vapour, and to provide concepts for climate information enabling eco-efficient aircraft trajectories;
- to investigate aviation's climate impact mitigation potential by developing robust flight-planning algorithms by incorporating in ATM uncertainties from the climate impact analysis and ensemble weather forecasts;
- to identify eco-efficient aircraft trajectories, and related weather situations, that enable a reduction in both climate impact and operational costs ('win–win') by avoiding ATM inefficiencies or which largely reduce the climate impact of aviation at almost unchanged costs by avoiding extreme climate-sensitive regions ('cherry-picking');
- to provide recommendations for target stakeholders on policy actions and supporting measures to implement eco-efficient aircraft trajectories enabled by a better understanding of the climate impact of individual aircraft trajectories.

The **FMPMet** project (Meteorological uncertainty management for Flow Management Positions) framework integrates MET forecast uncertainty information into the decision-making process for the flow management position (FMP). The FMP is an operational position located in area control centres (ACCs) that serves as an interface between ATC and the NM. The FMP monitors the level of traffic in ATC sectors, adjusts the available capacity in the case of unexpected events, and coordinates possible traffic flow measures with the ACC supervisor and the NM when demand in excess of capacity is detected. The presence of convective weather challenges this task, because it makes it difficult to predict sector demand and increases complexity, thus reducing sector capacity.

The goal of FMPMet, which kicked off in 2020, is to provide the FMP with an intuitive and interpretable probabilistic assessment of the impact of convective weather on operations, up to eight hours in advance, through probabilistic forecasts of sector demand, complexity and capacity reduction, to allow better-informed decision-making. The provision of a trustworthy forecast of the future sector demand and complexity and of a reliable estimation of the impact of the convective weather in the sector capacity will support the FMP in taking anticipated, appropriate and timely tactical flow measures, which will lead to a reduction in delays and an improved passenger experience.

The **HAAWAII** project (Highly Automated Air Traffic Controller Workstations with Artificial Intelligence Integration) aims to build on a very large collection of data, organised with a minimum of expert effort, to develop new sets of assistant-based speech recognition (ABSR) models for the complex environments of Icelandic en route and London TMA. The project aims to perform proof-of-concept trials real-life audio and surveillance data from the operations room. HAAWAII also aims to significantly enhance the validity of the speech recognition models, to the extent that it can even enable the application of pilot read-back error detection.



The SESAR JU kicked off HAAWAII in June 2020. The main objectives of the project are:

- using new unsupervised learning algorithms, to exploit huge numbers of unlabelled voice data to train an ABSR system;
- to develop automatic recognition of controller–pilot datalink communications (CPDLC) for the London TMA and Isavia en-route airspace;
- to facilitate automatic detection of pilot read-back errors;
- to achieve pre-filling of radar labels and CPDLC messaging by means of non-integrated application (proof-of-concept);
- to improve ATCO staffing and rostering, as well as flow management planning and responses to changes in flow, for the London TMA by measuring and anticipating the workload from voice communications;
- to ensure data privacy issues are sufficiently considered, that is, the number of anonymised data stored is minimised.

The **ICARUS** project (Integrated Common Altitude Reference system for U–space) targets the development of an altitude translation service (geodetic to/from barometric) for drones and GA pilots in the form of an innovative U-space service to be used in both the strategic and tactical phases of the flight. Pilots may use the ICARUS service to obtain information about the terrain profile, distance from the ground and known ground obstacles, while keeping a common reference altitude datum.

The SESAR JU kicked off ICARUS in May 2020. The main objectives of ICARUS are to:

- define the technical requirements for GNSS-based altimetry;
- investigate the vertical accuracy of existing digital terrain models to be used for avoidance of ground obstacles;
- design a U-space service for height transformation,
- define a safe common altitude reference system for drones and GA to enhance the VLL capacity and safety.

Since the kick-off meeting, the project management plan, the communication and dissemination plan and other documents, such as ethics requirements, necessary to ramp up the project have been written. The project team has been working on the technical aspects and delivered its first

outcome, the first deliverable, a document that establishes the ICARUS concept, analyses the state-of-the-art in height systems, digital terrain models and geospatial products relevant to the problem, specifies the requirements of the system/service and reports the findings of a gap analysis and identifies the components to be developed. This wide-ranging analysis is essential for prototyping the system/service.

The **IMHOTEP** project (Integrated Multimodal Airport Operations for Efficient Passenger Flow Management) kicked off in June 2020. The airport of the future is expected to be a multimodal connection platform, creating the conditions for travellers to reach their destination by the most efficient and sustainable combination of modes and allowing the airport and its surrounding region to make the best use of their resources. The goal of IMHOTEP is to develop a ConOps 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.

The specific objectives of the project are the following:

- to propose a ConOps for the extension of airport collaborative decision-making to ground transport stakeholders, including local transport authorities, traffic agencies, transport operators and mobility service providers;
- to develop new data collection, analysis and fusion methods able to provide a comprehensive view of the door-to-door passenger trajectory through the coherent integration of different types of high-resolution passenger movement data collected from personal mobile devices and digital sensors;
- to develop predictive models and decision support tools able to anticipate the evolution of an airport's passenger flows within the day of operations and assess the operational impact on both airport processes and the ground transport system, with the aim of enabling real-time collaborative decision-making between airports and ground transport stakeholders and enhanced passenger information services;
- to validate the proposed concept and the newly developed methods and tools through a set of case studies (two airports with heterogeneous characteristics and serving different markets, namely Palma de Mallorca and London City airports) conducted in direct collaboration with airports, local transport authorities and transport operators.

In 2020, work on developing the ConOps got under way, based on a review of the latest multimodality developments and stakeholders' requirements, and the definition of the case study was initiated. IMHOTEP also launched the modelling of the passenger terminal access and egress processes.

The **INVIRCAT** project (IFR RPAS Control in Airports and TMA**)** aims to provide the means of safely and efficiently integrating RPAS into existing ATC procedures and infrastructures within the TMA under IFRs. The main goals of the INVIRCAT project are the creation of a ConOps for RPAS in the TMA of airports, assessing it through simulations and drafting a set of recommendations for rule-makers and standardisation bodies.

The SESAR JU kicked off INVIRCAT In July 2020. The main objectives are to:

- develop a complete ConOps to enable IFR RPAS integration in TMA;
- define technical and operational requirements for RPAS integration into TMA operations;
- investigate alternative means of integrating airport-located remote pilot stations for the control of RPAS in a TMA; and
- analyse accommodation and integration with U-space:
  - a risk-based method for determining separation minima;

- a method for calculating conflict frequencies;
- a method for calculating the collision risk in a conflict;
- a methodology for generating and simulating UAS representative trajectories based on basic trajectory patterns.

Since the kick-off meeting, the project management plan, the communication and dissemination plan and other documents, such as ethics requirements, necessary to ramp up the project have been submitted. The project has delivered its first technical outcomes to the SESAR JU. These include:

- the current state-of-the-art with regard to regulation, standardisation and technical advancements; and
- definition of use cases and an outline of possible integration concepts.

The main objective of the **ISOBAR** project (Artificial Intelligence Solutions to Meteo-Based DCB Imbalances for Network Operations Planning) is to improve the network performance and achieve mutual benefits though AI-enabled collaborative decision-making.

Network performance is very sensitive to weather conditions, the prediction of which is notoriously uncertain. In addition, current air traffic flow and capacity management (ATFCM) operations have not been systematically evaluated. Taken together, these two factors mean that network performance is highly dependent on the skill and experience of human operators. The ISOBAR project, which kicked off in 2020, aims to address these challenges by contributing to an AI-based network operations plan (NOP) enhanced weather prediction, tailored to ATFCM and ATM, demand–capacity imbalance characterisation and the ability to mitigate demand–capacity imbalance.

ISOBAR will focus on preventing and deconflicting chaotic situations in the pre-tactical phase and continuous plan readjustment. Decision-making will be triggered by high or very high convective area risk prediction and a collaborative process with a continuous reassessment and refinement taking advantage of digitalisation of the support tools.

Summing up, the project aims to integrate enhanced convective weather forecasts in order to predict imbalances between capacity and demand and to employ AI to prescribe mitigation measures at the local and network levels.

The **ITACA** project (Incentivising Technology Adoption for Accelerating Change in ATM) 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.

ITACA kicked off in May 2020. The project objectives are to:

- identify the main drivers of and barriers to technological change in ATM and devise a set of policy measures and regulatory changes with the potential to lower such barriers and incentivise faster technology upgrade;
- develop an agent-based model of the R & I life cycle allowing the representation of complex decisions and interactions between ATM stakeholders and their impact on the development and implementation of new technologies;
- validate the behavioural assumptions of the agent-based model through a set of participatory simulation experiments involving the direct participation of ATM stakeholders;
- demonstrate and evaluate the potential of the newly developed methods and tools through a set of policy assessment exercises that will analyse the impact of a variety of policies and regulatory changes aimed at accelerating technology change in ATM, with particular focus on the distributional effects of the proposed

policies across ATM stakeholders and society at large;

- consolidate the methods, tools and lessons learnt delivered by the project into a coherent policy assessment framework and a set of policy recommendations, and provide guidelines for the future maintenance, evolution and use of the proposed framework.

The **MAHALO** (Modern ATM via Human/Automation Learning Optimisation) project will develop a prototype ML modelling system, coupled to an enhanced ecological user interface, and empirically explore the effects of ML conformance and transparency, as well as contextual factors (e.g. traffic complexity), on human and ATM system performance. The objective is not only to demonstrate ML conflict detection and resolution capability, but to create an empirically derived framework and guidelines for how to develop advanced future AI, both in ATM and in other relevant domains.

The MAHALO project kicked off in June 2020. The objectives of the project are to:

- create and demonstrate an ML system comprising layered deep learning and reinforcement models that is trained on controller performance, control strategies and eye scan data, and which learns to resolve ATC conflicts;
- develop both a control model of ATC and an associated ecological user interface that (when operating in automated mode) augments the typical plan view display with machine intent and decision selection rationale (to help foster transparency);
- experimentally evaluate, using human-in-the-loop simulations, the relative impact of conformance and transparency of advanced AI, in terms of, for example, controller trust, acceptance, workload and human/machine performance, and how these are affected by factors such as air traffic complexity or degraded mode operations;
- define a framework to guide development of future AI systems, including guidance on the effects of conformance, transparency,

complexity and non-nominal (degraded mode) conditions.

The **Metropolis 2** project 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. The main objective of the project is to develop a unified approach to airspace rules that takes account of flight planning and separation management approaches and to demonstrate these principles in a real-world validation exercise. It will build upon the results of the current U-space projects, the first Metropolis project and established separation algorithms. SESAR JU kicked off Metropolis 2 in November 2020. The specific objectives of Metropolis 2 are to:

- extend the segmentation and alignment principles of geovectoring to an operational concept for airspace rules to enable high-capacity urban airspace;
- develop a unified design approach to the management of traffic in high-density urban airspace on all timescales;
- determine the benefits and drawbacks of separation management paradigms with different approaches to who acts as separator (the drone, the U-space service or a combination thereof) and different

combinations of procedural and tactical separation;

- investigate a priority-based integration of manned aviation in urban (drone-only) airspace that robustly integrates with airspace rules and separation provision and to demonstrate the final concept coming out of the Metropolis 2 project in a real-world validation.

Since the kick-off meeting, the project management plan, the communication and dissemination plan and the other documents, such as ethics requirements and first technical documents necessary to ramp up the project (e.g. a review on the state of art summarising the outcomes of previous U-space projects and demonstrators), were written.

The **Modus** project (Modelling and assessing the role of air transport in an integrated, intermodal transport system) 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.

The Modus project kicked off in June 2020 and has the following objectives.

- The project aims to understand how ATM and air transport can help improve passengers' intermodal journeys and with a view to enhancing the performance of the transport system as a whole. This requires:
  - the identification, by means of a modal choice analysis, of the drivers of future transport demand and supply in order to better understand the factors that influence the allocation of demand across different transport modes in the short-haul market;
  - the development of scenarios and passenger archetypes that take account of future developments that the European (air) transport system might need to address, such as new regulatory contexts, the need to meet new environmental standards or new transport operators' business models, covering a time horizon of 2030+, which will be modelled to assess both the landside and airside impacts.

- The connection between and interdependence of ATM / air transport and other transport modes will be explored and modelled, with a special focus on the interplay between short- and medium-haul air and rail connections. This will involve:
  - an integrated modelling approach that includes the development of data-driven models of air and ground passenger transport in Europe, and analysis of the effects of different passenger behaviours on the future growth of (air) transport in Europe;
  - the consideration of passenger mobility metrics that enable quantitative insights into the performance of the European transport network, such as how capacities across modes can be better aligned to provide integrated point-to-point travel options, and thus addressing how capacity constraints at airports can be alleviated by fostering better air–rail integration.
- The final objective is to identify the main barriers to achieving European (air) mobility goals and how air transport can evolve by efficiently connecting information and services with other transport modes to achieve the four hours door-to-door goal and a seamless journey experience for passengers.
  - the identification and definition of various use cases that reflect a particular aspect of the transport system or the passenger journey, and which are relevant to meet the high-level goals and ambitions outlined in the Flightpath 2050 document and other high-level strategic goals from various transport domains;
  - the derivation of performance and connectivity indicators, with specific business and operational targets, constraints and performance metrics that are common to all transport modes (these indicators will be assessed throughout the project by an industry board to derive and assess recommendations and solutions on how the overall performance of the transport system can be increased);
  - the application of performance and connectivity indicators to specific use cases for realistic combinations of ATM with other modes.

The **NewSense** project (Evaluation of 5G Network and mmWave Radar Sensors to Enhance Surveillance of the Airport Surface) started in November 2020 aims to improve the safety and efficiency of operations, primarily in secondary airports, by developing innovative low-cost surface surveillance solutions allowing the implementation of affordable advanced-surface movement guidance and control systems (A-SMGCS).

It also aims to develop gap-filling solutions that can be deployed at larger airports to address current system limitations. such as coverage issues, to extend ATCOs' situational awareness in the parking and apron areas, and to enable an increase in automation levels through, for example, automated detection of airport collaborative decision-making (A-CDM) milestones events.

The objectives of the project are:

- to design a 5G signal-based surveillance function for use in A-SMGCS including three dimensional (3D) vector antenna: source of angle of arrival (AOA) estimation; a 5G positioning function identifying cooperative targets and calculating their position using AOA and estimating time of arrival (TOA) from their transmitted 5G RF signals; and a radar-like system relying on 5G signals to calculate all targets position from AOA and TOA of reflected 5G Base Station (BS) RF signals;
- to evaluate low-cost mmW radar for use in A-SMGCS combined with AI to recognise target types from reflected mmW radar signals;
- to propose an initial system design for use of these solutions in A-SMGCS.

The activities of the Nostromo project in 2020 are described in paragraph 1.2.1, 'Contributions of transversal steering projects'.

The **SAFELAND** project (SAFE LANDing through enhanced ground support) is intended to enhance safety in the event of single pilot incapacitation, through an improved ATM-centred concept, offering ground support for the management of the flight until it lands safely. SAFELAND will focus on the ground side, and in particular on the potential role of ATM in managing the transition from a single-pilot-operated flight to operations in which the on-board pilot is reduced/absent for landing.

The SESAR JU kicked off SAFELAND in July 2020. In summary, the project will:

- define a SAFELAND operational concept, with the related ground support procedures, for the management of incapacitation of a single pilot until safe landing, focused on the ATM perspective;
- analyse the different possible implementations of the SAFELAND concept, including, for example, the allocation of the remote piloting functions, the presence and location of the ground remote pilot and the level of automation;
- evaluate the SAFELAND concept and procedures with the support of different stakeholders and with a variety of exercises including simulations;
- identify the functionalities of possible new additional systems that could help the ground personnel (e.g. the ATCO or remote pilot) in supporting the flight management; and;
- exchange information and results with complementary projects in Clean Sky and SESAR, and analyse the compatibility of their operational concepts with the SAFELAND one.

Since the kick-off meeting, the project management plan, the communication and dissemination plan, the data management plan and the ethics requirements necessary to ramp up the project have been submitted. The project has delivered the first technical document, which describes the initial concept of operations with different implementation options and models of flight tasks.

The **SafeOPS** project is investigating how to integrate data-driven and automation-based decision intelligence into the current ATM system. Machine learning technologies have the ability to analyse vast amounts of diverse data (usually coming from different sources) to extract patterns. This hidden knowledge can be used to identify/predict safety risks or performance inefficiencies and, in doing so, offer support to controllers in their decision-making. By processing years of operational data (i.e. years of practice), AI can also support controllers' training needs and subsequent performance in the operational room.

The SafeOPS project was ready for kick-off at the end of 2020 and kicked off in January 2021. The objective of the project is to design and evaluate a prototype risk management system for identifying and actively managing probabilistic information within an operational risk framework. The overall research goal is to move 'from prediction to decision' with the following elements:

- a common operational concept of probabilistic performance indicators for certain safety scenarios for which AI works;
- a methodology for operational risk analysis that can support risk assessment with richer probabilistic information;
- a dissemination forum that will engage key operational stakeholders to adopt and implement richer digitalisation tools.

The **SIMBAD** project (Combining Simulation Models and Big Data Analytics for ATM Performance Analysis) aims to develop and evaluate a set of ML 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.

The SIMBAD project kicked off in January 2021. The objectives of the project are as follows:

- The project intends to explore the use of ML techniques for the modelling of trajectories and the estimation of hidden variables in historical air traffic data. Particular attention will be paid to the estimation of variables related to AUs' preferences and behaviour (e.g. airline cost functions), which are one of the major unknowns when assessing the performance benefits actually delivered by a certain ATM concept or solution.
- A further goal is to develop new ML algorithms for traffic pattern classification. Given the complexity of large-scale air traffic simulations, running simulation models for each and every day of the year is usually prohibitive. On the other hand, limiting simulations to one or a few particular days may not be representative of the impact of a certain operational improvement under other scenarios. SIMBAD will investigate how different clustering and ML classification techniques can be used to identify a representative set of demand patterns that allows a comprehensive impact assessment of new SESAR solutions at ECAC level.
- The use of active learning metamodelling will be investigated with a view to enabling a more efficient exploration of the input–output space of complex ATM simulation models. Given the computational cost of realistic air traffic simulations, a goal when exploring the simulation space should be to pick only the most informative instances. The questions to be answered are 'If we have a limited number of data points that we can obtain, where in the input space should we place them?' and 'How can we approximate the rest of the points?'. In recent years, the concept of active learning has been proposed to address these questions. SIMBAD will explore how active learning can be used to translate a complex simulation model into a performance metamodel, that is, an analytical input–output function that approximates the results of a more complex function defined by the simulation model itself, improving computational tractability and interpretability of results.
- Finally, the project aims to demonstrate and evaluate the newly developed techniques in order to assess their maturity, derive recommendations on how to apply them to ATM performance assessment and propose a roadmap for the transition of the project results to the next stages of the R & I cycle. To this end, two case studies will be developed in which the proposed techniques will be integrated with existing, state-of-the-art ATM simulation tools and used to analyse a variety of ATM performance problems.

The **SINAPSE** project (Software defined networking architecture augmented with Artificial Intelligence to improve aeronautical communications performance, security and efficiency) started in May 2020 and aims to propose an intelligent and secure aeronautical datalink communications network architecture design based on the software-defined networking (SDN) architecture model augmented with AI to predict and prevent safety services outages, to optimise available network resources and to implement cybersecurity functions protecting the network against digital attacks.

The project has the following objectives:

- To design a solution suitable for ATM needs. This includes the identification of relevant ATM operational, performance, safety and security requirements. In addition, it is intended to propose a consolidated SDN design, augmented with AI, that complies with these requirements.
- To guarantee ATC datalink services performance by designing and prototyping AI applications to anticipate and prevent service issues and outages. In addition, it is intended to design an SDN-based aeronautical network integrating the ML application.
- To optimise network resources through design and prototype AI application supporting quality of service prediction to optimise network resources. It is also planned to design an SDN-based

aeronautical network integrating the ML application.

- To implement cybersecurity mechanisms to detect and prevent digital attacks. This includes designing and prototyping an AI application to provide cybersecurity against prevalent network threats. Threats violating network confidentiality and integrity will also be covered along with a security architecture for SDN-based aeronautical network integrating the AI application.

The **SINOPTICA** project (Satellite-borne and IN-situ Observations to Predict The Initiation of Convection for ATM) aims to explore the potential of assimilating remote sensing (Earth observation derived and ground-based radar) as well as GNSS-derived datasets and in situ weather station 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.

This will be done by setting up a continuously updated database of remote sensing-derived, GNSS-derived and in situ weather station observations, in combination with an automated assimilation system to feed a numerical weather model (NWM). The usefulness of deploying dedicated networks of sensors to monitor atmospheric variables in the vicinity of ATM hotspots such as airports will also be investigated. The added value of SINOPTICA tools and their incorporation into ATM procedures and decisional support systems will be evaluated.

SINOPTICA kicked off in July 2020. The project has the following objectives:

- to provide access to satellite and ground-based weather data for different study regions in Europe;
- to provide access to ground-based weather radar data for different study regions in Europe;
- to develop a near-real-time data assimilation system into a high-resolution NWM;
- Investigate the usefulness of the augmented NWM forecasts for ATM activities;
- to integrate the augmented NWM forecasts into ATM procedures and decision support systems;

- to develop a near-real-time ground-based GNSS water vapour monitoring system;
- to investigate the usefulness of deploying dedicated cost-effective GNSS stations near airports;
- to provide access to GNSS radio occultation products over the study region in Europe.

The **SlotMachine** project, which kicked off in 2020, project will focus on the user-driven optimisation in the allocation of air traffic flow management (ATFM) slots to flights. ATFM slots are allocated times of departure, which are issued by EUROCONTROL's Network Manager to regulate traffic in congested areas of airspace. Until now, simple exchanges between two flights from the same airline company have been possible. These are a helpful way for airlines to prioritise expensive flights in order to minimise delays and keep costs down.

Flight exchanges between different airlines are currently limited due to the confidentiality surrounding flight cost structures, which may vary for any number of reasons, from the provisioning of connecting flights for passengers or work-time restrictions for crew members. This is where the SlotMachine project comes in. By using blockchain technology and a secure multi-party computation, the project aims to extend the existing user-driven prioritisation process (UDPP) solution currently in development in SESAR 2020 to allow more flexible flight sequences with no need for the disclosure of any confidential information.

This technology allows secure, auditable transactions without the need for a central broker, whereby stakeholders are able to enter flight sequence transactions without disclosing information to other users. By demonstrating the feasibility of a privacy-preserving platform for exchanging ATFM slots, the foundation can be laid for the development of a product that will be an essential element in the aviation industry in the future. It is also expected to lead to a better use of existing resources at airports, higher efficiency of airlines, lower emissions, and shorter delays for passengers.

The **START** (a Stable and resilienT ATM by integrAting Robust airline operations into the neTwork) project addresses TBO. One of the key enablers of TBO is the automated updating of trajectories in reaction to developing uncertainties. However, a high frequency of updates and modifications leads to degraded system stability. The overall goal of START, which kicked off in 2020, is to develop, implement and validate optimisation algorithms for robust airline operations that result in stable and resilient ATM performance even in disturbed scenarios.

START's goal will be reached by a suitable combination of methods from applied mathematics (mathematical optimisation, optimisation under uncertainty, AI and data science) as well as by algorithm design. Furthermore, insight into the uncertainties relevant in TBO systems will be gained through simulations. The main focus of the project is the optimisation of conventional traffic situations while considering disruptive weather events such as thunderstorms.

The **Syn+Air** project (Synergies between transport modes and air transportation) aims to generate common goals for transport service providers (TSPs) that will justify data-sharing while facilitating the user to execute a seamless door-to-door 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 (following the ATFCM phases: strategic, pre-tactical, tactical), powered by data-sharing.

Syn+Air kicked off in January 2021. The main project objectives are:

- to determine the willingness of TSPs to collaborate and share data by examining and determining planning and operational goals;
- to develop a data flow model for TSPs of all transport modes and execute an impact

assessment of data-sharing with the goal of developing quantifiable metrics on data-sharing;

- to create a business process model for the design and implementation of the smart contracts framework;
- to explore if data collected from travel companion apps can enrich the data of TSPs in the strategic, pre-tactical and tactical phases, thereby enabling informed decision-making during the creation and execution of smart contracts.

The **TAPAS** project (Towards an Automated and exPlainable ATM System) aims to explore highly automated AI-based scenarios through analysis and experimental activities applying XAI and visual analytics, in order to derive general principles of transparency, which, it is hoped, will pave the way for the application of AI technologies in ATM environments, enabling higher levels of automation.

The TAPAS project kicked off in January 2020. The objectives of the project are to:

- describe and analyse in detail two operational cases, conflict detection and resolution as it applies to ATC (tactical) and ATFM (pre-tactical), considering in each case automation levels 1–3 according of the SESAR model, which involve various types of interaction between the system and the human operator;
- develop an XAI method that addresses the requirements of both operational cases and which focuses on the needs of operators concerning the quality and transparency of solutions generated by XAI methods;
- to apply visual analytics techniques to assess and enhance the explainability of AI/ML systems in ATM.
- to run experiments that assess the applicability of XAI methods in the various levels of automation considered, exploring different ways of interaction and information exchange, the objective being to understand how operators (and potential other actors) can increase their trust in XAI methods;
- to draw conclusions and develop general principles and recommendations based on these experimental results and analysis

that will serve as an enabler for the implementation of XAI methods in higher levels of automation in ATM.

The **TRANSIT** project (Travel Information Management for Seamless Intermodal Transport) aims to develop a set of multimodal 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.

The TRANSIT project kicked off in May 2020. The objectives of the project are as follows:

- to propose innovative intermodal transport solutions based on information-sharing and coordinated decision-making between air transport and other transport modes;
- to develop multimodal KPIs to evaluate the quality and efficiency of the door-to-door passenger journey;
- to investigate new methods and algorithms for mobility data collection, fusion and analysis, allowing a detailed reconstruction of the different stages of long-distance multimodal trips and the measurement of the new multimodal KPIs;
- to develop a modelling and simulation framework for the analysis of long-distance travel behaviour that allows a comprehensive assessment of intermodal solutions in terms of the proposed multimodal KPIs;
- to assess the expected impact of the proposed intermodal concepts and derive guidelines and recommendations for their practical development and implementation.

The **URClearED** project (Unified Integrated Remain Well Clear Concept in Airspace D-G Class) aims to support studies of RWC (remain well clear) functionalities by defining and analysing operational scenarios and then assessing the requirements set out and assumptions made in current standards and applicable documents, thus paving the way to future industrial-level activities.

SESAR JU kicked off URClearED in May 2020. In brief, project will:

- define a set of operational scenarios of interest to the integration of an IFR RPAS into class D–G airspaces taking into account the assumptions made and requirements set out in existing documents and projects;
- develop an RWC algorithm to support evaluation of assumptions and requirements;
- integrate an implementation of the RWC algorithm developed for evaluation of a DAA (detect and avoid) system,
- define a test plan for verification activities and conduct both fast-time simulations and real-time human in the loop validations,
- assess DAA system performance requirements; and
- analyse procedures for the management of RPAS flying in airspace classes D–G.

Since the kick-off meeting, the project management plan, including the communication and dissemination plan, and ethics requirements that are necessary to ramp up the project have been submitted. The project reports to be line with their schedule.

The **USEPE** project (U-space Separation in Europe) will propose, develop and evaluate a ConOps and a set of enabling technologies aimed at ensuring the safe separation of drones (from each other and from manned aviation) in the U-space environment, with particular focus on densely populated areas.

In order to achieve this goal, four specific objectives have been identified. These are to:

- identify the predetermined separator (the drones themselves or the U-space systems) throughout the strategic and tactical planning phases;
- define and simulate a set of concepts to provide safe separation of different kinds of drones in each planning phase;

- assess the impact of the proposed concepts on different KPAs, in particular on safety, capacity and efficiency, in order to derive conclusions and recommendations on the most adequate approach for each operational environment; and
- disseminate the project results to all stakeholders in order to collect their feedback regarding the appropriateness of the transition to the subsequent stages of the R & I cycle.

The project was ready for kick-off at the end of 2020 and was kicked off by the SESAR JU in January 2021.

The **X-TEAM** project (eXTEnded AtM for Door2Door travel) was kicked off by the SESAR JU in June 2020. It aims to define, develop and initially validate a ConOps for the seamless integration of ATM and air transport into an overall intermodal network serving urban and extended urban mobility, including other available transportation means (surface, water), to enable the door-to-door connectivity, in up to four hours, between any two locations in Europe. The project will take into account the transportation and passengers service scenarios envisaged for the next decades, according to baseline (2025), intermediate (2035) and final (2050) time horizons.

The ConOps will be preliminarily evaluated against existing and specifically defined KPAs and KPIs, implementing both qualitative and quantitative performances assessments.

The X-TEAM D2D project will develop a simulation-based approach for validating the proposed concept, considering the most relevant elements of transport in the future, such as mode–mode interfaces, the high-level network model and the passenger-centric paradigm.

1.3.4. Other exploratory research activities

1.3.4.1. SESAR Innovation Days

The SESAR JU's flagship conference, SESAR Innovation Days, is the main vehicle by which the SESAR JU shares progress and disseminates the results of its exploratory research programme. Unlike other scientific events in ATM research, the SESAR Innovation Days focus explicitly on long-term and innovative research.

More specifically, the objectives of the event are to:

- bring together the members of Europe's academic and scientific ATM research community and provide them with a platform to showcase their achievements and disseminate their results;
- in particular, disseminate the results of SESAR 2020 ER;
- report on the new thinking and ideas that have come out of SESAR's exploratory research projects and how they can feed into ATM IR;
- provide a backdrop to the SESAR Young Scientist Award.

The 10th edition of the SESAR Innovation Days took place between 7 and 10 December 2020 and was held in virtual mode owing to the situation with COVID-19 and the associated impact on travel and gatherings.

The SESAR JU organised the event with the support of the SESAR KTN Engage project, which took responsibility for the programmatic (i.e. scientific) content. Engage provided a detailed report, the main points of which are summarised in the subparagraphs below.

The conference started with a welcome from the SESAR JU Executive Director and the coordinator of the Engage KTN project. This was followed by keynote speeches from the Director-Generals for Mobility and Transport and EUROCONTROL. Given the virtual format of the event, the SESAR Innovation Days agenda continued with a combination of virtual networking events, technical sessions, comfort breaks, plenary talks, virtual exhibitions and one global panel discussion on higher airspace operations.

The closing session on Thursday afternoon included the Young Scientist Award ceremony and closing keynote speeches from the Head of Unmanned Traffic Management at Airbus, the Chief Technical Officer of Thales and the Head of the Air Transport Innovation Unit of EUROCONTROL.

The 2020 edition of the SESAR Innovation Days was successful in attracting the involvement and presence of representatives of industry and the European Commission. In many cases, dialogue between industry representatives and researchers has led to very tangible, beneficial outcomes.

As indicated by the number of scientific submissions, the number of attendees and the results of a feedback survey, the SESAR Innovation Days are now an established and recognised scientific event, with many researchers choosing SESAR Innovation Days as a forum to disseminate the results of both SESAR and non-SESAR research projects.

More information about the logistics of and participation in the SESAR Innovations Days can be found in subparagraph 1.6.3.1, 'Events and conferences'.

1.3.4.2. Young Scientist Award

Along with the publication of the call for contributions for the SESAR Innovation Days, the most recent annual edition of the Young Scientist Award was publicly launched on 7 April 2020, with a deadline for the

submission of applications of 6 September 2020. The call targeted young scientists whose Bachelor's, Master's or PhD thesis contributed to scientific achievements in the field of ATM and aviation and which they had defended not more than 18 months before the date of publication of the call, as well as on-going PhD students who are a citizen or a resident in an EU Member State or an H2020 Associated Country.

Each application was first checked by the SESAR JU Legal Unit against the eligibility criteria described in the 2020 Young Scientist Award contest rules (published together with the call). Successful applications were sent to the evaluation panel for the award phase. The evaluation panel comprised of three members of the Scientific Committee. At the end of October 2020, the panel submitted its evaluation report to the SESAR JU. The report recommended a shortlist of three applicants and ranked them as follows:

- first place: Christian Eduardo Verdonk Gallego for his research in the area of the extraction of trajectory contextual factors and its application in the trajectory prediction, focusing on descent profiles;
- second place: Álvaro Rodríguez Sanz for his research in the area of methodologies for predicting and evaluating the operational state of the airport system (uncertainty management);
- third place: Eulalia Hernández Romero for her research in the area of the development of methodologies to manage weather uncertainty suitable to be integrated into the ATM process.

The SESAR JU Executive Director endorsed the recommendation of the independent panel.

The three shortlisted scientists were presented with their awards during the 2020 SESAR Innovation Days virtual event.

1.3.4.3. SESAR Digital Academy

The SESAR Digital Academy, launched in 2019, is a learning initiative supporting Europe's future aviation and ATM workforce. The mission is to nurture Europe's brightest minds and advance learning, scientific excellence and innovation in aviation and ATM. The SESAR Digital Academy seeks to bring together under one umbrella access to SESAR ER activities and outreach relating to education and training.

In 2020, some activities initially planned, such as walking tours at the World ATM Congress (specifically targeting young scientists) and the Engage Summer School, had to be replaced by virtual activities because of the COVID-19 pandemic. Despite these challenges, several activities were carried on under the umbrella of the SESAR Digital Academy: 18 webinars (each lasting 90 minutes) were organised, and attracted, on average, more than 400 participants. These webinars featured content from the SESAR programme and usually consisted of three or four technical presentations followed by moderated session to address questions from the audience. All material, including webinar recordings, presentations and question and answer (Q&A) sessions, has been made available online, constituting an invaluable educational online resource library for the future. More information can be found in paragraph 1.6.3, 'Communications', below.

The Engage Summer School, organised under the umbrella of the SESAR Digital Academy and the Engage KTN project, took place between 21 and 25 September 2020 as a virtual event with over 80 participants. The event provided an opportunity for Engage and EUROCONTROL PhD students to present and discuss their work. It also featured seven presentations from industry experts and five tutorials, aligned with needs/requests of Engage PhD students, as well as presentations on four projects funded by the Engage catalyst fund. Lecturers included SESAR JU experts. The event achieved the objective of establishing a forum for the exchange of ideas between representatives of industry and academia, thereby fulfilling an educational purpose as well as supporting the uptake of academic research by the ATM industry. More information can be found in paragraph 1.2.1, 'Contributions of transversal steering projects'.

The Engage KTN compiled a list of undergraduate and postgraduate programmes at European universities related to ATM and air transport. This database currently contains more than 40 undergraduate programmes, more than 50 Master's programmes and more than 10 PhD programmes. This database is publicly available as part of the Engage wiki: https://wikiengagektn.com/. The wiki functionality enables institutions to log in and enter or update their own data. This database provides an unprecedented overview for students and organisations interested in ATM.

Throughout the year, Engage also collected information on PhD funding provided by external partners as well as jobs and internships in the domain of ATM research and development. These opportunities are published on the Engage website and the recently launched wiki.

The SESAR Digital Academy also used its communication channels to promote the SESAR Young Scientist Award by increasing awareness among potential applicants and providing an opportunity for previous winners and shortlisted applicants to share their results.

At the beginning of 2020, a task force was established within the Scientific Committee to support the SESAR Digital Academy, building on the results of the former Scientific Research Agenda Task Force. The aim of this task force is to support the JU in building up, maintaining, evaluating and further developing the SESAR Digital Academy initiative in collaboration with external stakeholders. More information can be found in subparagraph 1.2.3.2, 'Contributions from the Scientific Committee in 2020'.

1.4. Strategic area of operation 3: delivery industrial research and validation

The SESAR JU met all its objectives related to IR in 2020, set out in Paragraph III of the SPD 2020-2022. This includes the following achievements and results.

- Execute validation exercises of Release 9 and close Release 9. Release 9 was completed and the SESAR JU circulated the close-out report to DMSC for review.
- Prepare Release 10 and execute validation exercises of Release 10. The Programme Committee approved the Release 10 plan and the validation exercises took place as per the plan. Release 10 will be closed by April 2021.
- Prepare Release 11. The Programme Committee approved the Release 11 plan in December 2020.
- Call with reference H2020-SESAR-2015-2 (IR-VLD Wave 1 call for proposals) – delivery of results of IR Wave 1 projects. Delivery of Wave 1 was completed by the end of 2020.
- Call with reference H2020-SESAR-2019-1 (IR-VLD Wave 2 call for proposals) – delivery of results of IR Wave 2 projects. All Wave 2 IR projects kicked off and delivered their project management plan. The delivery of Wave 2 has been secured in collaboration with the DMSC/ Programme Committee.
- Call with reference H2020-SESAR-2019-1 (IR-VLD Wave 2 call for proposals) – grant budget amendment of IR Wave 2 projects: the grant budget amendment procedure has been successfully implemented for all grants.
- Call with reference H2020-SESAR-2020-2 – launch IR Wave 3 projects into execution. The call was launched in March 2020 as planned, proposals were evaluated during the summer and the selected proposals proceeded to the grant agreement preparation phase. All grant agreements had been signed by the end of the year.

At the beginning of 2020, 14 IR projects and three transversal steering activities projects resulting from the IR/VLD Wave 1 call for proposal launched in 2015 (call reference H2020-SESAR-2015-2) were closed and three IR projects from the same call for proposal were still in execution. This represents a total EU co-financing amount of EUR 202.7 million.

In 2019, the SESAR JU ran the IR-VLD Wave 2 call process, which led to the signature of 15 grant agreements (12 in IR, three in VLD) and the launch of the corresponding projects in execution for a total value of EUR 142.3 million.

With the aim of assessing the maturity of the SESAR Solutions developed in the IR projects, the SESAR JU and its members finalised Release 9 and conducted Release 10 in 2020. In addition, the SESAR JU started the planning phase of Release 11, which is expected to be completed at the beginning of 2021. This chapter presents the status of the projects resulting from the Wave 2 call for proposals and their main achievements in 2020, followed by the results and achievements of Release 9 and the execution status of Release 10.

Furthermore, in 2020 the SESAR JU ran the IR-VLD Wave 3 call process, which led to the signature of five grant agreements (three in IR, two in VLD) and the launch of the corresponding projects into execution for a total value of EUR 29.9 million.

1.4.1. Completion of SESAR 2020 Wave 1 industrial research and validation projects (call H2020-SESAR-2015-2)

The first call for proposal on IR, which was restricted to SESAR JU members other than the EU, within the call with reference H2020-SESAR-2015-2 ([24]), and which also covered VLD, closed in 2016; 17 IR projects were awarded funding. The main outcomes of the three projects that were closed in 2020 are summarised below.

In 2020, the three IR projects that were in execution provided 915 deliverables. Furthermore, IR projects contributed to the validation exercises presented in paragraph 1.4.4, 'SESAR solutions delivery: the release process in 2020', below, which summarises execution and results of the SESAR release.

HIGH-PERFORMING AIRPORT OPERATIONS

Under the **high performing airport operations** key feature, IR projects delivered the following:

Project **PJ.02**, **EARTH**, 'Increased runway and airport throughput', closed in March 2020. The project focused on developing, validating and delivering separation and procedures to improve runway and airport throughput considering wake vortex, weather, the environment and noise while taking account of different levels of traffic demand, future aircraft capabilities and airport configurations. The activities in the project scope were as follows.

- **PJ.02-01, 'Wake turbulence separation optimisation'.** This activity was split into seven ATM solutions and one technological solution at the end of the project:
  - Solution PJ.02-01-01, 'Optimised runway delivery on final approach', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-02, 'Optimised separation delivery for departure', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-03, 'Weather-dependent reductions of wake turbulence separations for departures', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-04, 'Wake turbulence separations (for arrivals) based on static aircraft characteristics', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-05, 'Weather-dependent reductions of wake turbulence separations for final approach', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-06, 'Wake turbulence separations (for departures) based on static aircraft characteristics', which achieved the targeted V3 maturity,
  - Solution PJ.02-01-07, 'Reduction of wake turbulence risk considering acceleration of wake vortex decay in ground proximity', which achieved the targeted TRL-6 maturity,
  - Solution PJ.02-01-08, 'Reduction of wake turbulence risk through wake risk monitoring', which did not achieve the targeted V3 maturity.
- **PJ.02-02, 'Enhanced arrival procedures'.** The targeted V3 maturity was not achieved. As a result of the maturity gate the activities were split up and with each enhanced approach procedure considered as a standalone solution.

[24] The call documentation is available on the Funding and Tenders Portal.

- **Solution PJ.02-03, 'Minimum-pair separations based on required surveillance performance (RSP)'**. This achieved the targeted V3 maturity.
- **Solution PJ.02-05, 'Independent rotorcraft operations at the airport'.** This achieved the targeted V3 maturity.
- **PJ.02-06, 'Improved access into secondary airports in low visibility conditions'.** The targeted V2 maturity was not achieved. As a result of the maturity gate, it was recommended that the activities be split up into deployable solutions in the next R & I phase.
- **PJ.02-08 ,'Traffic optimisation on single and multiple runway airports'.** This activity was split up into four independent solutions at the end of 2019:
  - Solution PJ.02-08-01, 'Trajectory based integrated runway sequence', which achieved the targeted V3 maturity level,
  - Solution PJ.02-08-02, 'Runway manager', which achieved the targeted V3 maturity level,
  - Solution PJ.02-08-03, 'Increased runway throughput based on local runway occupancy time (ROT) characterisation (ROCAT)', which achieved the targeted V3 maturity level,
  - Solution PJ.02-08-04, 'Optimised use of runway capacity for medium airports with the use of enhanced prediction of ROT', which did not achieve the V3 level as expected because of the lack of quantitative benefits, its limited applicability and unsolved technical limitations.
- **Solution PJ.02-11, 'Enhanced terminal area for efficient curved operation'.** This achieved the targeted V1 maturity.

In 2020, the project team finalised the delivery of the solution data packs under its scope and participated in the maturity assessment of these solutions.

ENABLING AVIATION INFRASTRUCTURE

Under the **enabling ATM infrastructure** key feature, IR projects delivered the following.

Project **PJ.17**, **SWIM-TI, 'System-wide information management technical infrastructure'**, relies on a network of system-wide information management (SWIM) nodes (also called 'ATM intranet') that dramatically reduces the number of interfaces, decouples information providers from information consumers and capitalises on open standards. At the SWIM nodes, SWIM-enabled applications use interoperable services to exchange information conveyed through SWIM technical infrastructure (SWIM-TI) middleware based on an internet protocol (IP)-based network.

In 2020, PJ.17 was successfully completed and all project data packs were submitted and approved at the agreed maturity levels. These focused on the three following parts of the SWIM-TI:

- air–ground advisory information sharing: Solution PJ.17-01 and feasibility study under the task PJ.17-07,
- ground–ground civil–military information-sharing: Solution PJ.17-03,

- common runtime registry: Solution PJ.17-08.

For each of the first two parts, a set of interoperability requirements corresponds to a 'SWIM profile'.

- **PJ.17-01, 'SWIM-TI purple profile for air–ground advisory information-sharing'**, enables the integration of the aircraft into the SWIM network, thus giving it access to air–ground advisory SWIM services. The solution started at TRL-4 and has achieved the TRL-6 maturity level.
  - It has successfully demonstrated the technical feasibility of the SWIM purple profile (technical architecture, technical use cases, reliability, security and QoS) and shown that overall performance is highly dependent on deployment options.
  - Recommendations for the next steps (from TRL-7 onwards) have been identified with regard to the assessment of performance, security management, deployment options, interface with external systems, human factors analysis and airworthiness evaluation.
- **PJ.17-07, 'Feasibility study for air–ground safety-critical information exchange'**, has demonstrated that the air–ground SWIM for safety-critical information-sharing should be built on top of the SWIM TI purple profile for air–ground advisory information-sharing (reuse, specialisation, etc.). The results will be valuable inputs to the Wave 2 TRL-2 activities, in which case it is recommended that:
  - both functional and technical viewpoints be refined and completed;
  - the avionics architecture be addressed as part of the technical viewpoint;
  - and initial safety and security assessment be performed.
- **PJ.17-03, SWIM-TI green profile for ground–ground civil–military information-sharing** started at TRL-0 and has successfully achieved TRL-4. The solution demonstrated the technical feasibility of the green profile at laboratory level and its positive contribution to relevant KPAs:
  - Taking into account the military expectations and the 2015 European ATM Master Plan, the solution concluded that the green profile will extend existing ground/ground SWIM profiles to support military-specific needs, which were limited to the yellow profile in Waves 1 and 2. The main military expectations are better security, greater resilience, support for exchanges of military-sensitive data and, when necessary, the right level of performance in terms of capacity (latency, throughput).
  - The solution, having reached TRL-4, and therefore able to proceed to TRL-6 activities in the next R & I phase, should demonstrate the ability of GP to run in a close-to-real-world environment, taking into account its integration with civil and military SWIM-enabled applications and infrastructure services such as public key infrastructure and IP network infrastructure(s).
- **PJ.17-08, 'SWIM-TI common runtime registry'**, started in TRL-0 by collecting and defining the functional requirements for a SWIM runtime registry. However, the solution suffered from a lack of operational requirements and its original scope had to be extended to include the definition of such requirements. This work revealed that the real value of a runtime registry for operational purposes is not so much the ability to dynamically search for suitable services and bind to them during runtime but, rather knowledge it provides of the operational status of a service.

- As a result of budget limitations, the scope of the project was reduced, such that it concentrated on delivering an updated technical architecture of the SWIM registry, and the solution achieved only a partial TRL-4 maturity level. Rather than distinguishing separate design-time and runtime registries, a single registry system containing both static and dynamic information, to serve different purposes, was delivered. Two fundamentally new functionalities (criteria-based search and service status handling) were introduced and three registry technical implementation architecture options were proposed.
- As a result of the work carried out so far, it is recommended that the suspended work resumes as part of a next R & I phase in order to achieve full TRL-4.

Project **PJ.18-W1, '4D trajectory management'**, was extended and ended in November 2020. It aimed to define a harmonised and global trajectory information-sharing, including improved negotiation mechanisms, enabling significant operational benefits for flight management. This was achieved thanks to new tools and capabilities, including improved trajectory calculations in the ground ATM systems by using aircraft information and a unique and integrated view of flights trajectories, including military ones.

In addition, it defined and validated new MET and aeronautical information management (AIM) capabilities and services, increasing the accuracy of predicted trajectories and providing a common, harmonised and standard way to share information among different ATM stakeholders.

In 2020, the following PJ.18 W1 solutions progressed and were completed:

- **Solution 18-02b ('Flight object interoperability')** was split into two solutions, 18-02b ('Flight object interoperability ATC–ATC') and PJ.18-02b1 ('Flight object Interoperability ATC–NM').
- **Solution PJ.18-02b developed flight object (FO) IOP** mechanisms between ATC centres (en route and TMA). These ensure that all actors have a coherent and synchronised view of the trajectory, allowing a seamless coordination among ATC centres. The technology relies on the SWIM infrastructure for the different collaborative decision making (CDM) processes and flight information sharing. The FO IOP solution is a-consolidated step towards the implementation of the reference business trajectory and TBOs, enabling truly seamless navigation across ANSP borders.
- **Solution PJ.18-02b1** complements Solution PJ.18-02b by looking at the ATC–NM FO-IOP interface.

At the maturity gate assessment in November 2020, Solution 18-02b achieved TRL-6 while it was considered that Solution PJ.18-02b1 will need further work to achieve TRL-4.

1.4.2. Status of IR projects under the Wave 2 call (H2020-SESAR-2019-1)

The Wave 2 call for proposals with reference H2020-SESAR-2019-1 (25) was conducted in 2019. It resulted in the award of 12 grants, amounting to a total value of EUR 129 932 520, and the launch in execution of the corresponding projects. These projects will deliver their results from 2020 to 2022.

Two projects address transversal activities, and their contributions in 2020 are summarised in paragraph 1.2.1, 'Contributions of transversal steering projects', Solutions PJ.19 W2, 'Content integration, performance management and business case development', and PJ.20 W2, 'Master planning'.

The other projects are summarised in the following paragraphs.

HIGH-PERFORMING AIRPORT OPERATIONS

Project **PJ.02-W2, 'Airport airside and runway throughput'**, aims to improve the efficiency and resilience of arrival and departure operations at capacity-constrained airports and to improve access to secondary airports. The project plans to address the human, technical, procedural and performance aspects of the following proposed improvements.

- **Advanced geometric GNSS-based procedures in the TMA:** enhancing TMA efficiency using more GNSS and advanced curved PBN for arrival and departure operations. This covers the development of new support tools for ATCOs and airspace design concepts to enable a greater use of continuous descent operations (CDOs).
- **Evolution of separation minima for increased runway throughput:** refining separation minima as a function of the operational conditions. The most constraining minima (wake, runway occupancy, etc.) to be applied will be determined and ATCO support tools further developed for better separations delivery, including delegating separation to the flight crew.
- **Improved access to secondary airports:** enhancing availability and accessibility of airports with limited infrastructure in low-visibility conditions. Alternative ground surveillance will increase runway safety and will include both ATC and (Aerodrome flight information service) AFIS requirements as a more cost-efficient and flexible ATS provision. From an airborne perspective, enhanced flight vision systems, synthetic vision guidance systems, combined vision systems and LPV-100 capability will enable approach and landing.
- **Digital evolution of integrated surface management:** extending the A-SMGCS routing and guidance functions to improve tactical conflict management in the taxi phase. Optimised routing and planning will deliver more accurate taxi times, improve predictability and minimise delays and controller workload. Automation, A-CDM and datalink will support conflict management.
- **Safety support tools for avoiding runway excursions:** detecting, preventing and alerting risks of runway excursions by synchronising the air–ground exchange of information on runway surface condition.

[25] The call conditions were set out in the SESAR JU annual work programme for 2019. The call documentation is available on the European Commission's Funding and Tenders Portal.

In 2020, the project initiated the definition or, in most cases, refinement of the concepts and technologies supporting the improvements listed above. The project team also started planning the validation activities in the different areas, refining the validation roadmap at solution level. Significant effort was put into organising the project into deployable, standalone candidate solutions, clarifying in each case the initial and target maturity level. It is expected that, by the end of Wave 2, the following solutions will be delivered.

- In the 'Advanced geometric GNSS-based procedures in the terminal manoeuvring area' WP:
  - **PJ.02-W2-04.1, 'Advanced curved approach operations in the terminal manoeuvring area with the use of barometric altitude'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-04-2, 'Advanced curved departure operations in the terminal maneouvring area'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-04-3, 'Advanced curved approach operations in the terminal manoeuvring area with the use of geometric altitude'**, targeting V2 at the end of 2022.
- In the 'Evolution of separation minima for increased runway throughput' WP:
  - **PJ.02-W2-14.2, 'Second runway aiming point'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-14.3, 'Increased glide slope'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-14.5, 'Increased glide slope to a second runway aiming point'**, targeting V3 by the end of 2022,;
  - **PJ.02-W2-14.6, 'Enhanced optimised runway delivery for arrivals',** targeting V2 by the end of 2022,
  - **PJ.02-W2-14.7, 'Dynamic pairwise separations for arrivals'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-14.8, 'Enhanced optimised separation delivery for departures'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-14.9, 'Dynamic pairwise wake separations for departures'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-14.10, 'Dynamic pairwise runway separations based on ground-computed arrival runway occupancy time'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-14.11, 'Dynamic pairwise runway separations for arrivals (based on air–ground data exchange)'**, targeting V2 by the end of 2022;
  - **PJ.02-W2-14.13, 'Delegation of arrival separation to the flight crew'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-14.14, 'Meterological data and services for wake turbulence separation'**, targeting TRL-4 by the end of 2022,;
- In the 'Improved access to secondary airports' WP:
  - **PJ.02-W2-17.1, 'Improved capacity and safety of runway operations at secondary airports in low-visibility conditions'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-17.2, 'Improved approach procedures into secondary airports in low-visibility conditions'**, targeting V2 by the end of 2022,
  - **PJ.02-W2-17.3, 'Airport safety nets for controllers at secondary airports'**, targeting V3 by the end of 2022,

- **PJ.02-W2-17.4, 'Equivalent visual approach and landing operations providing improved resilience to low-visibility conditions'**, the scope, nature and target maturity level of which ere still being refined at the time of writing of this report.

- In the 'Digital evolution of integrated surface management' WP:
  - **PJ.02-W2-21.1, 'Extended airport safety nets for controllers at advanced-surface /movement guidance and control systems (A-SMGCS)airports'**, targeting V3 by the end of 2022;
  - **PJ.02-W2-21.2, 'Enhanced guidance assistance to airport vehicle driver combined with routing',** targeting V3 by the end of 2022,
  - **PJ.02-W2-21.3, 'Management and control of vehicle operations via datalink'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-21.4, 'Full guidance assistance to mobiles using "follow the greens" procedures based on airfield ground lighting (aprons/taxiways/runways)'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-21.5, 'Enhanced safety in low-visibility procedures through use of dynamic virtual block control'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-21.6, 'Surface route planning and management operations'**, targeting V3 by the end of 2022.
- In the 'Safety support tools for avoiding runway excursions' WP:
  - **PJ.02-W2-25.1, 'Enhanced runway condition awareness for runway excursion prevention'**, targeting V3 by the end of 2022,
  - **PJ.02-W2-25.2, 'Support tools for pilots for better prevention of runway excursions and monitoring of aircraft (A/C) trajectory'**, targeting V1 by the end of 2022.

Project **PJ.04-W2, 'Total airport management'**, will develop 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 project aims to improve airport–network integration for large and medium-sized or regional airports, to improve airport airside–landside integration, to reduce the impact of MET aspects on airport operations and to further investigate how environmental factors can be monitored and managed in day-to-day airport operations.

The aims will be achieved by increasing coordination between airports and the network, validating the concept of regional connected airports. On the airport side, the project focuses on the airport hypervision concept, and how airport operations could be better predicted with anticipated impact, managed in a proactive way and synchronised in various situations. This includes the development of performance and role-based dashboards as well as what-if, prediction and impact assessment tools. Here data-driven airport operations management and digital technologies are required enablers, as connected, data-based, intelligent toolboxes supporting all airport stakeholders must be developed.

Achieving the full benefits and the expected performance improvements in the context of overall ATM network will require close coordination with other projects, particularly those addressing network management, airport airside and runway throughput and enhanced arrivals and departures as well as overall integration within the programme.

In 2020, the project team initiated the project by refining the scope and initial and target maturity levels of the different solutions for which they are responsible. Concept, operational and technical development activities were complemented by the initiation of the validation planning. The refined solutions in PJ.04-W2 are:

- in the **'Network connected airports'** WP:
  - **PJ.04-W2-28.1, 'Connected regional airports'**, targeting V3 by the end of 2022,
  - **PJ.04-W2-28.2, 'Collaborative management at regional airports'**, targeting V2 ongoing by the end of 2022,
  - **PJ.04-W2-28.3, 'Connected large airports'**, targeting V3 by the end of 2022;
- in the 'Digital smart airports' WP:
  - **PJ.04-W2-29.1, 'Airside/landside performance management'**, targeting V3 by the end of 2022,
  - **PJ.04-W2-29.2, 'Meteorological performance management'**, targeting V3 by the end of 2022,
  - **PJ.04-W2-29.3, 'Environmental performance management'**, targeting V2 by the end of 2022.

Project **PJ.05-W2, 'Digital technologies for tower'**, aims to contribute to the increased digitalisation of ATM from two different angles. First, it proposes the development of a remote aerodrome ATS in which services from various aerodromes are combined in a centralised control room independent of airport location. Second, it intends to validate innovative human–machine interface modes and related technologies in different airport towers. The project's solutions will not only provide shorter travel times and better point-to-point connections, but also increase flight safety and controller productivity.

In 2020, PJ.05-W2 initiated its activities by ensuring that the candidate solutions under its scope could be deployed independently from each other and would deliver the expected benefits once mature. Building upon the work performed in previous SESAR projects, the solution teams secured the initial and target maturity levels of the newly created solutions, refined their validation roadmap and initiated the operational and technical developments as well as the validation planning activities.

The solutions under the project's scope are:

- **PJ.05-W2-35, 'Multiple remote tower and remote tower centre'**, targeting V3 by the end of 2022;
- **PJ.05-W2-97.1, 'Virtual/augmented reality applications for tower'**, targeting TRL-4 by the end of 2022;
- **PJ.05-W2-97.2, 'Improving controller productivity by automatic speech recognition at the tower controller's working position'**, targeting TRL-4 by the end of 2022;
- **PJ.05-W2-97.3, 'New interaction modes at the tower controller's working position'**, targeting TRL-4 by the end of 2022.

ADVANCED AIR TRAFFIC SERVICES

Project **PJ.01-W2, 'Enhanced arrival and departures'**, will develop concepts, tools and procedures to increase the capacity of TMAs in a safe, cost-effective and environmentally sustainable manner. This will be achieved by taking advantage of the latest technological developments from both an airborne perspective and a ground-system perspective and through the secure sharing of data. The needs of all AUs, including RC, will be addressed.

The aim will be to improve the capacity whilst exploiting the environmental benefits achieved from optimised descent operations and improved arrival sequencing. A focus will be to minimise delays and improve the resilience and predictability of capacity-constrained high-density/high-complexity TMAs. This will be achieved by enhancing arrival and departure management by the dynamic use of precision navigation routes and optimised profiles. Traffic flows will be optimised by improving the integration of the management of departures with arrivals, including extended arrival manager (AMAN) and ground holding from in-horizon departures, and by improving the capability to balance traffic demand and available capacity across the network and airports.

The use of procedures and technologies to improve the integration of RC operations within TMAs, and interoperability with GA, drones and RPAS, will be addressed which will also provide increased resilience in poor weather.

Overall, the PJ.01-W2 project is on track to deliver its target objectives. In this reporting period, the solutions have been mainly in the scoping and definition phase. The SESAR JU has been closely involved in this phase, in order to ensure that the scoping activities support the delivery of the European ATM Master Plan, and that the baseline considers the maturity achieved by each of the conceptual elements at the end of Wave 1. This has led to some key decisions. At meetings and workshops conducted early in 2020, operational improvements were reviewed against the outcomes at the end of Wave 1 and against the current understanding. EATMA change requests were raised to create/amend the operational improvements as agreed amongst the Solutions partners and with the SESAR JU.

Another key decision that was reached was to split the two threads, A1 and A2, of PJ.01-W2-08A into two distinct and separate solutions, PJ.01-W2-08A1 and PJ.01-W2-08A2.

The project is now composed of the following four solutions that are currently in execution.

- **Solution PJ.01-W2-08A1, 'Short-term demand–capacity balancing optimisation of terminal manoeuvring area and extended terminal maoeuvring area airspace with terminal manoeuvring area management tool'**, will develop concepts for digital synchronisation of arrivals and departures in high-density/high-complexity environments. The solution will investigate the management of TMA/E-TMA traffic, taking advantage of predicted demand information provided by local arrival and departure management systems to identify excess demand on a sector or route or additional capacity and to balance the sector/flow load.

During the reporting period, good progress has been made in the definition phase of the solution, and the initial validation plan and OSED have been delivered. Work on the development phase of the prototype is now under way and organisational

preparation work for the validation exercise will start shortly. The solution targets V3 maturity at the end of Wave 2.

- **PJ.01-W2-08A2, 'Automatic controlled time of arrival for the management of arrival en route and on the ground'**, will investigate the concept of automatic imposition of arrival management constraints direct to the aircraft en route and on the ground prior to start-up for 'in-horizon' departures. It aims to validate the implications for both the ground and the airborne side regarding automation of controlled time of arrival (CTA) constraints. It will also provide enhancement for ATM using upstream delay sharing to the aircraft and via ATC systems on the ground.

Like Solution 08A1, this solution has made good progress in the definition phase and delivered initial documents for SESAR JU review. In addition, work has started on the development phase and on the preparatory work for the RTS validation exercise. It is intended that this solution will be assessed at the maturity gate in 2021 for this solution to demonstrate V1 before proceeding with the hope that it can achieve its target maturity of V2 by the end of 2022.

- **PJ.01-W2-08B, 'Dynamic extended terminal manoeuvring area for advanced optimised descent operation'**, is based on four validation threads that will investigate dynamic TMA/E-TMA for advanced optimised descent operation in high-density/high-complexity environments.

The solution has made a good progress against schedule in the initial documentation phase and preparation for validation phase. The initial OSED has been delivered and approved by the SESAR JU. The initial validation plan, which specifically details the plans for threads B1 and B4, has also been delivered and approved by the SESAR JU. The solution targets V2 maturity at the end of Wave 2.

- **PJ.01-W2-06, 'Advanced rotorcraft operations in the terminal manoeuvring area'**, will investigate the benefits deriving from the implementation of enhanced technology that better supports new, advanced. procedures for RC, beyond those already researched in SESAR 1. The solution will seek to improve integration of IFR RC operations within TMAs, assuring a high level of operational interoperability, safety, synchronisation and resilience and improved pilot (RC) and ATCO performances in the TMA environment populated by different AUs (major airlines and RC).

The solution has made good progress in the definition phase and delivered initial documents for SESAR JU review (the initial OSED and initial validation plan) and started on the development phase and on the preparatory work for the validation exercises. The solution targets V2 maturity at the end of Wave 2.

Project **PJ.10 W2, 'Separation management and controller tools'**, builds upon previous work in SESAR 2020 Wave 1. The project will further mature the concept of flight-centric ATC, which means that all ATCOs are responsible for a certain number of aircraft throughout their entire flight segment within a given airspace. Another objective is to enable collaborative control operations, which will allow ATCOs to issue instructions to aircraft that involve out-of-sector manoeuvring, without the coordination required in conventional operations. This will be accompanied by an activity to identify and validate needs that might allow an ATCO to operate in any airspace classified as a particular type. That is, the ATCO will be validated on method and tools rather than on a specific geographical airspace.

- In addition, the project will investigate and develop the contingency and delegation of airspace operational use cases. It will identify the impacts on the services defined in the virtual centre concept and validate the concept within a realistic environment based on contingency needs or on organisation needs (either static, on a fixed-time transfer schedule, or dynamic, when the traffic density is below/above a certain level). In order to reduce the workload and mental strain on the controllers in the ATC centre, especially in high-density/high-complexity situations, the project will investigate new human–machine interface interaction modes and technologies. This work will consider modern design and development approaches as well as methodologies such as modularity, service-oriented architecture and adaptive automation. The project will in particular address automatic speech recognition (ASR), attention guidance and enhanced user profile management systems.
- The project will address the following solutions that are currently in execution:
  - **PJ.10-W2-73, 'Collaborative control',**
  - **PJ.10-W2-73, 'Flight-centric air traffic control',**
  - **PJ.10-W2-73, 'Increased flexibility in air traffic control officer validation',**
  - **PJ.10-W2-93, 'Delegation of air traffic management services provision among air traffic system units',**
  - **PJ.10-W2-96, 'Automatic speech recognition',**
  - **PJ.10-W2-96, 'Attention guidance',**
  - **PJ.10-W2-96, 'User profile management system'.**

The SESAR JU kicked off PJ.10-W2 in January 2020, and helped the project to structure the work required so that the project will deliver the EU policy objectives reflected in the ATM Master Plan, including the updated Master Plan level 2, will reflect the agreed scope of the project and will link to the architecture vision of the Airspace Architecture Study. In particular, the SESAR JU provided support to kick off the Eurocae working group for the standardisation of the virtual centre, which is a key step in preparing the deployment of the virtual centre technology and the service-oriented architecture made possible by the modular ATM data service providers (ADSPs) concept.

The SESAR JU has also supported the project in the successful scoping of the delegation of ATS activities that will be conducted, which include the game-changing use cases of night delegation (enabling the consolidation of ATC services during the night) and contingency delegation (supporting the resilience of the ATM network). In the area of automation (collaborative control, flight-centric ATC, ASR and attention guidance), the SESAR JU provided support to the projects whose plans had to be changed owing to COVID-19 in order to prioritise the activities and ensure a coherent delivery in accordance with the priorities of the ATM Master Plan. All the solutions have made progress during the year in the preparation of the validation activities to be conducted in 2021–2022, with the exception of user profile management systems: during the ramp-up of this solution, the SESAR JU assessed the project as being ready for industrialisation, and it was agreed to cancel the planned validations in order to avoid wasting resources on the validation of a solution that is already mature.

- Project **PJ.13 W2, 'IFR RPAS'**, covers the IFR RPAS integration in controlled airspace mainly used by airlines (classes A–C) by developing a framework for the insertion of RPAS into the non-segregated airspace, allowing their routine access and operations. It also develops a DAA system for IFR RPAS operations that will allow the remote pilot to contribute to safety by preventing collisions in the event of failure of normal separation provisions. During 2020, the project activities have been mainly in the scoping and definition phase. The SESAR JU has been closely involved in this phase, in order to ensure that the scoping activities support the delivery of the objectives of the European ATM Master Plan, and that the baseline considers the maturity achieved by each of the conceptual elements at the end of Wave 1. The SESAR JU has also facilitated stakeholder involvement in this project, by supporting the participation of professional staff organisations (PSOs) and the EDA in the PJ.13 Technical Advisory Committee through, respectively, the SESAR JU support contract with the PSOs and the memorandum of cooperation (MoC) with the EDA. The SESAR JU has also taken a leading role in supporting coordination between PJ.13 and PJ.14 in order to that R & I meets operational needs. The project will address the following three solutions that are currently under execution.
- **PJ.13-W2-111, 'Collision avoidance for instrument flight rules for remotely piloted aircraft systems'.** DAA systems for IFR RPAS have two functions: RWC and collision avoidance. For RPAS to be allowed into the airspace, the DAA performance should be at least as good as traffic collision avoidance system (TCAS) II and see and avoid. Collision avoidance for RPAS (ACAS Xu) is a DAA system that will be assessed. Early in 2020, the SESAR JU supported the project during the scoping phase in order to ensure the implementation of the approach to this safety net agreed by the SESAR JU with the EASA and the EDA during the call definition phase. Now that scoping is complete, the project has made good progress towards the achievement of the expected maturity level at the end of Wave 2.
- **PJ.13-W2-115, 'IFR RPAS accommodation in airspace classes A–C'**. This solution aims to accommodate IFR RPAS, in the short to medium term, during their transit phase through non-segregated controlled class A–C airspace by establishing harmonised procedures across European airspace of low/medium density and complexity. The SESAR RPAS accommodation solution targets reduced planning and approval time and routine access of small numbers of IFR RPAS. The initial RPAS demand will benefit from routine access procedures to transit and operate in airspace classes A–C, as general air traffic (GAT) with limited restrictions. Departure/arrival remains from/to dedicated airfields or dedicated mission areas. The work of this solution progressed well during the year, with the SESAR JU having provided continuing support to the solution in broadening the scope in order to provide, as far as possible, a solution that is relevant at European level, even if based on the experience of mitigations that have been successful at local level.
- **PJ.13-W2-117, 'IFR RPASintegration in airspace classes A–C'.** The solution aims at enabling IFR RPAS to operate alongside manned aircraft in the controlled airspace classes A–C completely transparently, with no mitigations because they are unmanned. The long-term operational concept will be developed in order to allow RPAS to file a flight plan, obey ATC instructions, follow clearances and deal with emergencies in a manner that is safe and fully understandable to ATCOs, with no additional adverse effect on the ability of the ATM system to handle IFR RPAS in this cooperative environment. The SESAR JU has supported this solution in the architecture and concept definition phase in order to ensure consistency

with the rest of the SESAR programme and the objectives of the ATM Master Plan, including in particular coherence with the PJ.14 CNS architecture and the consideration of the ground–ground link in a multilink environment for the communication of the RPAS pilot with ATC. The solution has progressed well in the preparation of the validation activities that will take place in 2021–2022.

The SESAR JU kicked of PJ.13-W2 in January 2020.

Project **PJ.18 W2, '4D skyways'**, builds on the previous work on SESAR 2020 Wave 1 and continues the research on trajectory management to enable the deployment of the SESAR TBOs.

PJ.18-Wave 2 will deliver mature trajectory management operational improvements to accelerate deployment and to achieve the associated benefits. In the longer term it will also work on the definition of a consolidated trajectory management solution to drive the coherence and efficiency of research on trajectory management and on architecture alternatives to address the European ATM fragmentation.

PJ.18 W2, '4D skyways, started in December 2019, and five kick-off meetings for the project and its solutions were held between the end of January and beginning of February 2020. During 2020, the project activities have been mainly in the scoping and definition phase. The SESAR JU has been closely involved in this phase, in order to ensure that the scoping activities support the delivery of the objectives of the European ATM Master Plan, and that the baseline considers the maturity achieved by each of the conceptual elements at the end of Wave 1. The SESAR JU has also taken a leading role in supporting the coordination between PJ.18 and PJ.14 in order to ensure consistency in the programme between research into operational concepts and research into the CNS required to support the operational concepts.

The project is composed of the following five solutions that are currently in execution.

- **PJ.18-W2-53A, 'Increased automation in planning and tactical separation management,**
  - This solution develops and validates enhanced assistance to the en route and TMA (planner or tactical) controllers in their conflict detection and resolution tasks. It provides enhanced resolution support information based on predicted conflict detection and associated monitoring features.
  - The solution has achieved good progress in the design phase activities (initial OSED, safety and performance and interoperability requirements document (SPR/Interop), initial TS, validation plan) including document informal assessments at internal checkpoints. The formal delivery of the combined solution, Solution 53A/B OSED, to SESAR JU was delayed for few months to allow the remaining work on the safety requirements and the approvals process to be completed. The solution targets V2 maturity at the end of Wave 2.
- **PJ.18-W2-53B, 'Improved performance of conflict detection and resolution tools enabled by reduced trajectory prediction',**
  - The solution will provide the (planner or tactical) controller with conflict detection and resolution tools that use more accurate parameter settings and are based on an enhanced ground predicted trajectory through the use of improved and/or additional relevant data (e.g. aircraft trajectory data downlinked via automatic dependent surveillance contracts (ADS)-C, more

recent weather information). Improved and/or additional relevant trajectory data may be made available via air–ground datalink exchanges (e.g. using real recorded downlinked ADS-C information). During the reporting period, the design phase was completed and significant progress was made in identifying the activities that remain to be undertaking to achieve V2 maturity, taking into account the assessed maturity level of the outcomes of Solutions 10.02b and 18.06a/b at the end of Wave 1. During this gap analysis phase, the SESAR JU engaged with project members through meetings and workshops in order to review the operational improvements against the outcomes at the end of Wave 1 and against current understanding, in order to ensure that the objectives of the European Master Plan are delivered. The SESAR JU plans to assess whether not the solution has achieved V2 'maturity level in March 2021. The solution targets V3 maturity at the end of Wave 2.

- **PJ.18-W2-56, 'Air/ground trajectory synchronisation via lateral and vertical complex controller–pilot datalink communications clearances to support trajectory-based operations':**
  - The solution will research enhanced operational procedures that make more efficient use of CPDLC with lateral and vertical data link clearances. The proposed work will improve the alignment of the airborne trajectory with the trajectory that the ground actors plan to execute by sending complex clearances more and more in advance. The airborne trajectory will become more useful on the ground as it will integrate the impact of future ground actor's instructions, allowing more efficient decision-making. With the proper automation, this will decrease both ATCO and flight crew workload, leading also to a better management of ATC and flight crew resources .
  - During the reporting period, there has been significant progress in the design phase activities (initial OSED, SPR/Interop, initial TS, validation plan) including document assessments at internal checkpoints. The formal delivery of the TS and validation plan is progressing on schedule but formal delivery of the OSED to the SESAR JU has been delayed until March 2021 owing to the time taken to address comments from partners and AUs. Work on the development and validation phase work is progressing (e.g. preparatory work on the EUROCONTROL ESCAPE platform for the real-time simulation exercise on 'air–ground synchronisation with CPDLC complex clearances and automation' including the development of remote training modules for ATCOs). The solution targets V2 maturity at the end of Wave 2.
- **PJ.18-W2-57, 'Reference business trajectory revision supported by datalink and increased automation':**
  - This solution aims to improve the benefits of future trajectory management developments by investigating the possibility of greater automation of trajectory exchanges. The project team responsible for this solution also developed and maintain a trajectory management document integrating the outcomes of the SESAR and non-SESAR trajectory management developments. Further to a number of partner withdrawals, the team is considering the relaunch of the trajectory management document task at project level.
  - During the reporting period, the Solution continued to engage with partners via monthly WebEx meetings, and early work has started on the validation plan. Further to the withdrawal of Honeywell International, it is planned that leadership of the OSED work will be taken over by NATS in early 2021. The

way forward for this solution is under review and subject to grant amendment during 2021.

- **PJ.18-W2-88, 'Trajectory prediction service':**
  - The solution will continue to investigate the feasibility of a common service acting as a single point of truth for trajectory information for all ground ATM stakeholders, reducing European ATM system defragmentation.
  - During the reporting period, engagement with partners has continued by means of monthly WebEx meetings, and initial drafts of the high-level architecture and system design document have been assessed at project internal checkpoint. The solution will be subject to a TRL-2 maturity gate' assessment, planned for April 2021.

OPTIMISED ATM NETWORK SERVICES

Project **PJ.07 W2, 'Optimised airspace users' operations'**, aims to enhance the integration of the AU trajectory and the mission trajectory into network management processes to increase the involvement of civil and military AUs in ATM collaborative processes.

- **Solution PJ.07-W2-38, 'Enhanced integration of airspace users' trajectory definition and network management processes'**, kicked off in 2020.
  - The objective of this solution is to reduce the impact of ATM planning on AUs' costs of operations, by enabling them to better cope with ATM constraints and to exploit network opportunities. Among other benefits, better collaborative decision-making planning between providers and users ensures better adherence to the agreed trajectory during execution and, hence, better predictability of traffic demand.
  - The solution is intended to improve AUs' flight planning and ATM network management by improving the participation of the flight operations centre (FOC) in the ATM network collaborative processes in the context of flight and flow – Information for a collaborative environment (FF-ICE) and its potential evolutions.
- **Solution PJ.07-W2-39, 'Collaborative framework managing delay constraints on arrivals'**, kicked off in 2020.
  - This solution develops a collaborative framework that will enable the integration and necessary coordination of 4D constraints (limited to arrivals management) from various stakeholders (airports, ANSPs, AUs and NM). This will ensure the continued stability and performance of the network and will enable AUs to prioritise their most important flights, hence reducing the impact of ATM planning constraints on the costs of their operations.
  - The main objective of this solution is to define and validate a framework to enable coordination of and collaboration between different ATM processes (including UDPP3), dealing with delay constraints on arrivals (considered the most important contributor to capacity performance issues).
- **Solution PJ.07-W2-40, 'Mission trajectories management with integrated dynamic mobile areas (type 1 and type 2)'**, kicked off in 2020.
- **Solution PJ.07-W2-40** focuses on the refinement and further validation of the concept elements of mission trajectory and dynamic mobile areas (DMAs) types 1 and

2, together with the associated collaborative processes between relevant actors: AUs, airspace and flow managers, ANSPs and the NM.

- The objective is to improve fuel efficiency and the use of airspace capacity for both civil and military users and the efficiency of airspace management by introducing more automation and increased flexibility in the civil–military coordination, as well as by enhancing the harmonisation between civil and military processes across Europe and facilitating cross-border operations.
- The goal of this solution is to integrate the management of the military AU demand for airspace reservation/ restriction (ARES) (DMA types 1 and 2) and the initial mission trajectory through enhanced automation and participation in CDM. The key improvement is the integration of military demand with all adherent to mission trajectory attributes into collaborative traffic management and participation in DCB by sharing ATM-related data through improved operational air traffic flight plan.
- In the context of the solution, the initial mission trajectory indicates the transition from time-based to trajectory-based operations with limited capabilities to address the 4D dataset. The coordination between wing operations centre (WOC) and the regional NM is a key element of this solution, providing flexibility and supporting the integration of dynamic airspace configuration (DAC) management in the DCB processes.

PJ.09 W2, 'Digital network management service', is intended to enable both civil and military AUs to make better use of the available airspace capacity by increasing the granularity and flexibility of airspace configuration and management within and across ANSPs' areas of responsibilities. Increasing the digital information available in the NOP will ensure that all interested actors (e.g. traffic forecast, traffic complexity representation) have up-to-date, real-time ATM situational awareness.

- **Solution PJ.09-W2-44, 'Dynamic airspace configurations'**, kicked off in 2020.
  - This solution aims to improve both civil and military AUs' use of airspace capacity by increasing the granularity and the flexibility of airspace configuration within and across ANSPs' areas of responsibility.
  - It will address the integration of concepts and procedures to allow flexible sectorisation to be dynamically modified based on demand. This includes potential impact assessment for ATCO licences, international boundaries and potentially IOP and air–ground multi-datalink communication capabilities.

Building on the results of PJ.08 and PJ.09 in Wave 1, on DAC, INAP processes, tools and coordination with the NM, the S44 will focus on the use of automation support to combine INAP and DAC in a single step.

- **Solution PJ.09-W2-45, 'Enhanced network traffic prediction and shared complexity representation',** kicked off in 2020 and initial documents were produced in 2020.
  - The first aim of this solution is to improve the quality of the pre-tactical traffic forecast to allow planning in the pre-flight phase to be extended with confidence to all network stakeholders.
  - The solution will address this challenge by further integrating, in a rolling and dynamic process, the local tools, in particular AU, airport and ANSP (FMP/ INAP), with the NM and internally by providing better forecasts using data science techniques such as AI and ML.
- **Solution PJ.09-W2-49, 'Collaborative network performance management',** kicked off in 2020.

- This solution will improve the current monitoring process by introducing network state monitoring methodology, which combines performance indicators collected at the local level with advance data science and prediction techniques to identify and anticipate disruptive operational situations across the network.
- By developing a network performance management dashboard, Solution 49 enables the NM to view network view and to focus on areas that are of particular interest because they may be subject to performance degradation. Solution 49 enables identification of the most appropriate stakeholder to manage DCB, likely to be a local stakeholder in the case of nominal status and a network-oriented stakeholder in the event of a critical situation. Initial documents were produced in 2020.

ENABLING AVIATION INFRASTRUCTURE

PJ.14 W2, 'Integrated communications, navigation and surveillance solutions', has as its main goal the development of an integrated suite of CNS solutions to overcome the inefficiencies of fragmented services while improving the operational efficiency of the ATM system in the short, medium and long terms. In the communications area, it covers multilink technologies to enable the digital transfer of flight-critical data and voice communications between aircraft and ground ATM services in a resilient, secure and timely manner. The navigation solution consists in the development of satellite navigation-based robust positioning for all phases of flight, taking advantage of signals from multiple constellations, including Galileo. In the surveillance domain, the project harmonises and integrates cooperative and emerging non-cooperative sensors, advanced multisensor data fusion capabilities and security-related functionality together with methods of and tools for surveillance performance monitoring.

- **Solution PJ.14-W2-76, 'Integrated communications, navigation and surveillance and spectrum'**, is a transversal solution that aims to increase CNS consistency across domains, in terms of robustness, spectrum use and interoperability, including the civil–military aspects, by providing a global view of future CNS services and defining the future integrated CNS architecture (and CNS spectrum strategy).
  - The solution builds on the work carried out in Wave 1 under PJ.14-01-01.
  - The solution will act as the federating solution for the project and all its solutions to ensure a harmonised and integrated approach. Coordination and contribution transversal and operational projects activities. Initial versions of 'CNS service assessment V1' and 'CNS performance-based approach V1', along with a 'CNS evolution roadmap and strategy V4', are in development.
- **Solution PJ.14-W2-60, 'FCI terrestrial data link (L-band digital aeronautical communications system)'**, builds on the work performed by SESAR Solution PJ.14-02-01 and covers the technical enabler 'New air–ground datalink using aeronautical telecommunication network / internet protocol suites over L-band (CTE-CO2e)'.
  - The objective of Solution 60 is to integrate and verify the L-band digital aeronautical communications system (LDAC) datalink with aeronautical telecomunication network (ATN) services in a relevant end-to-end environment.
  - This solution will focus on the ground component of the air–ground datalink and aims to take it to TRL-6. The air component will be addressed under a complementary call under PJ.33-W3-FALCO.

- **Solution PJ.14-W2-61, 'Hyperconnected air traffic management'**, explores the concept of enlargement of the future communication infrastructure (FCI) (as defined by PJ.14-W2, Solution 77) through integration of open network services and commercial public radio links or technologies. The resulting hybrid open/protected 'hyperconnected' communication infrastructure is intended to be an enabler of future ATM and U-space operations, supporting safety and non-safety air–ground and air–air data. The concept definition and functional requirements document are currently on schedule.
- **Solution PJ.14-W2-77, 'Future communication infrastructure services'**, addresses FCI network technologies and seeks to validate and standardise the FCI elements that integrate all components of the end-to-end communication chain for safety-critical applications. These include the future data link systems (LDACS, SATCOM and AeroMACS (aeronautical mobile airport communication system)) and ground infrastructure elements.
  - This solution also addresses transversal topics such as security, safety, deployment and civil–military interoperability with ground–ground communications networks. Wave 2 continues and completes the work performed by PJ.14-02-04 in Wave 1.
  - The objective is to achieve TRL-6 for the FCI elements needed to support ATN-B1 services, ATN-B2 services, future ATN-B3 services (the solution will provide for such services in the future), AOC services and safety SWIM services, as well as interoperability with ATN/OSI systems and infrastructure.
  - The solution 'Overall concept of operation future communication infrastructure Services – TRL-6' first edition has been produced and all other tasks, including the development of deployment and transition strategies and building of prototypes, are under way.
- **Solution PJ.14-W2-107, 'Future satellite communications datalink'**, addresses the development of the future satellite datalink technologies, also referred as 'long-term' or 'class A' SATCOM for both the continental and remote/oceanic regions to for support the future concepts beyond 2020.
  - The solution represents one of technologies that in Solution 77 are called 'ICAO technologies' (FCI services). It is an essential part of the seamless, resilient and integrated FCI to allow the real-time sharing of 4D trajectories and timely access to ATM data and information services.
  - In terms of performance benefits, the solution will increase datalink availability and capacity and will improve safety and security (resilience). The solution represents a technical enabler required for achieving the performance and safety objectives of the 4D trajectory management operational concept.
  - This solution will continue and complete the work performed by PJ.14-02-02 in Wave 1 on long-term class A SATCOM. In particular, the activities in Wave 2 will include completion of technical specifications; completion of the development and specification of a performance monitoring and control concept for long-term SATCOM in ATN/IPS; contributing to the functional FCI architecture developed by and under the responsibility of Solution 77 (FCI services); development of SATCOM voice as a full HF alternative in oceanic and remote continental airspace; in coordination with ESA Iris, ensuring, in the long term, harmonisation at global level of the proposed solution; technical validation at TRL-5 and taking the initial steps towards TRL-6 of satellite air–ground datalink for long-term SATCOM integrated in the FCI; supporting the elaboration of the required standards at global level.

- **Solution PJ.14-W2-100, 'System-wide information management technical infrastructure purple profile for air–ground safety-critical information-sharing'**, addresses the distribution (uplink and downlink) of safety-critical information through air–ground SWIM infrastructure and ATN/IPS networking, rather than legacy point-to-point contracted services.
  - The aim is to analyse, design, specify and validate the purple profile for safety-critical information-sharing. The solution concerns only the SWIM infrastructure layer: design, specification and prototyping of the SWIM services and network layers demand other solutions.
  - The solution will, when relevant, build on the results from SESAR 2020 Wave 1 projects PJ.17-01 and PJ.17-07 and deployed SESAR1 Solutions specifically related to SWIM. SESAR 2020 Wave 1 outcomes will be further constrained taking into account the domain (safety-critical) and the analysis of OSED and SPR concerning candidate safety-critical air–ground SWIM services.
  - The solution is a technical enabler (for the SWIM infrastructure layer only) allowing an aircraft to be integrated into the SWIM network and thus giving it access to air–ground safety-critical SWIM services. SWIM-enabled aircraft, flight crews and ground-based systems will all benefit from the SWIM concept and principles. It is envisaged that the solution will achieve maturity level V2/TRL-4 but the likelihood of this will be further evaluated taking into account limitations in avionics and airborne contributions (in both the specification and validation phases).
- **Solution PJ.14-W2-101, 'System-wide information management technical infrastructure green profile for ground–ground civil–military information-sharing'**, aims to enable ground–ground civil–military SWIM-based coordination at SWIM TI level by developing SWIM profiles with adequate QoS, including the (cyber) security needed by military stakeholders and agreed by civil stakeholders.
  - This SESAR Solution aims to increase cost efficiency and improve civil–military cooperation and coordination.
  - The solution provides specifications for security and performance additional to those in the SWIM yellow profile standard in order to maximise civil–military interoperability at minimum cost.
  - The solution builds on the results of SESAR 2020 Wave 1 project PJ.17-03 and, it is hoped, will achieve the V2/TR-4 maturity level. In Wave 2, the objective is to reach V3/TRL-6 maturity such that the complementary green profile technical requirements can be integrated with the yellow profile standard for standardisation.
- **Solution PJ.14-W2-79, 'Dual-frequency/multiconstellation ground-based augmentation system'**, aims to advance as a technical enabler and to take advantage of the operational benefits that GBAS can provide. In addition, to advance in the standardisation activities with the existing working groups on dual-frequency multi-constellation (DFMC) at Radio Technical Commission for Aeronautics (RTCA) and ICAO/NSP levels. As contributions from the partners were lower than expected, not least because Airbus, Honeywell and Thales did not actively participate in the solution, a review of the scope described in the DoW is proposed in this BAFO. The activities will include GBAS activities, but airborne architecture, including advanced received autonomous integrity monitoring (ARAIM) and the satellite-based augmentation system (SBAS), will not be addressed because of the very low contribution from the airborne side. Support for DFMC standardisation activities will remain. With respect to GAST-F, the project will advance in the definition at system level and at subsystem level (for the ground segment); however, the airborne

segment cannot achieve this level of maturity. By way of recovery, the objective will be to promote the definition of the standards at RTCA and ICAO levels.

- **Solution PJ.14-W2-81, 'Alternative position, navigation and timing'**, has as its objective the development of an alternative position, navigation and timing (A-PNT) system as a technical enabler to support PBN/required navigation performance (RNP) operations in the event of GNSS degradation or outage. The solution addresses two different level of maturity for the two main subsolutions, namely the mid-term Solution and the long-term Solution:
  - The mid-term solution, 81a, aims to develop, consolidate and test the multi-DME approach with autonomous integrity monitoring while targeting a V3/TRL-6 maturity level.
  - In the long-term solution, newer technologies and hybrid techniques will be investigated, including terrain-aided and vision-based navigation, targeting full TRL-4. This will involve investigation of enhanced DME (81b), LDACS (81c) and vision-/terrain-based navigation (81d). The operational concepts developed in the long-term subsolution aim to reduce the congestion of L-band while minimising the changes required to on-board and ground hardware.
- **Solution PJ.14-W2-110, 'Aircraft as an aeronautical information management / meteorological sensor and consumer'**, continues the development work of PJ.01 in Wave 1 although the objectives were refined in 2020.
  - The target remains the development of new and improvement of existing AIM/MET services to support the use of weather data by systems for flight management, efficiency and environmental sustainability.
  - The solution is intended to improve the performance of services by providing better localisation of phenomena, higher update frequency and improved prediction and comprehensive observation coverage.
  - The solution will improve awareness among the crew, the airline dispatcher and the ATCO of weather and climate-impacting conditions encountered by aircraft.
  - The solution will support and awareness and monitoring of underperformance of GNSS services due to environmental events and disseminate information about GNSS.
  - By supporting the processing of aeronautical Information, the solution will enable more accurate predictions of operational flight constraints. Future enhancements will address: (a) improvement in the weather information (fusion of local observations from aircrafts and predictions from ground) and (b) services applications to increase the efficiency of relevant operations.
  - The target environment is en route as well as airport/TMA. Air–ground and ground–ground communication are considered.
- **Solution PJ.14-W2-84, 'New use and evolution of cooperative and non-cooperative surveillance'**, aims to address the separate evolution of non-cooperative surveillance systems such as multistatic primary surveillance radar and video trackers and cooperative surveillance systems such as ADS-B, airport and wide-area multilateration (MLAT/WAM) systems as well as establishing new surveillance sensors to support emerging operational needs (such as multiple remote tower surveillance). A further objective is the harmonisation and development of surveillance performance monitoring tools to support a performance-based surveillance approach. This complex work package was divided into six solutions:

- **PJ.14-W2-84a, 'New use and evolution of cooperative and non-cooperative surveillance – multisensor data fusion'** (TR-L6);
- **PJ.14-W2-84, 'New use and evolution of cooperative and non-cooperative surveillance – Multi Remote Surveillance module'** (TRL-6);
- **PJ.14-W2-84c, 'New use and evolution of cooperative and non-cooperative surveillance – secured surveillance systems (single and composite systems)'** (TRL-6);
- **PJ.14-W2-84d, 'New use and evolution of cooperative and non-cooperative surveillance – future automatic dependent surveillance-B communications link'** (TRL-6);
- **PJ.14-W2-84e, 'New use and evolution of cooperative and non-cooperative surveillance – surveillance performance monitoring tool for cooperative sensors'** (TR-L6);
- **PJ.14-W2-84f, 'New use and evolution of cooperative and non-cooperative surveillance – surveillance performance monitoring – end-to-end'** (TRL-4).

1.4.3. Status of the Wave 3 call (H2020-SESAR-2020-2)

The objective of the Wave 3 call for proposals is to optimise coverage of the R & I topics identified in the SESAR 2020 programme as necessary to address ATM Master Plan phase C (see Figure 8 in subparagraph 1.1.2.3, 'Delivery of very large-scale demonstration activities'), taking due account of the outcome of the Airspace Architecture Study.

Following consultation with the Programme Committee (see subparagraph 1.2.3.3, 'Contributions from the Programme Committee in 2020', the SESAR JU started the 'Finalisation of call material' phase, which was conducted with the aim of consolidating the technical specifications into the call material for further publication. The final Wave 3 call conditions were documented in the 2020–2022 SPD and served for the financing decision authorising the launch of the call for proposals and the use of the dedicated budget. The Wave 3 call was published at the beginning of 2020 with a short deadline and requiring proposals to be submitted in Q2 2020. The SESAR JU then evaluated the proposals very quickly, allowing the grant agreement preparation phase to be launched in September. Grant agreements were signed in December 2020 and execution of the Wave 3 projects started in January 2021. Delivery of candidate SESAR Solutions is expected in 2021 and 2022. IR-VLD Wave 3 is the last call covering IR, securing the commitment of SESAR JU members until the end of the SESAR 2020 programme operations.

Five projects, awarded in total EUR 29 925 861.82 (i.e. 99 % of the funds available under the call), have been launched in execution, of which three are IR projects, summarised below, and two are VLD projects, summarised in subparagraph 1.5.1.5, 'Status of the Wave 3 call (H2020-SESAR-2020-2)', below.

ADVANCED AIR TRAFFIC SERVICES

- Project **PJ.32 W3, Virtual centre**, complements SESAR Solution PJ.10-W2-93, 'Delegation of ATM services provision among ATSUs, in addressing airspace delegation, and SESAR Solution PJ.09-W2-44, 'Dynamic airspace configurations', as regards investigation of the cross-border use of the dynamic airspace configuration'. PJ.32 W3 aims to further validate airspace delegation in the virtual centre context (airspace delegation for two ATSUs, either from two different ANSPs or from the same ANSP, that can deliver service over the same volume of airspace, potentially including a cross-border rostering scheme). In addition, it aims to increase the maturity level of the virtual centre concept itself. The overall objective is to demonstrate the positive impact of the virtual centre concept on the network:
  - by improving its ability to dynamically adapt to changes in capacity, for example in the event of contingency in an ATSU, traffic needs or ATCO shortage;
  - by increasing cost efficiency through the decoupling of ATM data provision from ATC service provision, thus enabling flexible, scalable and resilient ATM service provision.

The SESAR JU kicked off PJ.32-W3-VC in January 2021.

The objective of project **PJ.33 W3, FALCO**, is to increase the efficiency of ATM in two different ways:

- First, building on the work done in PJ.10-W2-73, ATC capacity will be increased by investigating and validating changes in techniques and procedures to enable the reorganisation of the endorsement of ATCOs working in the lower and upper area control services (explicitly excluding the approach control service). This will be achieved by introducing new endorsement rules that are based more on traffic complexity, sector classes and controllers' skills, experience and training in a specific class of working environment and supporting system.
- Second, the efficiency of air–ground communication will be increased by investigating the technical enabler to broadly introduce voice capability supported by LDACS with the ultimate goal of replacing analogue voice communication. Furthermore, the future air–ground terrestrial datalink (LDACS) will increase connectivity between air and ground, something that is essential to future concepts, and will also support the resilience of aircraft navigation.

The SESAR JU kicked off PJ.33-W3, FALCO, in January 2021 and the WP3 is linked to Enabling Infrastructure Project 14-W2 ICNSS Solutions 60 LDACS.

Project **PJ.34 W3, AURA** aims to lay the foundations for the integration of the new entrants to the current and future air traffic environment, developing the required ConOps and validating information exchange between U-space services and ATM systems.

- The AURA project will identify the requirements for information exchange between U-space services and ATM through SWIM and will validate a set of selected U-space services, developing the service definition for the SWIM candidate services.
- Secondly, it will define and validate a novel collaborative ATM–U-space ConOps for drones that goes beyond the existing concepts developed for U-spaces.

In addition, the project will provide inputs to the current regulatory and standardisation initiatives regarding U-space, in which external stakeholders will be closely involved, in the form of an advisory board.

The SESAR JU kicked off PJ.34-W3, 'AURA', in January 2021.

Additional outcomes of the Wave 3 call are described in subparagraph 1.5.1.5, 'Status of the Wave 3 call (H2020-SESAR-2020-2)', below.

1.4.4. SESAR Solutions delivery: the release process in 2020

The release process is the process by which the maturity of candidate solutions is assessed. In 2020, Release 9 was completed and the majority of the work of Release 10 was carried out, with the last activities of Release 10 expected to take place in 2021. The outcomes of these two releases are presented in the subparagraphs below.

During 2020, the SESAR JU and its members were supported by SESAR Development Support Services (SDSS) in the implementation and execution of the processes and procedures required to guarantee consistency in the programme life cycle. SDSS contributed to the definition of the Release 9 plan in identifying the different candidate solutions to be validated and delivered in accordance with the release process. Activities related to the maturity assessment of the candidate solutions were also supported by SDSS through the delivery and maintenance of the maturity assessment tool together with the organisation of the maturity gates and the preparation of the material required as the inputs and outcomes of the gates. Some features were added to STELLAR, the SDSS collaborative platform used by the SESAR JU and by all projects for planning, scheduling and monitoring project progress. In particular, the system now enables the schedules for all project to be integrated into the overall programme schedule. This ensures consistent development of interdependent projects and provides different users with different views on planning, deliverables assessment, maturity gates and release delivery.

1.4.4.1. Release 9 outcome

Release 9 was launched into execution at the beginning of 2019 and concluded in September 2020, delivering 35 SESAR Solutions ready for industrialisation and further deployment (V3 or TRL-6). The SESAR Solutions in Table 3 have been delivered in the context of Release 9.

TABLE 3 OUTCOMES OF RELEASE 9

HIGH-PERFORMING AIRPORT OPERATIONS		
Solution ID	**Solution name and description**	**Maturity level**
PJ.02-01-01	**Optimised runway delivery on final approach** Optimised runway delivery (ORD) on final approach is an ATC support tool to enable safe, consistent and efficient delivery of the required separation or spacing between arrival pairs on final approach to the runway landing threshold. The ORD tool is used to support the application of distance-based and time-based wake separation rules including the ICAO, RECAT-EU, pairwise separation (PWS) and weather-dependent separation (WDS) wake separation schemes, and to manage, consistently and efficiently, the spacing compression that occurs on short final approach from the lead aircraft crossing the deceleration fix. **Expected performance benefits** The solution has validated performance benefits in terms of airport capacity (runway throughput), resilience, predictability and fuel efficiency.	V3
PJ.02-01-02	**Optimised separation delivery for departure** Optimised separation delivery (OSD) for departure is the ATC support to enable safe, consistent and efficient delivery of the required separation or spacing between departure pairs from the following aircraft becoming airborne. This includes the departure wake separations of ICAO, RECAT-EU, PWS – departure (PWS-D) and WDS – departure (WDS-D) and may also include departure route separations such as the standard instrument departure separations, minimum departure intervals and average departure interval). Time-based separations and spacing are supported by the time-based separation variant of the OSD tool; distance-based separations and spacing are supported by the distance-based separation variant of the OSD tool. In airports that require support for both time-based and distance-based separation and spacing rules a combined time-based/distance-based variant of the OSD tool may be necessary. **Expected performance benefits** The solution has validated performance benefits in terms of airport capacity (runway throughput), resilience, predictability and fuel efficiency.	V3

Solution ID	Solution name and description	Maturity level
PJ.02-01-03	**Weather-dependent reductions in wake turbulence separations for departures** The solution optimises ICAO wake turbulence separation by using weather-dependent separation minima for departures with a common initial departure path from the runway, taking into account the prevailing wind conditions. This allows conditional reduction in or suspension of separation minima for most aircraft pairs, enabling greater runway throughput than is possible with the ICAO scheme, while maintaining acceptable levels of safety. **Expected performance benefits** The results to date show that weather-dependent separation for departures is operationally feasible and acceptable. The tools developed give ATCOs more control of wake separations, which can be reduced if weather conditions allow.	V3
PJ.02-01-04	**Wake turbulence separations (for arrivals) based on static aircraft characteristics** The solution 'Wake turbulence separations (for arrivals) based on static aircraft characteristics (PWS-A)' provides efficient pairwise wake separation rules for final approach taking into account aircraft type. It incorporates both the 96 × 96 aircraft type-based wake separation minima (for the most common aircraft in the ECAC area) and the 20 wake category (20-CAT)-based wake separation minima for arrival pairs of all remaining aircraft types. The distance-based pairwise wake separation scheme (96 × 96 pairwise and 20-CAT matrices) developed in RECAT-PWS-EU Safety Case Ed. 1.4 submitted to EASA was used to derive the time-based separation variant, which has been validated in combination with the ORD tool (see PJ.02-01-01). **Expected performance benefits** The validation results showed that the solution is operationally feasible and acceptable to controllers in a high-complexity approach and large airport environment in both segregated and mixed mode operations. The results of fast-time and real-time simulations showed that this solution brings significant benefits in terms of runway throughput.	V3
PJ.02-01-05	**Weather-dependent reductions in wake turbulence separations for final approach** The solution 'Weather-dependent reductions of wake turbulence separations for final approach (WDS-A)' enables the conditional reduction or suspension of wake separation minima on final approach in predefined wind conditions so as to enable greater runway throughput than is the case with the current standard weather-independent wake separation minima. It is based on the premise that, under the predefined wind conditions, the wake turbulence generated by the lead aircraft is either wind transported out of the path of the follower aircraft on final approach or has decayed sufficiently to be acceptable to the follower aircraft. **Expected performance benefits** The solution has shown benefits in terms of airport capacity (runway throughput), although the extend of the benefit depends on the cross-wind conditions measured on the ground and over the glide.	V3

Solution ID	Solution name and description	Maturity level
PJ.02-01-06	**Wake turbulence separations (for departures) based on static aircraft characteristics** The solution 'Wake turbulence separations (for departures) based on static aircraft characteristics (S-PWS)' intends to optimise wake separations between departures on the initial departure path by moving from schemes defined by a small number (four to seven) of wake categories to a scheme defined between pairs of each combination of the 96 aircraft types that most commonly depart from European major airports, together with a scheme defined by a larger number of wake categories (20-CAT (6-CAT + 14-CAT)) for other aircraft type combinations. It uses the ATCO OSD tool. **Expected performance benefits** The solution has validated performance benefits in terms of airport capacity (runway throughput), resilience, predictability and fuel efficiency.	V3
PJ.02-01-07	**Reduction in wake turbulence risk considering acceleration of wake vortex decay in ground proximity** Wake vortex decay-enhancing devices, so-called plate lines, can be installed at any major European airport and increase safety by reducing the risk of low-altitude wake encounters. In addition, further capacity gains may be possible through further optimisation of the wake turbulence separations on final approach. Plate lines reduce the lifetime of long-lived wake vortices in ground proximity by about 30 %, making wake encounters less likely. Each plate line consists of several upright plates that are installed beyond the ends of runways, underneath the approach glide path, with the individual plates are oriented parallel to the runway centreline. During aircraft descent, wake vortices interact with the plates, generating disturbances that propagate in and against flight direction. These disturbances reduce the lifetime of the long-lived and potentially most hazardous wake vortices. **Expected performance benefits** The solution contributes to safety: the lifetime of the long-lived wake vortices in the flight corridor under calm wind conditions can be reduced by the installation of plate lines by about 30 %.	TRL-6
PJ.02-03	**Minimum pair separations based on required surveillance performance** The solution 'Minimum pair separations based on required surveillance performance' (RSP)' allows the application (by ATCOs) of non-wake turbulence pairwise separation (of two NMs for arrivals on final approach (at the point that the leading aircraft in the pair crosses the runway threshold), based on RSP. **Expected performance benefits** The solution has validated performance benefits in terms of airport capacity (runway throughput), resilience, predictability and fuel efficiency.	V3

Solution ID	Solution name and description	Maturity level
PJ.02-05	**Independent rotorcraft instrument flight rules operations at the airport** Independent RC operations at the airport are RC-specific approach procedures and SBAS-based point-in-space that aim to improve access to secondary airports in low-visibility conditions. **Expected performance benefits** The solution improves RC access to busy airports and improves RC insertion in high-density/high-complexity airspace (IFR RC are removed from the active runways sequence). It also reduces fuel consumption and track mileage (e.g. by enabling more direct routing in dense terminal airspace) and enables a better transition to point-in-space RC approaches to / departures from heliports and from en route to TMA.	V3
PJ.02-08-01	**Integrated runway sequence for full traffic optimisation on single- and multiple-runway airports** The main goal of the Integrated runway sequence function is to establish an integrated arrival and departure sequence by providing accurate target take-off times and target landing times, including dynamic balancing of arrivals and departures while optimising runway throughput. The look-ahead time horizon, for example one hour, is the time at which flights become eligible for the integrated sequence. The stable-sequence time horizon is the time horizon within which no automatic swapping of flights in the sequence will occur but landing and departure times will still be updated. The value of these time horizons is determined locally, and they are not necessarily the same for arrivals and departures. **Expected performance benefits** The solution has measured potential performance benefits in terms of capacity, predictability and fuel efficiency.	V3
PJ.02-08-02	**Optimised use of runway configuration for multiple-runway airports** This solution helps the tower supervisor to determine the optimal runway configuration and distribution of demand accounting for capacity and local constraints. During the medium-term/short-term planning phase, the runway management tool compares the expected demand with the available capacity and forecasts imbalances, raising alarms and alerts based on the indicators provided. In the execution phase, the runway management tool monitors departures, arrivals and overall delay and punctuality, in addition to proposing changes in the event of capacity shortage. Since demand is constantly changing, the runway management tool continuously computes the optimal runway configuration and the associated forecasted landing and take-off (FTOT) times of arrivals and departures to maximise runway throughput. **Expected performance benefits** The solution helps to maintain a stable and reliable arrival/departure sequence. The average delay is reduced since the solution optimises take-off and landing times, taking advantage of gaps in the sequence that would have been missed otherwise.	V3

Solution ID	Solution name and description	Maturity level
PJ.02-08-03	**Reduced separation based on local runway occupancy time characterisation** Increased runway throughput based on local ROT characterisation is intended to reduce in-trail separation on final approach with the aim of increasing runway throughput by taking into account ROT. The major factor limiting the reduction of the separation, other than wake turbulence, is ROT. The solution computes a new separation minimum based on the prediction of the ROT, the minimum required separation (MRS) and the wake categorisation separation. **Expected performance benefits** Arrival runway throughput is increased and controller workload is reduced. Safety benefits are observed as controller performance is improved, with fewer separation infringements and missed approaches.	V3
PJ.03a-04	**Enhanced visual operations** Enhanced visual operations are enhanced or synthetic vision systems that will enable more efficient taxi, take-off and landing operations in low-visibility conditions. This solution is applicable to all platforms: although main airline platforms have autoland capabilities to facilitate approaches in low-visibility conditions, they have no capability to facilitate taxi and take-off in order to maintain airport capacity. **Expected performance benefits** The solution has validated benefits in terms of safety, resilience and cost efficiency.	V3
PJ.03b-05	**Traffic alerts for pilots for airport operations** Traffic alerts for pilots for airports operations are enhancing on-board systems that can detect risks of collision with other traffic during runway and taxiway operations. In all cases, the flight crew are provided with appropriate alerts. **Expected performance benefits** The solution has validated benefits in terms of safety.	V3
PJ.05-02	**Multiple remote tower module** The multiple remote tower module enables a single ATCO or aerodrome flight information service officer (AFISO) to provide an aerodrome control service or aerodrome flight information service for more than one aerodrome from a remote location, that is from a control tower that is not local to any of the aerodromes. The ATCO (or AFISO), using this facility, performs the remote ATS for the aerodromes concerned. It includes further development of the CWP and MET information from multiple airports. This solution goes beyond the scope of Solution 52 (two small aerodromes). **Expected performance benefits** The solution has validated benefits in terms of cost efficiency, while maintaining capacity and safety.	V3

ADVANCED AIR TRAFFIC SERVICES

Solution ID	Solution name and description	Maturity level
PJ.01-06	**Enhanced rotorcraft operations in the terminal manoeuvring area** Enhanced RC operations in the TMA further develop the simultaneous non-interfering ConOps to allow RC to operate to and from airports without conflicting with fixed-wing traffic or the need for runway slots. **Expected performance benefits** The solution improves access and equity, safety, predictability and airport/TMA capacity.	V3
PJ.06-01	**Optimised traffic management to enable free routing in high- and very high-complexity environments** Optimised traffic management to enable free routing in high- and very high-complexity environments enables AUs to plan flight trajectories in high- and very high-complexity environments without reference to a fixed-route network or published directs so that flights can be optimised to meet individual operators' business needs or military requirements. The solution describes the high- and very high-complexity cross-border free routing environment in the upper airspace (at the 2022 timeframe – as per PCP AF#3) and aims to improve aircraft-to-aircraft separation provision to enable free routing operations with minimum structural limits in order to better manage airspace demand. **Expected performance benefits** The solution improves fuel efficiency and the predictability benefits are influenced greatly by the airspace design of the cross-border free routing area.	V3
PJ.10-01a1	**High-productivity controller team organisation en route (including in the extended terminal manoeuvring area) (one planning controller to two executive controllers (1PC–2ECs))** The solution 'High-productivity controller team organisation en route (including in the extended terminal manoeuvring area) (1PC–2ECs)' developed operating procedures such that the planning controller provides support to two executive controllers operating in different sectors. Traditional intersector coordination procedures are maintained, although the internal boundaries (those between executives in the same multi-sector planner (MSP) group) will be entirely the responsibility of the MSP and will therefore not require any coordination dialogue – the planner will just set the boundary transfer level (which may be amended by the executives as necessary). In this configuration, the MSP ensures suitable coordination agreements between sectors and assists in managing the workload of the executive controllers, thus ensuring that potentially critical traffic situations and the associated workload are manageable. **Expected performance benefits** The solution improves cost efficiency, safety and fuel efficiency.	V3

Solution ID	Solution name and description	Maturity level
PJ.10-02a1	**Integrated tactical and medium conflict detection and resolution services and conformance monitoring tools for en route and the terminal manoeuvring area** The solution aims to improve separation (tactical layer) in the en-route and TMA operational environments through improved ground trajectory prediction. This is achieved using existing information on lateral and vertical clearances that are known by the ground system and airborne information such as mode S data. **Expected performance benefits** The solution improves cost efficiency, human performance, predictability, safety and fuel efficiency.	V3
PJ.11-A1	**ACAS Xa European acceptability framework** This solution aims to develop an enhanced framework for the acceptability of ACAS Xa in a European context and to use this framework to identify areas for improvement by the developers of ACAS Xa, to advise joint Eurocae/RTCA working groups and to provide data to support the EASA decision-making process. **Expected performance benefits** The solution improves safety.	V3
	OPTIMISED ATM NETWORK SERVICES	
PJ.07-01-01	**Reactive flight delay criticality indicator** The flight delay criticality indicator (FDCI) allows AUs to identify flights that need to progress as scheduled and to arrive on time. Flights flagged as critical should ideally suffer no or little delay, and any allocated delay should be reduced if possible. The solution addresses reactive delay, which means that it flags critical flights that have already been delayed by ATFCM and have been issued a flight slot. **Expected performance benefits** The solution is beneficial to AUs as it constitutes an efficient mechanism to notify the NM/FMP of critical flights and to improve the situational awareness (through the NOP) of all stakeholders (FMP, APT, NM and AUs). The AU simple preference (FDCI) shared in the network operations plan supports decision-making.	V3
PJ.09-03-02	**Airport operations plan / network operations plan departure information integrated in extended flight plan** The solution provides harmonised and improved integration of airport operations plan (AOP) / NOP departure information in trajectories calculated by FOCs and the NM. The alignment of the AU, NMF and airport views of 4D trajectories in the planning phase and the increased predictability provided by the exchange of dynamic AOP/NOP departure information – in particular runway configurations in use, departure taxi times, planned runways and standard instrument departure routes – allow the FOC to plan and share a more accurate and up-to-date 4D trajectory. **Expected performance benefits** The solution improves predictability, punctuality and capacity.	V3

ENABLING AVIATION INFRASTRUCTURE

Solution ID	Solution name and description	Maturity level
PJ.14-02-06	**Aeronautical mobile airport communication system integrated with aeronautical telecommunication network, digital voice and multilink** The objective of this solution is to complete the validation of AeroMACS by carrying out trial deployment(s) at airport(s) involving multiple mobile users at the same time and to integrate AeroMACS on vehicles and aircraft equipped with an electronic flight bag. It is hoped to validate other potential uses of the AeroMACS datalink to support digital voice communication (especially voice over internet protocol (VoIP)) and multilink and to prepare the AeroMACS enabler for in VLD(s) that will demonstrate AeroMACS capabilities to interested airport(s) and airlines. **Expected performance benefits** AeroMACS, with its large bandwidth and high throughput, provides better support to ATN/AOC data traffic and can easily support the increasing level of automation expected of ATM services on the airport surface, offering good business opportunities to airlines/AUs. The security features offered by AeroMACS can offer valid protection against intentional attacks and, as a result, this solution is highly beneficial in terms of safety.	TRL-6
PJ.14-03-04	**RNP1 reversion based on DME–DME** This solution addresses the need to introduce ground and airborne systems that can support currently defined and standardised PBN and other CNS-based operations and provide a backup with the required level of performance in the event of corruption, degradation or absence/loss of GNSS. This solution seeks to enhance DME–DME/IRS to provide a navigation reversion mode targeting RNP. **Expected performance benefits** The solution has confirmed the performance benefits of the DME transponders that are currently in production in terms of integrity, range accuracy and service continuity.	TRL-6
PJ.15-01	**Sub-regional demand–capacity balancing service** The solution aims to facilitate better use of the airspace at sub-regional level, and to enable tactical interventions when necessary, ensuring that any potential disruptions are managed appropriately. **Expected performance benefits** The solution improves use of the airspace at subregional level and facilitates tactical interventions when necessary, ensuring that any potential disruptions are correctly managed. The solution improves cost efficiency.	TRL-6

Solution ID	Solution name and description	Maturity level
PJ.15-02	**Extended arrival manager service** The solution operates the AMAN functionalities within an extended horizon to provide local and overall arrival sequences for planning and tactical operational purposes in a cross-border environment. Assuming that providers are capable providing extended AMAN (E-AMAN), based on a SWIM foundation, deployment of this common service results in: • the requirement to deploy fewer engineered capabilities; • improvements in the service roadmap because it is consistent across Europe and the associated costs are spread among common service ANSP consumers. **Expected performance benefits** The solution aims to increase cost efficiency by reducing the number of systems that need to be implemented and by cutting annual operating costs because fewer technical systems needs to be securely maintained in operation.	TRL-6
PJ.15-10	**Aeronautical data service** The function of the aeronautical data service is to provide both static (long-term permanent changes, e.g. a new runway) and dynamic (short-term, temporary changes, e.g. temporary closure of a runway for maintenance) aeronautical data in digital form to be used by different ATM systems (e.g. safety nets). The output is an aeronautical information exchange model (AIXM)-compliant dataset whose subsets can be retrieved by individual requests demanding specific geographical areas, attributes or functional features. **Expected performance benefits** The solution improves cost efficiency by reducing the number of systems deployed and the number of technical systems that need to be securely maintained in operation.	TRL-6
PJ.15-11	**Aeronautical digital map service** The aeronautical digital map service provides digital maps ready to be used by different ATM systems (e.g. safety nets) when performing separation functions. The output is highly customisable in order to meet the different requirements from the consumers and is easily convertible among different digital formats – AIXM, GML (Geography Markup Language), XML (Extensible Markup Language), etc. **Expected performance benefits:** The solution improves cost efficiency by reducing the number of system deployments and the number of technical systems to be securely maintained in operation.	TRL-6

Solution ID	Solution name and description	Maturity level
PJ.16-03	**Enabling rationalisation of infrastructure using virtual centre** The solution will provide an operating environment in which different ATSUs, even across different ANSPs, will appear as a single unit and will be subject to operational and technical interoperability. It includes the development of the ATSU architecture from a service-oriented approach with a focus on the technical services and common interfaces. Based on the virtual centre concept, the CWP/human–machine interface (HMI) needs to interface with multiple ADSPs. A high-performing and reliable underlying communication infrastructure may be needed. This solution encompasses en-route, TMA and airport/tower environments. It has been proven that: • ATSUs can subscribe to services, in particular those offered by an ADSP where the ATSU and ADSP have different suppliers. • CWP(s) developed by a vendor can subscribe to services offered by other vendors. • CWP(s) developed by different vendors can subscribe to services offered by one ADSP; • ATSU(s) can connect remotely to ADSP(s) through a wide-area network. • An initial estimation of quality of service indicators for the virtual centre concept has been obtained from exercise data. **Expected performance benefits** The solution aims to enable Europe to move to an interoperable, cost-efficient and flexible service provision infrastructure. Decoupling of the CWPs should enable more efficient use of the most valuable and expensive resource, humans. By enabling increased flexibility, ANSPs should better manage staffing for prevailing traffic conditions and assure service continuity.	TRL-6
PJ.16-04-01	**Multitouch inputs** Multitouch input is a technology that enables a surface, for example a touchscreen, to recognise the presence of several points of contact with the surface. The results indicate that multitouch systems are in general able to overcome mental bottlenecks in the human–system interaction. **Expected performance benefits** The solution aims to increase ATCO productivity by using a new HMI to increase automation and reduce the number of ATCO actions required.	TRL-6
PJ.17-01	**SWIM TI purple profile for air–ground advisory information-sharing** The solution supports ATM operational improvements that depend on air–ground information exchanges to enable better situational awareness and collaborative decision-making. This includes the specification of the technical architecture and functions required to achieve full interoperability between air and ground SWIM segments and meet the safety and performance requirements required by airborne operations. **Expected performance benefits** The solution supports ATM operational improvements that depend on air–ground information exchanges to enable a better situational awareness and CDM, with a focus on advisory information. The solution aims to contribute positively to global interoperability by designing and validating an innovative and open standards-based solution for the integration of the aircraft into the SWIM 'network', ensuring that safety and security requirements are met.	TRL-6

Solution ID	Solution name and description	Maturity level
PJ.18-02c	**Extended flight plan distribution to air traffic control** The extended flight plan (FF-ICE (flight and flow information for a collaborative environment) phase 1) with the agreed trajectory built based on the information provided by the AU will be distributed to ATC by the NM. The take-off weight, the weight on each trajectory point, the 4D trajectory and climb/descent profiles will be used by the ATC system to create the initial system flight plan. **Expected performance benefits** The performance benefits include improvements in cost efficiency, capacity, safety and fuel efficiency.	TRL-6
PJ.18-04a	**Aeronautical dataset service** The aeronautical dataset service consists of a SWIM service providing digital datasets defined by the ICAO. The aeronautical dataset service supports the provision of the aeronautical information product digital dataset as defined by ICAO Annex 15: • Aeronautical Information Publication (AIP) dataset, • obstacle dataset, • terrain dataset, • airport mapping dataset, • instrument flight procedure dataset. The target service provider could be any aeronautical information service provider that wishes to provide its datasets in digital format and the service could be offered to any interested parties that need to use these datasets (AU, ANSP, ATS provider, MET service provider, data service provider, NM, etc.). **Expected performance benefits** The aeronautical dataset service aims to improve the consistency and quality of the data and enhance the exchange of information.	TRL-6
PJ.18-04b1	**Ground weather monitoring system (enhanced capability coupled with glide wind profile capability and METForTAM service)** The solution enhances the ground weather monitoring system (GWMS) capability by making all its output SWIM compatible (i.e. developing and implementing the MET-GATE functional block for the local instance of 4DWxCube), and therefore links to new MET service developments, for example METForTAM. The provision of METForTAM by GWMS has been designed and validated to be compliant with the SWIM technical infrastructure yellow profile using AMQP1.0 messaging. This information service should provide enhanced local MET information (e.g. METEO forecasts and observations) to a specific airport (airport operational centre). The new capability, glide wind profile, has been developed to provide glide wind data to the GWMS using mature sources such as radar and lidar sensors. The purpose is to enhance separation procedures based on the collected wind data. **Expected performance benefits** The solution aims at enhancing MET data provision capabilities in order to improve the accuracy and timely delivery of expected Meteorological conditions at an airport. Specifically, supporting the airport operator and other local stakeholders and, in turn, AUs to improve their situation awareness and decision-making.	TRL-6

Solution ID	Solution name and description	Maturity level
PJ.18-04b2	**Cumulonimbus global capability and service** Cumulonimbus global capability uses data from geostationary satellites to detect, track and nowcast thunderstorms to give pilots an overview of the current weather hazard situation beyond the limited view provided by on-board radar. It is relevant for the upper airspace en route and enables a pilot to strategically plan a safe and smart flight route around the thunderstorms in good time, instead of flying tactical manoeuvres and searching for gaps between the thunder cells. The service provides MET hazards information to the flight management operation of a civil AU operation centre. **Expected performance benefits** The results have shown that, if cumulonimbus global is used for flight planning, considerable fuel savings can be achieved, avoidance manoeuvres are no longer necessary at all and landing at alternative airports can be avoided.	TRL-6

A further 48 SESAR Solutions show signs of progress and have successfully achieved the V1/TRL-2 or V2/TRL-4 maturity level. These results represent the baseline for activities that will continue in Wave 2.

Three VLD projects went through their final iterations and were successfully completed, while, in the case of a fourth (PJ.31), a final consolidation will take place in Release 10. The following paragraphs provide an overview of the contributions of the demonstration projects in the context of Releases 9 and 10.

Project **PJ.24, Network collaborative management (NCM)**, aimed to demonstrate the maturity of SESAR Solutions validated in SESAR1 projects and to show network performance benefits in a larger part of Europe. The concept elements included were ATFCM measures such as level-capping, airport–network planning integration and target times measures, and improved data exchange linking network and local tools. In addition, NCM included elements that were close to operational introduction, such as regulation proposals via business-to-business, targeted flow regulation using an improved ATFCM NM scenario repository, flight improvements through exclusions and forced calculated take-off times.

Demonstration exercises have been carried out in a large part of Europe, involving eight different ANSPs, four major airports, the European NM and major European airlines representing about 70 % of European air traffic; in addition, many other airlines have made informal contributions. The demonstration exercises were, as far as possible, carried in the operational context to be able to confirm operational performance improvements.

The scope of the demonstration covered the following.

- **Network coordination.** Identification of a local DCB imbalance (possibly supported by automated local tools) initiates a local–network coordination process between relevant local stakeholders and the network based on the selection of predefined ATFCM scenarios (i.e. ATFCM re-route measures) by local FMPs and on network impact assessments (including what-if simulations).
- **Tactical capacity management (local level).** The identification of targeted measures to reduce ATFCM delay through optimisation of workflow processes is supported by integrated data exchange and the introduction of flow- and flight-specific measures as part of the short-term ATFCM measures (STAM) collaborative process in the ANSP local tools.
- **AU collaborative processes.** The intervention of AUs in decision-making (STAM proposal, priority flights) was explored. Where appropriate, flexibility is given to select, based on minimised business impact, the flights to which specific measures will be applied.

- **Airport network integration (local–network level).** The exchange of information between airport operations planning (aligned with current processes such as A-CDM, gate management, etc.) and network operations planning takes place sooner. Airport arrival requirements are shared with the network to optimise delivery of flights to airports with the aim of making the best use of limited runway capacity and as a result enhancing network performance, for example by reducing. delay to AUs.

PJ.24 has demonstrated network performance benefits as a result of cooperation and better information exchange between operational actors (including AUS) supported by local tools connected to the network. It enables the application of targeted flow measures and improved cooperation at a European ATM network level with no impact on safety and a positive effect on predictability.

Improvements in coordination between the airport and network have resulted in massive reductions in the time needed to implement flight delay measures, which involves in each case the identification of bottlenecks, the proposal and assessment of a solution, feedback and, finally, implementation of the measure. A single FMP or NM operations centre controller can manage many more measure proposals than before, which enables the application of specific flight delay measures.

Over a relatively short period (a few days or weeks), demonstration exercises were able to show reductions in total delays amounting to hundreds to a few thousand minutes by minimising the impact of otherwise applied global regulation. In the exercises, which simulated the application of measures to many flights (e.g. flight improvements at the Maastricht Upper Area Control Centre (MUAC) or Heathrow's target times of arrival (TTAs)), delay reductions of thousands of minutes were achieved. For instance, the Heathrow TTA demonstration reduced pre-departure delays by 26–41 %.

However, during the trials, the fuel efficiency of flights subjected to re-route proposals dropped. It was estimated that, on average, several dozens of kilograms (and sometimes well above 100 kg) of additional fuel per flight was required to fly at lower altitudes or to re-route to avoid ATFCM regulations. However, applying targeted measures and avoiding regulations could result in fuel savings. Demonstrations and simulations in the FAB CE (functional airspace block – Central Europe) area and target time demonstrations at London Heathrow showed opportunities for fuel reduction resulting from more flights on optimal tracks and less holding time because of targeted measures and better managed arrival times.

For airlines, the reduced delay measures reduce the impact on passengers and the financial impact for the company. For example, if a delayed flight is approaching crew duty time limitation or curfew, reduced delay measures could avoid costly measures such as additional ferry flights or other unplanned flights for positioning.

The overall conclusion of the PJ.24 demonstrations is that a cooperative and transparent approach to current network inefficiencies and the application of flight- and flow-specific targeted measures, supported by integrated system-supported coordination processes, leads to significant network performance benefits.

The demonstration project received third prize in the 'service provision' category of the 2019 *ATM Magazine* Awards. The project was recognised for bringing together multiple stakeholders (the Lufthansa Group, Ryanair, Air France, British Airways and EasyJet) in a collaborative project to reduce network inefficiencies in ATFCM.

Project PJ.25 has demonstrated, at a very large scale, new E-AMAN tools and techniques that improve flight efficiency and flight predictability at airports, in the TMA and E-TMA, and en-route ACCs and the upper air control centre (UAC). It included the following solutions:

- **E-AMAN (between 200 and 350 NMs).** The main target of xStream is to provide a ready-for-implementation solution for PCP deployment, with an E-AMAN horizon of up to at least 200 NMs in order to enable delay

absorption earlier in the flight and at higher altitude, which is more fuel-efficient. When dealing with high levels of arrival delay, or for pre-sequencing the aircrafts before a detected congestion at the entry of the E-TMA, this horizon can be extended by up to 350 NMs for maximum efficiency (XMAN).

- **Target times.** The concept of target times for airborne long-haul flights was also applied with a horizon outside the European network and involving AUs' operations control centres (OCCs) in the process.
- **Handling of multiple inbound flows to multiple airports in the sectors of upstream ACCs.** With the extension of AMAN horizon, the cumulative effect of E-AMAN requests in the same sector may lead to an increase in ATCO workload, because of competition between the flows, and induced conflicts. To prevent this, a CDM process has to be implemented to better coordinate E-AMAN activities, and assess upstream ACCs' ability to deliver the E-AMAN service.
- **Improvement of arrival planning**. By sending locally computed pre-departure TTA to the NM, combined with a collaborative process to integrate AUs' preferences/priorities, the impact and cost of ATFCM delays can be reduced. Targeted time of arrival allocation also contributes to the AMAN process by enhancing short-haul adherence to the targeted sequence.
- Integration of AUs' preferences in the arrival planning process, thus limiting the cost of delay for airlines. UDPP and arrival flexibility (A-FLEX) provide an efficient solution to reallocate ATFCM delay in order to optimise arrivals according to AUs' needs, reducing the impact on airline operations.

To address these topics, live and shadow mode trials were carried out between July 2017 and October 2019 in major hub airports: Zurich, Paris Charles De Gaulle and Orly, London Gatwick and Heathrow, and Frankfurt-Main. The aim was to demonstrate that these concepts are sufficiently mature to be implemented in high-density areas. Details of demonstration exercises planned for the Release 9 time frame are available in the Release 9 plan. They involved:

- a large number of ACCs around those platforms (in fact, most ACCs of the core area),
- the NM,
- AUs (Lufthansa Group, Air France, British Airways, EasyJet, Ryanair).

These demonstrations were successful and delivered the following operational benefits:

- **Environment sustainability**. Several benefits were demonstrated:
  - a reduction in airborne holding and vectoring in lower airspace,
  - in the Paris and London demonstrations, fuel savings in the arrival phase of up to 30 kg of fuel per flight (based on base of aircraft data) estimates), equivalent to a reduction in greenhouse gas emissions of up to 90 kg of CO_2 per flight.
- **Capacity.** Again several benefits were demonstrated:
  - a reduction in congestion and complexity in the TMA, enabling capacity improvements in the terminal area during traffic peaks,
  - optimisation of ATFCM constraints, by better matching available capacity with traffic demand,
  - a reduction in arrival ATFCM delays in the Paris area of up to 5 %.
- **Flexibility.** Two benefits were identified:
  - the ability to integrate AUs' priorities in capacity-constrained situations or not (arrival streaming), thus allowing optimised hub carrier operations at the destination airport, as well as reducing the cost of ATFCM delay for airlines,
  - through UDPP, the ability to reallocate ATFCM delay in order to optimise arrivals according to AUs' needs, reducing the impact on airline operations.
- **Safety.** Reduction in TMA workload, while maintaining a safe management in the upper airspace.
- **Predictability.** Improvement of arrival sequence predictability, allowing better anticipation of operations for flow managers and supervisors.

Following the success of PJ.25 in saving in fuel and reducing CO_2 emissions, as well as holding times, XMAN was introduced into operation for Gatwick Airport from November 2019. This represents the first deployment of single-runway (mixed-mode) XMAN. XMAN's success relies on the sharing of information between NATS, Gatwick Airport and surrounding ANSPs, who work together to slow down aircraft, which are up to 350 NMs from London. This ultimately reduces the holding times for aircraft arriving into the airport. NATS's Swanwick and Prestwick Control Centres, EUROCONTROL's MUAC, France's DSNA (Direction des Services de la navigation aerienne) and the Irish Aviation Authority's Shannon Control Centre, along with Gatwick Airport, have all been involved in the recent trial, the first time that these concepts have been demonstrated for a single-runway airport. This follows the success of XMAN's introduction for Heathrow Airport in 2015.

Absorbing delay before aircraft reach the airport is expected to save more than 26 000 minutes every year in airborne low-level holding, in turn saving the airlines around 1 200 tonnes of fuel, reducing CO_2 emissions by 3 800 tonnes and helping to reduce noise in local communities.

The demonstration project received first prize in the 'environment' category in the 2019 *ATM Magazine* Awards for delivering ready-to-use operational cross-border AMAN solutions following the trials in Paris, Zurich and Frankfurt. These positive results justified the creation of two new solutions that will be included in the Release 10 close-out report and in the SESAR catalogue.

Project **PJ.28**, 'Integrated airport operations,' has delivered its solutions in the Release 9 time frame. More information can be found in subparagraph 1.5.1.1, 'Completion of SESAR 2020 Wave 1 VLD projects (call H2020-SESAR-2015-2), below'.

Project **PJ.31**, Digits, 'Initial trajectory information sharing', has performed the final series of demonstration activities in the Release 10 time frame (see next subparagraph).

1.4.4.2. Release 10 execution

The Programme Committee approved the Release 10 plan at its ninth session, in December 2019. Release 10 will take place during 2020 and last until the end of April 2021. The Release 10 plan covered initially:

- six SESAR solutions that are expected to achieve V1/TRL-2;
- 11 SESAR solutions that are expected to complete V2/TRL-4;
- five SESAR solutions that are expected to complete V3/TRL-6.

Since the approval of the release plan, a number of changes to the execution of Release 10 activities have been made.

- Maturity gates for Solutions PJ.01-W2-06, 'Advanced rotorcraft operations in the terminal manoeuvring area', and PJ.01-W2-08A2, 'Automatic controlled time of arrival for management of arrival en route and on the ground', have been moved to Release 11.
- Solutions PJ.18-02b and PJ.18-06b have been split into more deployable solutions.
- The detailed analysis of the demonstration project PJ.25 output has identified two new solutions ready for industrialisation and deployment.

The Release 10 plan also covers two VLD projects that will carry out demonstration exercises and/or demonstrations gates during the course of 2020.

- Table 4 provides information on the solutions that are part of Release 10. A further five solutions may reach the stage of industrialisation and deployment in Release 10 (which will be concluded in April 2021).

TABLE 4 PLANNED OUTCOMES OF RELEASE 10

HIGH-PERFORMING AIRPORT OPERATIONS

Solution ID	Solution name and description	Target maturity level
#119	**GBAS landing system CAT II operations using GBAS GAST-C** The solution improves resilience in low-visibility conditions by enabling GBAS landing system (GLS) CAT II operations, including CAT II Autoland, based on enhanced GAST-C ground equipment. In contrast to GAST-D, in the standard GAST-C the integrity requirements associated with detection of anomalous ionospheric conditions that could induce an erroneous GBAS position outside the protection levels (and therefore go undetected by the system) are not monitored on board. Instead, with the enhanced GAST-C ground station, they are monitored on the ground and, when the GBAS position is properly bounded, CAT II operations can be performed (this is referred to as GAST-C service level B). When the integrity levels are not fulfilled, for example in severe anomalous ionospheric conditions, protection levels are inflated, and only CAT I operations are supported (this is referred to as GAST-C service level A). The aircraft needs to be equipped for GAST-C but does not need to be equipped for SBAS. SBAS messages are used by the ground in order to monitor the integrity of the GAST-C service. From the ATC perspective, CAT II operations based on GAST-C service level B are the same as CAT II operations based on GAST-D, except that an approach category indication (GLS CAT I/II) is needed. As for GAST-D availability, GAST-C GBAS availability levels will be broadcast in the automatic terminal information service. If the automatic terminal information service has not yet been updated after a service level change, ATCOs will pass the information directly to pilots. From the flight crew perspective, CAT II operations based on GAST-C are the same as CAT II operations based on GAST-D. However, with GAST-C there is no possibility of being alerted to on-board service level degradation, as can happen in GAST-D, as in GAST-C information on service level degradation will always come from ATC. **Expected performance benefits** The solution aims to improve resilience and safety.	V3

Solution ID	Solution name and description	Target maturity level
#120	**Enhanced flight vision system to land using visual-infrared** The solution provides an enhanced flight vision system (EFVS) for landing operations supported by infrared and visual-based technology. The solution allows the pilot to descend below decision altitude / decision height and to land at a runway visual range as low as 300 m without the need to transition to natural vision. The EFVS comprises a head-up system (or equivalent head-wearable display) and a multispectral camera that has the capability to see further ahead than the naked eye in degraded weather conditions. This capacity of the EFVS to provide a significant visual advantage in fog or snow at decision altitude / decision height will enable successful landing, something that would be not possible otherwise. The solution can be deployed in the near future thanks to the new EU all-weather operations regulation from EASA (NPA AWO 2018-06), and some aircraft manufacturers have already been certified by EASA. **Expected performance benefits** This EFVS advanced operation concept differs from other standard CAT II/III concepts (which are usually available only at main airports and used by airlines) as it allows pilots to land at any airport in adverse weather conditions, and not just at airports that fully CAT II/III equipped, of which there are relatively few. The strength of this EFVS is that it relies on advanced aircraft capacity provided by technology rather than on costly aerodrome infrastructure. The EFVS can be used with, and improves the functioning of most 3D instrument approaches.	V3
PJ.02-W2-17.1	**Improved capacity and safety of runway operations at secondary airports in low-visibility conditions** The solution provides new methods for the surveillance of aircraft and vehicles and enables operations in MET conditions below ILS CAT I at secondary airports. This solution addresses the need to evaluate the infrastructure, services and procedures necessary to benefit from the new capabilities, considering the new technologies involved and the particular context of secondary airports with limited demand. As a result, runway safety and capacity at secondary (small/medium) airports is improved in the MET conditions below ILS CAT I thanks to use of alternative ground surveillance. **Expected performance benefits** Benefits in the KPAs of predictability, capacity and safety are expected.	V2 (maturity gate planned in 2021)

Solution ID	Solution name and description	Target maturity level
PJ.02-W2-17.2	**Improved approach procedures into secondary airports in low-visibility conditions** This solution focuses on approach procedures to adequate minima that make it possible to complete operations in low-visibility conditions, reducing the risk of deviations or missed approaches. The solution aims to reduce decision height through the development and validation of LPV-100 capabilities. The procedures will be supported by systems that do not involve capital investment by major airports or ANSPs while at the same time, comply with performance requirements related to low-visibility operations. Access to secondary (small/medium) airports can be maintained in low-visibility conditions thanks to the new airborne features as well as infrastructure, services or procedures that enable a safe and cost-effective approach in MET conditions below CAT I minima. **Expected performance benefits** Benefits are expected with respect to resilience to adverse weather.	V2 (maturity gate planned in 2021)
PJ.02-W2-21.2	**Enhanced guidance assistance to airport vehicle driver combined with Routing** The solution includes the development and validation of a system that provides vehicle drivers with dynamic traffic context information, including the status of runways and taxiways, the position of obstacles and routes, by application of an airport moving map. This improvement is needed to enhance guidance assistance to vehicle drivers operating in the airport manoeuvring area under low-visibility conditions. Guidance assistance information is automatically shown on a dedicated display in the vehicle as a graphical path to be followed. The benefits include: • improved efficiency of surface operations using an enhanced guidance assistant for vehicle drivers to exchange routing information between vehicle drivers and tower controllers; • optimised and efficient control of airport vehicles both on the apron and in the manoeuvring area. **Expected performance benefits** Safety will benefit because misunderstanding of clearances will be minimised and because information is no longer given only by voice.	V2 (maturity gate planned in 2021)

Solution ID	Solution name and description	Target maturity level
PJ.02-W2-21.3	**Airport ATC provision of ground-related clearances and information to vehicle drivers via datalink** Vehicle movements at the airport are a necessary part of a wide range of operations in support of the safe and efficient execution of ground airside operations, for example runway and taxiway inspection, towing of aircraft, follow-me, emergency, cleaning, catering, fuelling and baggage handling. Vehicles are additional users of control and guidance services and, therefore, datalink technology can benefit their operations by increasing safety, human performance and situational awareness. Routing and guidance services, when supported by datalink technology, can use electronic communications between ATCOs and vehicle drivers, thereby reducing misunderstandings and ambiguity in the provisioning of clearances and requests from either side. The ATCO has constant awareness of all the contacts and requests received via datalink, as opposed to voice communication, while vehicle drivers have constant visual access to all clearances in digital format. **Expected performance benefits** The solution is expected to improve safety, efficiency and human performance.	V2 (maturity gate planned in 2021)
PJ.02-W2-21.4	**Full guidance assistance to mobiles using 'follow the greens' procedures based on airfield ground lighting (aprons/taxiways/runways)** This solution intends to automate the prioritisation of mobiles along their cleared route throughout the movement area. The guidance service, taking into account other traffic, guides the mobile as it progresses along its assigned route and at the holding points. It prioritises mobiles based on local operating rules (e.g. runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at interparagraphs and taxiways passing close to push-back routes or other taxiways where insufficient wingtip separation exists) as well as known constraints from the surface management system. Automatic guidance will be provided using 'follow the greens' concept on the airfield ground lighting infrastructure. **Expected performance benefits** The solution is expected to increase safety performance in all weather conditions, to improve predictability through guidance and to reduce workload and stress for ATCOs and vehicle drivers.	V2 (maturity gate planned in 2021)

Solution ID	Solution name and description	Target maturity level
PJ.02-W2-21.5	**Enhanced safety in low-visibility procedures through use of dynamic virtual block control** This solution is intended to progress the maturation of the dynamic virtual block control concept investigated first in SESAR 1 and then in SESAR 2020 Wave 1. The solution makes use of real stop bars and virtual stop bars appropriately placed in the manoeuvring and movement areas, that is at any operationally relevant position, to reduce the size of control blocks while ensuring safe longitudinal spacing between taxiing aircraft or taxiing aircraft and vehicles in low-visibility conditions (when ATC is in charge of providing a safe longitudinal spacing among taxiing traffic). Tower controllers select the clearance limit at a virtual stop bar position for an aircraft under control and communicate the clearance via R/T. Guidance information towards the cleared virtual stop bar position is sent by means of an appropriate CPDLC message. The assigned virtual stop bar position and the guidance information become active when cleared by the controller. **Expected performance benefits** The solution is expected to improve safety, efficiency and human performance.	V2 (maturity gate planned in 2021)
PJ.02-W2-21.6	**Advanced automated assistance to controller for surface movement planning and routing** The solution consists in researching and validating enhanced capabilities at the airport ANSP to obtain the most suitable ground routes for all mobiles operating in the movement area (runways, taxiways and aprons) and taking into account users' preferences and known constraints (such as taxiway closures, aircraft types, etc.). The aim is to assist ANSPs in the short-term planning phase and in the execution phase, for example when re-routing. **Expected performance benefits** The solution is expected to enable more efficient allocation of airport resources and to have a positive impact on predictability, in terms of reduced variability of surface operations.	V2 (maturity gate planned in 2021)
PJ.04-W2-28.2	**Regional airport(s) collaborative management** This solution specifically aims to improve collaboration between different airports and airport stakeholders through the introduction of a simplified or centralised airport operations centre (APOC) for regional airports. The introduction of an APOC has been shown to improve airport resilience in larger airports. It may be possible to provide similar benefits for regional airports at a lower deployment cost through the use of automation and innovative approaches to information-sharing and by adopting a more decentralised approach. **Expected performance benefits** Expected benefits include improvements in predictability, efficiency, punctuality and resilience.	V1 (maturity gate planned in 2021)

ADVANCED AIR TRAFFIC SERVICES

Solution ID	Solution name and description	Target maturity level
PJ.25-01	**Collaborative decision-making between airports, terminal manoeuvring areas and area control centres for overlapping arrival managers** The solution aims to balancing demand for XMAN services with ATCO workload in order to make the best use of the available ACC/UAC resources. Information regarding the demand for / availability of the AMAN service is shared, via a portal, between TMAs/airports and ACCs: with the advent of multiple E-AMAN operations in the core area of Europe it will become necessary to coordinate such operations, especially between ATS units and the E-AMAN units. The solution increases the situational awareness at airports by providing information on the current arrival situation and a collaboration platform that incorporates a multilateral communication mechanism to facilitate information-sharing and decision-making, thus enabling the application of XMAN strategies. These XMAN strategies are defined and prepared per flow regarding sector airspace design, coordinated through a CDM process between all ATSUs involved and activated per flow and per period of time when required. **Expected performance benefits** The solution helps to make a better use of available resources and to reduce vectoring and holding and fuel consumption.	V3
PJ.25-02	**TTA management for seamless integration of out-of-area arrival flights** The solution optimises TTA management at an airport to better integrate the out-of-area inbound flights. TTAs for long-haul flights departing from airports outside the European Regulation Area are computed by the FMP at the arrival TMA relative to the estimated times of arrival provided by the FOC before departure, for the aircraft to adjust their take-off time. Once the aircraft is airborne, the FMP at the arrival TMA receives a new TTA through the FOC. If needed, a revised TTA is sent by the FOC to the aircraft to enable the pilot to adjust the aircraft speed in flight. The NM remains in the loop throughout this process, thereby ensuring that the network always has the most up-to-date information from long-haul flights: • estimated time overs received from long-haul flights outside the initial flight plan processing system zone are sent via B2B uplink channel to the NM to update flight profiles; • target time overs are sent via B2B uplink channel to update the enhanced tactical flow management system flight profiles and to provide the NM with full awareness of the airport targeted landing sequence; • archive flight data from the NM are retrieved via B2B downlink to establish a post-analysis treatment and presentation for statistics and analysis purposes. Note that out-of-area flights are flights departing from airports outside the European Regulation Area and arriving at European Regulation Area airports.	V3

Solution ID	Solution name and description	Target maturity level
	Expected performance benefits The solution enables the sequencing of aircraft before their entry into the lower airspace in order to optimise flight profiles, thus reducing vectoring, holding and fuel consumption. This is particularly useful when night curfew regulations are in place, resulting in demand–capacity imbalance when the airport opens caused by unregulated flights having departed from outside the European Regulation Area can result in long holding times. The solution takes also in consideration AUs' preferences (whenever possible) and the fact that AUs may have more than one flight in the sequence be able to swap their flights and exchange the TTAs of specific flights. The solution is supported by a dedicated AMAN tool that computes the local TTAs and transmits them to the airlines.	
PJ.10-W2-96 UPMS	**User profile management system (UPMS)** The objective is to ensure a complete and instant personalisation of workstations depending on each ATCO's operational needs, requirements and preferences so that, for instance, ATCOs will be prevented from overlooking potential misalignments of key functionalities or tools. Additionally, the UPMS shall also eliminate the currently existing risk of distraction of ATCOs' attention from operational situation due to the need for customisation. The concept consists of two main packages: the identification (authentication) system and the UPMS configuration system. **Expected performance benefits** The solution aims to improve ATCO productivity through new HMI interactions that increase automation and reduce ATCO actions.	V3 (maturity gate planned in 2021)
PJ.13-W2-115	**IFR RPAS accommodation in airspace classes A–C** This SESAR Solution aims to accommodate IFR RPAS in non-segregated airspace in the short term, in accordance with the drone roadmap in the ATM Masterplan. The main objective of the solution in the Release 10 time frame is to ensure that the actions required to bridge the gaps identified during the V2 maturity gate of Solution PJ.10-05 in Wave 1 are put in place. **Expected performance benefits** The solution aims to improve equity of access to the TMA and en-route environments by facilitating the safe accommodation of IFR RPAS in different types of airspace, for example airspace classes A to C.	V2 (maturity gate planned in 2021)
PJ.18-W2-53B	**Improved ground trajectory predictions enabling future automation tools** Solution PJ.18-W2-53B will provide the (planner or tactical) controller with conflict detection and resolution tools that use more accurate parameter settings and are based on enhanced ground predicted trajectory projections through the use of improved and/or additional relevant data (e.g. aircraft trajectory data downlinked via ADS-C, more recent weather information).	V2 (maturity gate planned in 2021)

Solution ID	Solution name and description	Target maturity level
	Improved and/or additional relevant trajectory data may be made available via air–ground datalink exchanges (e.g. using real recorded downlinked ADS-C information). The main objective of the solution in the Release 10 time frame is to ensure that the actions required to bridge the gaps identified during the V2 maturity gate of Solution PJ.10-02a2 in Wave 1 are put in place. **Expected performance benefits** Performance benefits include improvements in cost efficiency (ATCO productivity), safety and predictability.	
PJ.18-W2-88	**Trajectory prediction service** The trajectory prediction service aims to compute and distribute an accurate and consistent 4D trajectory and to update it as the flight progresses. The output can be used during different flight phases: to propose an initial reference trajectory in the planning phase, as input for DCM during the tactical phase or to facilitate transfers during the operations phase. **Expected performance benefits** The solution aims to improving cost efficiency.	TRL-2 (maturity gate planned in 2021)

ENABLING AVIATION INFRASTRUCTURE

Solution ID	Solution name and description	Target maturity level
PJ.14-W2-81b	**A-PNT – enhanced DME** The objective is to develop an A-PNT system as a technical enabler to support PBN/RNP operations in the event of a GNSS degradation or outage. **Expected performance benefits** The solution aims to achieve the SESAR objectives for service and performance-based CNS.	TRL-2 (maturity gate planned in 2021)
PJ.14-W2-100	**SWIM TI purple profile for air–ground safety-critical information sharing** SWIM TI purple profile for air–ground safety-critical information-sharing allows the distribution of safety-critical information through air–ground SWIM infrastructure ATN/IPS networking, rather than legacy point-to-point contracted services. **Expected performance benefits** The solution supports ATM operational improvements that depend on air–ground information exchange to improve situational awareness and collaborative decision-making, with a focus on safety-critical information. The solution contributes positively to global interoperability by designing and validating innovative and open standards based solution for the integration of the Aircraft into the SWIM 'network', ensuring that safety and security requirements are met.	TRL-2 (maturity gate planned in 2021)

Solution ID	Solution name and description	Target maturity level
PJ.18-02b	**ATC–ATC flight object Interoperability (FO IOP):** This solution provides flight object IOP between en-route and TMA ATC systems (ground–ground IOP) ATC–ATC interoperability will enable seamless coordination between systems as well more complex coordination dialogues enabling negotiation between controllers across ACC boundaries. Note that NM–ATC flight object Interoperability (NM FO IOP) (Solution PJ.18-02b1) did not achieve TRL-4. **Expected performance benefits** The solution aims to improve interoperability and safety, and supports further operational benefits, for example increased airspace capacity.	TRL-6
PJ.18-06a	**ATC planned trajectory performance improvement** The aim of this solution is to improve trajectory prediction and management using new ADS-C reports and new surveillance parameters. Detailed flight plan information from the FOC (FIXM) will be analysed and used to complement aircraft information. The outcome of the maturity gate was 'TRL-6 – not completed'. Although the use of ADS-C and eFPL gave positive results, the solution partners concluded that they had yet to demonstrate statistically relevant improvements in the trajectory prediction performance before transitioning to industrialisation and deployment. However, the results of the various exercises carried out provided enough confidence to continue validations of the trajectory prediction enhancement and the use of the enhanced trajectory prediction output for tools as part of the Wave 2 validations. A gap analysis against the maturity assessment in Appendix H of the technical validation (TVALR) was carried out and proposals for closing the gap were provided in TVALR Appendix H/Appendix B TS/IRS. These included the provision of a real-time tuning/optimisation of the base of aircraft data (BADA) parameters used in prediction and the implementation of a 'catch-up from below' special manoeuvre. Work on the use of surveillance data, conducted by partner ANS-CS Soft, achieved all its validation objectives and showed benefits in the TVALR. However, other aspects, such as modelling in EATMA, were incomplete. **Expected performance benefits** The solution aims to provide operational benefits such as improved predictability and fuel efficiency in other ATM solutions.	TRL-6 Not completed
PJ.18-06b	**Tactical and NM trajectory performance Improvement** The solution aims to improve the performance of trajectory prediction and management through the use of new ADS-C reports. The solution has been split into two deployable parts: PJ.18-06b, 'Tactical trajectory performance improvement', completed TRL-4 whereas PJ.18-06b1, 'Network manager trajectory performance improvement', did not complete TRL-4. **Expected performance benefits:** The solution aims to provide operational benefits such as improved predictability and fuel efficiency in other ATM solutions.	TRL-4

In addition, two VLD activities were performed in the Release 10 time frame.

VLD project AAL2, 'Augmented approaches to land 2', delivered its solutions through Release 10. More information on this can be found in subparagraph 1.5.1.2, 'Status of the VLD Open 1 call projects (Call H2020-SESAR-2016-2)', below.

The final demonstration activities of project **PJ.31, DIGITS, 'Initial trajectory information-sharing'**, were performed in the Release 9 and 10 time frames:

- Demonstration exercise #04 (DFS extended projected profile (EPP) usage) covered three different areas:
  - Acquisition of ADS-C data. This area addressed how to get ADS-C data from the aircraft with the aim of evaluating the technical performance of ADS-C via VHF data link (VDL) mode 2-based ATN and determining future implications for ADS-C system requirements and architecture.
  - Characteristics of ADS-C data. This area addressed understanding the content and behaviour of ADS-C data, and the meaning of the information, its behaviour, robustness, reliability, precision, across the range of real-world situations of commercial aviation, in interaction with ATC procedures and flight-crew behaviour.
  - Use and application of ADS-C. This area addressed the use of ADS-C applications and requirements for ATC end systems regarding ADS-C (in particular the interoperable air traffic control system): trajectory information display, air–ground discrepancy monitoring / two-dimensional (2D) consistency check and ground TP enhancements.
- Demonstration exercise #05 (ENAV EPP usage) consisted of two main threads: a shadow mode demonstration of the management of ADS-C with revenue flights and an operational evaluation (offline) of the downlinked ADS-C data and its potential benefits in terms of predictability, human performance, safety and efficiency.
- The aim of demonstration exercise #06 (MUAC EPP usage) was to display ADS-C information to a selected group of controllers and to evaluate EPP usage in the normal working environment. ADS-C data were received from the revenue flights, the 2D path and estimated times of arrival as in the EPP were displayed on the CWP, and an automated 2D consistency check of the ground-based flight plan and the downlinked EPP was provided to the controller.
- Demonstration exercise #07 (NATS EPP usage) consisted of two threads: a shadow-mode demonstration of the management of ADS-C contracts during flight trials, with subsequent offline assessment of the downlinked ADS-C data, and an industrial based platform for demonstration activities using ATCOs that aimed to demonstrate the application of EPP in an ATC operation. The primary purpose of the shadow mode was to demonstrate how to manage ADS-C contracts efficiently as a flight progresses from one centre to another. The purpose of the offline analysis was to understand the operational behaviours that affect downlinked ADS-C data in a revenue flight context, and their effect on the usability of EPP data to support ATM processes.
- A final demonstration exercise, exercise #08 (revenue flights), was completed in the Release 10 time frame (after April 2020). The operational scope of the final demonstration exercise was the collection of ADS-C data from revenue flights to identify potential benefits of trajectory information-sharing based on analysis of a large number of data stemming from tens of thousands of revenue flights under real day-to-day operational conditions in busy central European airspace. The consolidated results of PJ.31 will be documented in the Release 10 close-out report.

The demonstration project received second prize in the 2019 *ATM Magazine* Awards in the category 'research and innovation' for successfully trialling the exchange of

trajectory data and making traffic flows more fluid and aircraft speed easier to manage.

1.4.4.3. Release 11 planning

Release 11 will cover four SESAR Solutions that are expected to achieve the following maturity levels:

- two SESAR Solutions is expected to achieve V1/TRL-2;
- two SESAR Solutions are expected to complete V2/TRL-4;
- no SESAR Solution is planned to complete V3/TRL-6.

The Release 11 plan also covers:

- ER projects whose activities will be completed in the Release 11 time frame;
- demonstration exercises that will be completed by the SORT and STAIRS projects during the course of 2021.

The planning of Release 11 took into account the launch of Wave 3 projects and VLD Open 2 projects in execution. As a result, Release 11 was scheduled for Q4 2020. The scope of Release 11 may be expanded (if applicable) to include other Wave 2 activities (when plans are available), for example the DREAMS very large-scale demonstrations project, open very large-scale demonstrations and Wave 3 and ER4 projects.

1.5. Strategic area of operation 4: delivery of very large-scale demonstration activities

The SESAR JU met all its objectives related to VLD activities in 2020, as set out in Paragraph III of the SPD 2020–2022. This includes the following achievements and results.

- Call with reference H2020-SESAR-2016-2 (VLD Open 1 call for proposals) – delivery of results. All projects were closed for operations.
- Call with reference CEF-SESAR-2018-1 (U-space call for proposals – delivery of results. All projects were closed for operations.
- Call with reference H2020-SESAR-2015-2 (IR-VLD Wave 1 call for proposals) – delivery of results of VLD Wave 1 projects. All projects were closed for operations.
- Call with reference H2020-SESAR-2019-1 (VLD Wave 2). All Wave 2 VLD projects kicked off and delivered their project management plan on time. The delivery of Wave 2 was secured in collaboration with the DMSC and the Programme Committee.
- Call with reference H2020-SESAR-2020-1 – launch VLD Open 2 projects into execution. The call was launched in March 2020 as planned, proposals were evaluated during the summer and the selected proposals were launched in the grant agreement preparation phase. Six grant agreements were signed by the end of the year.
- Call with reference H2020-SESAR-2020-2 – launch VLD Wave 3 projects into execution. The call was launched in March 2020 as planned, proposals have been evaluated during the summer and the selected proposals have been launched in the grant agreement preparation phase. All grant agreements were signed by the end of the year.

1.5.1. Activities carried out under the Horizon 2020 framework

1.5.1.1. Completion of SESAR 2020 Wave 1 VLD projects (call H2020-SESAR-2015-2)

The first call on very VLD activities, which was restricted to SESAR JU members other than the EU, within the call with reference H2020-SESAR-2015-2 [26] also covering IR, closed in 2016, followed by the award of five VLD projects. The main outcomes of the two projects that were still in execution and closed by the end of 2020 are summarised in the paragraphs below.

VLD project **PJ.28, IAO, 'Integrated airport operations',** closed at the end of February 2020. The project performed demonstration exercises in close to real operational environments during the Release 9 time frame to highlight the applicability of a number of airport-related SESAR 1 Solutions and encourage their early adoption:

- Solution #02, 'Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances',
- Solution #22, 'automated assistance to controller for surface movement planning and routing',
- Solution #53 'Pre-departure sequencing supported by route planning'.

The project also aimed to bridge the gap between R & I and deployment. The demonstrations took place at the airports in Hamburg, which has a crossing runway

[26] The call documentation is available on the Funding and Tenders Portal.

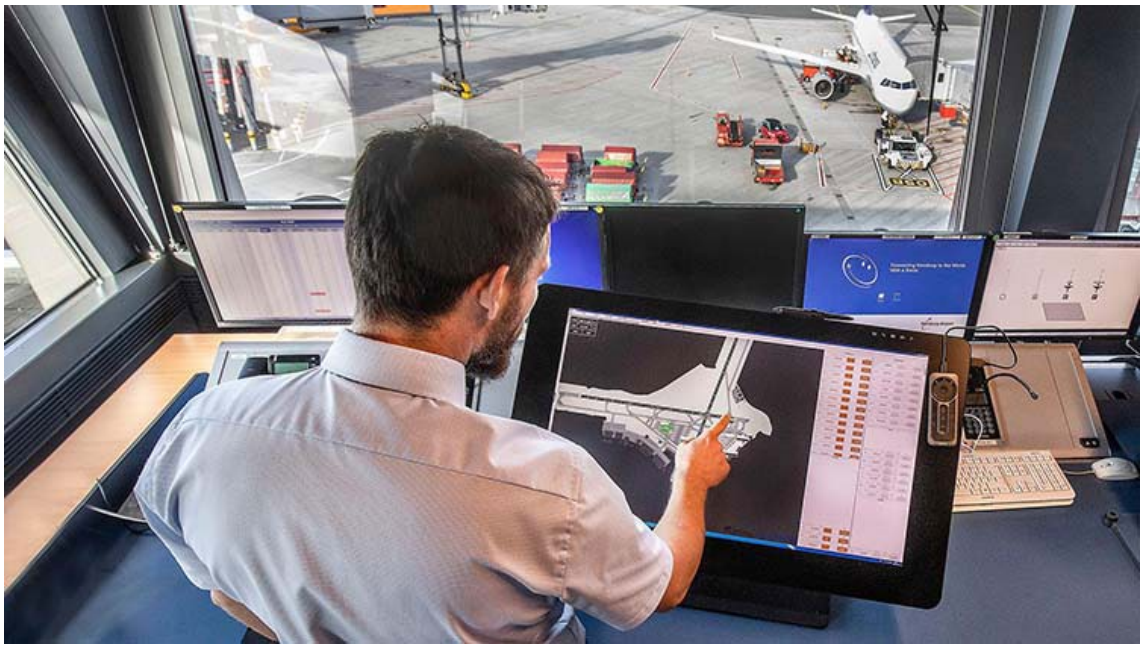
system (multiple dependent runways, non-complex surface layout), and in Nice and Budapest (multiple dependent runways, complex surface layout), both of which suffer from traffic congestion during the peak season.

In addition, project PJ.28 supports the development on-board alerting systems in safety-related solutions such as PJ.03b-05: ADS-B data performance is a key enabler for these systems and the demonstration provided evidence that the challenges of ADS-B employment for safety net application can be overcome to ensure sound use of this technology for the intended purpose. Local controllers from the ANSPs and airports took part in the exercises, bringing expert knowledge to the demonstrations.

The demonstration report delivered at the beginning of 2020 presented the following key conclusions.

- The demonstrations suffered from some limitations owing to the technique used (passive shadow mode for safety reasons) and the limited time available to train the participating ATCOs and to integrate and test all three sites.
- Constantly changing airport layouts (e.g. construction works) confirm the need for standardised and up-to-date airport information.
- It is essential that new systems and their algorithms be adapted to the local procedures, areas of ATCO responsibility and, as much as possible, working methods. This adds complexity and variability in the implementation of the solutions (one size does not fit all).
- The human factor is essential in the successful deployment of the new solutions.
- The solutions seem to provide the expected benefits 'in real life',
- In addition, the project proved that ADS-B performance is sufficient to support PJ.03b-05, 'Traffic alerts for pilots for airport operations', helping to deliver this solution at its targeted V3 maturity level.

VLD project **PJ.31, DIGITS, 'Initial trajectory information sharing'**, supplemented by DIGITS-AU (awarded through the VLD Open 1 call for proposals; see subparagraph 1.5.1.2, 'Status of the VLD Open 1 call projects'), aimed to demonstrate the ATM benefits that can be realised through the use of downlinked 4D trajectory data in ground systems. The project validated the downlinking of ADS-C/



EPP data in accordance with the ATN baseline 2 standard. Complementing project PJ.31, DIGITS-AU aimed to use the avionics supporting ADS-C/EPP in eight airlines and at demonstrating its use in the airspace of DFS, ENAV, MUAC and NATS. Consequently, PJ.31, DIGITS, captured and analysed the big data stemming from DIGITS-AU flights.

In the framework of DIGITS, MUAC, with the aid of ground industry partners, adapted its operational system, while DFS, ENAV and NATS built up shadow-mode system platforms capable of receiving and processing ADS-C data (in order to feed the pre-operational mode, simulation mode or shadow mode systems) including the EPP. These platforms display shared (air to ground) trajectory data on controllers' working positions and/or explore the integration of the shared data in flight data processing systems to enhance ground trajectory prediction. A system at the EUROCONTROL Experimental Centre collected ADS-C data (with complete EPP trajectories) for off-line data access and online distribution.

In DIGITS-AU, the AU complementary project, in which six AUs participated, up to 100 A320 family aircraft were upgraded (either during final assembly or through retrofit) by installing enhanced communication and surveillance capability compliant with the new ATN baseline 2 (ATN-B2) standard through the Airbus future air navigation system C (FANS C) avionics and to establish ADS-C on revenue flights. DIGITS-AU started in January 2018 and ended, as did DIGITS, in December 2020 following two six-month extensions due to the impact of the COVID-19 pandemic.

In parallel, other SESAR projects were working to integrate the predicted trajectory with ATCOs' support tools, the overall goal being to optimise the aircraft's trajectory and make traffic flows more fluid.

At the conclusion of the VLD, project PJ.31, DIGITS, had equipped, through its complementary project, DIGITS-AU, a total of 91 aircraft with certified ATS-B2 airborne equipment, which downlinked ADS-C data compliant with the ATS-B2 standard, released in March 2016. In total, four ANSPs (DFS, ENAV, MUAC and NATS) and EUROCONTROL received and processed the data. Six AUs (Air France, British Airways, EasyJet, Iberia, Novair and Wizz Air) participated in the

project, equipped aircraft and trained nearly 10 000 pilots to operate the new functionality. These AUs are representative of the different types of AUs operating in European airspace, and the conditions in which their flights operate, in terms of routes, weather conditions and industrial policies, are also representative; in other words, the flights that formed part of the demonstration are considered to exemplify operational use.

The project, which looked at around 20 000 revenue flights and close to 50 000 flight/ANSP combinations, proved that both the airborne and ground technology are mature and stable. The first applications have been trialled and the capability of basic versions of the display of the downlinked EPP and discrepancy algorithm has been demonstrated in pre-operational use at MUAC, involving more than 12 000 flights. Enhanced versions of the applications using ADS-C data have been trialled in shadow mode, and as a result further enhancements and evolutions are planned.

By the end of 2020, around 1.4 million ADS-C transactions had been recorded.

Overall, the downlinked data have proved to be useful in generating new ideas and acting as inputs to further analysis in the area of innovative research, and also for confirming assumptions made in, for example, datalink capacity studies.

In addition, data recorded under PJ.31 have been made available to other SESAR 2020 Wave 1 and Wave 2 projects to allow them to start working on, for example, enhancing trajectory prediction.

Project PJ.31 has laid the foundation for further demonstrations with more ground partners under Wave 3, for example PJ.38, ADSCENSIO, and the use of SATCOM, an has also paved the way for deployment preparation expected to be mandated under (proposed) CP1 AF#6, Initial trajectory sharing.

1.5.1.2. Status of the VLD Open 1 call projects (call H2020-SESAR-2016-2)

The VLD Open 1 call for proposals was opened in 2016 and closed in 2017. It constituted the second work area of the call, which also covered ER3 (see paragraph 1.3.2, 'Status of the exploratory research 3 call'). The resulting projects were launched in execution in 2018. Nine VLD projects resulted from this call for proposals, of which five completed their activities and were closed in 2020: AAL2, Airline Team xStream, Airline Team NCM, DIGITS-AU and Safedrone. One project, AUDIO, was still in execution at the end of 2020 and will complete its activities by the end of 2021. The following paragraphs outline the outcomes of these projects in 2020.

VLD project **AAL2, 'Augmented approaches to land 2'**, focused on increased access to airports for low-visibility mixed-fleet operations. It built upon the results from the former award winning SESAR 1 project AAL, and it aimed at demonstrating augmented approach and landing operations based on the following technologies.

- GBAS CAT II with CAT I airborne and ground equipment enables lower decision heights, down to CAT II minima (decision height 100 ft) and targets hub and medium-sized airports. AAL2 demonstrated that performing GBAS CAT II approaches with GBAS GAST-C technology is feasible and brings benefits in terms of environment and cost efficiency.
- EFVS to land (EFVS-L), using head-up or head-mounted display, provides operational benefit down to a runway visual range of 300 m in non-CAT II/III airports and targets small and medium-sized airports.

In 2020, the project team finalised the preparation of and carried out the last demonstration activities, analysed the results and delivered the demonstration report summarising the project results and recommendations.

During demonstration flights by a wide variety of aircraft at selected airports (Frankfurt

and Bremen Germany; Antwerp, Belgium; and Périgueux, France), data on more than 60 approaches were collected, analysed and evaluated. This VLD project benefited from the involvement of very relevant stakeholders.

AAL2 demonstrated that it is feasible to perform GBAS CAT II approaches with GBAS GAST-C technology and beneficial in terms of reduced environmental impact and increased cost efficiency.

The project also delivered a new SESAR Solution, Solution #120, 'Enhanced flight vision system to land operations supported by infrared and visual-based technology', bridging the gap with the deployment of EFVS to land (EFVS-L) by demonstrating the feasibility of EFVS-L flights at non-CAT II/III-equipped aerodromes (more information can be found in subparagraph 1.4.4.2, 'Release 10 execution').

The main objective of the Airline Team NCM project was to support the PJ.24 consortium by providing the insights of airspace users. The project provided inputs to the execution of trials and activities in the NCM demonstration and also evaluated results and helped harmonised communication and execution.

The Airline Team NCM, in close cooperation with PJ.24 consortium, took part in the deployment of scenarios and trials at different stages of the project: design, development, execution and result analysis and project communication.

Most effort during this this period of the project went into executing ATEAM validation/ demonstrations.

Measurement and evaluation was were carried out in close collaboration with airline partners as well as PJ.24 exercise leaders.

All partners ensured that performance is harmonised in the demonstration report in a structured basis, identifying a global project view from each individual execution. This is well reflected in the Airline Team demonstration report.

During 2019 and the beginning of 2020, effort was mostly devoted to:

- the final implementation and deployment of scenarios;
- the execution of the final trials,
- performance assessment using trial data,
- writing the NCM demonstration report, which covered all exercises.

Improved and transparent coordination processes at network level of particular interest to the AU participants. Currently, AUs are unaware of the context and content of ATFCM measures imposed on them. Some AUs are in contact with local FMPs, especially at airlines' hub airports, and coordinate with them in the event of major disturbances to airline planning, but more commonly AUs are kept in the dark when it comes to the reasons for ATFCM measures.

The demonstrations showed AUs the opportunities that can arise from their involvement in network collaborative processes. Unfortunately, the PJ.24 project was already well developed by the time the formal Airline Team became involved, leaving insufficient time for participating airlines to develop tools to explore the full potential of the exchange of data on network measures. However, even the team's involvement in the exercises and in the 'manual' interpretation and use of the coordination information will be of benefit to AUs' operations.

The information available to AUs during the demonstrations focused on flight suspensions and re-route proposals resulting from the application of ATFCM scenario on D-1, and re-route proposals resulting from pre-agreed STAM measures on the day of operations. In addition to the final messages to AUs (FLS and RRP), during the demonstrations, more information was available to clarify the measure context. This resulted in a better situation (planning) awareness to participating AOs.

The **Airline Team xStream** project aimed to extend the AMAN horizon up to at least 200 nautical miles from the destination airport and to evaluate its impacts and benefits. The project demonstrated how arrival constraints can be computed and provided to upstream ACCs.

As part of the SESAR 2020 programme, the demonstrations contributed to SESAR ConOps definition and engineering standardisation work concerning the benefits brought by E-AMAN.

The main objectives were to improve flight efficiency and flight predictability and to reduce workload in the TMA. Trials were carried out from July 2017 to October 2019 at major European hubs (London Gatwick, London Heathrow, Paris Orly, Paris CDG, Zurich and Frankfurt), and also involved a large number of surrounding ACCs, the UAC and airspace users. It was concluded that the project has the potential to benefit the environment (by reducing fuel consumption) as well as to increase capacity (by reducing ATFCM delays and reducing complexity in the TMA) and flexibility (reducing the cost of delays for AUs), all of which are further detailed in this report.

During 2019 and the beginning of 2020, effort was mostly devoted to:

- the final implementation and deployment of scenarios;
- the execution of the final trials;
- performance assessment using trial data;
- writing the xStream demonstration report, which covered all exercises.

During the rest of 2020, activity on xStream was essentially focused on the administrative and financial closure of the project.

The VLD project **AUDIO, 'Airspace user supporting demonstrations of integrated airport operations'**, aims to demonstrate that the safety and efficiency of aircraft movement on the airport surface can be increased by implementing an innovative advanced and connected moving map application for EFB applications. The technology was tested in an on-board demonstration at Hamburg Airport. The application provides the cockpit with local airport data such as the on-ground traffic situation and planned taxi routes. Equipped with this additional information, on-board operations are expected to run more smoothly as crews are aware of the planned ground trajectory and the surrounding complex environment. This also allows crew members to react more easily to last-minute re-planning of routes once the aircraft is off-block. This should result in a safer sequence,

a more reliable targeted take-off time, less complexity for the crew, more efficient taxiing and fewer emissions because fuel consumption is reduced.

In 2020, the project team continued to prepare the demonstrations by adapting the ground and airborne systems and planning the exercise. However, the project was badly affected by the COVID-19 outbreak. Lufthansa, a key contributor to the project, had to put its activities on hold as a consequence of the severe economic impact of the pandemic on the airline. Travel and access restrictions also prevented the project team from installing the necessary equipment on site. As a result, the demonstration had to be postponed to 2021 and, at the time of writing, the consortium had just requested a six-month extension to absorb the delay induced by the pandemic.

The DIGITS-AU project supplemented VLD project PJ.31, DIGITS, with contributions from AUs, and a report of both projects can be found in subparagraph 1.5.1.1, 'Completion of SESAR 2020 Wave 1 VLD projects'.

The **Safedrone** project sought to define and detail pre-flight services including electronic registration, electronic identification, planning and flight approval, as well as in-flight services such as geofencing, flight tracking and dynamic airspace information and automatic technologies to detect and avoid obstacles in order to demonstrate how manned aviation and drones can operate at the same time in non-segregated airspace. The objective was to accumulate evidence and experience about the services and procedures necessary to operate drones in a safe, efficient and secure way within U-space.

The project closure meeting and maturity assessment at the ER/IR gate took place in June 2020 and the SESAR JU concluded the project has fully achieved its objectives:

- Safedrone has organised the demonstrations activities in four trials;
- a complete architecture has been designed in order to implement the necessary U-space services and interfaces to perform the trials;
- with respect to the integration of GA aircraft and U-space, it is important to highlight that a new concept has been defined, called 'cooperative but passive';
- the drones' ground control station software has been modified to enable drones to communicate with Unifly's U-space system;
- a number of adaptations to GA aircraft have been implemented, including the integration of an ADSB out transponder and the development of a specific interface related to U-space services for the pilot.

In the case of autonomous aerial vehicles, a set of advanced functionalities have been developed and tested based on a simulation framework. A DAA method based on point clouds from different types of sensors (3D lidar, stereo camera, time-of-flight camera, etc.) and an algorithm for path planning has been developed and tested.

- a software architecture to handle swarming operations, such as coordinated monitoring missions, has been implemented, tested and integrated with Unifly´s U-space system;
- a number of drones have been adapted to the project requirements, including the configuration of the autopilot to be used by the project ground control station software.
- more than 100 flight experiments have been performed, providing a large number of interesting results that are detailed in the demonstration report deliverable.

1.5.1.3. Status of VLD projects under the Wave 2 call (H2020-SESAR-2019-1)

The Wave 2 call for proposals with reference H2020-SESAR-2019-1 [27], was conducted in 2019. It resulted in the award of three grants for very VLD activities, amounting to a total value of EUR 12 373 554, and the launch in

[27] Call conditions were set out in the SESAR JU annual work programme for 2019. The call documentation is available on the European Commission's Funding and Tenders Portal.

execution of the corresponding projects. These projects will deliver their results from 2020 to 2022. The following paragraphs provide information on the projects activity in 2020.

Project **VLD01-W2**, **DREAMS**, 'Demonstration of runway enhanced approaches made with satellite Navigation', started on 1 October 2020. It will focus on EAPs supported by advanced GNSS navigation technologies, GBAS CAT II/III to reach V3/4 maturity. This will be achieved through a proof of concept combining commercial and non-commercial flights with flight trials tests. The demonstration will cover business jets, commercial (Airbus) aircraft and commercial operators or flight test aircraft. Three types of operations will be covered (increased glide slope (IGS), second runway aiming point (SRAP), IGS-to-SRAP) and pioneer flight on GBAS GAST C+ for CAT I/II and GAST-D for CAT II/III. A-IGS-related work will be limited to technical studies. EAP encompasses:

- steeper operations, namely IGS,
- staggered threshold / additional point operations, namely SRAP, and
- mix of IGS, SRAP and IGS-to-SRAP.

In addition, the VLD01-W2 DREAMS project will address adaptive IGS (A-IGS) reviewing procedural aspects and, if deemed necessary, perform tests using aircraft simulators.

Project **VLD02-W2**, **STAIRS**, 'Surface traffic alerts improve runway safety', kicked off in February 2020. The project focuses on supporting the transition from R & I to deployment for Solution PJ.03b-05, Traffic alerts for pilots for airport operations', which achieved V3 in Release 9 (see subparagraph 1.4.4.1, 'Release 9 outcomes').

The solution validated two different implementations.

- Mainline aircraft implementation. The surface traffic alerts on runways for pilots without traffic display and warning alerts only (SURF-A) consists of an on-board system that detects risk of collision with other traffic during runway operations and provides the flight crew with aural alerts (mostly 'warning' alert level).
- Business aircraft implementation. The surface traffic alerts and indication on runways for pilots with optional display, caution and warning alerts (SURF-ITA) consists of an on-board system that detects potential and actual risks of collision with other traffic during runway and taxiway operations and provides the flight crew with visual and aural alerts (indication, caution and warning alert levels).

The demonstration activities in VLD02-W2 Stairs target a large number of commercial flights at many high-, medium- and low-

density airports to demonstrate the system performance. The activities should be performed in partnership with European airlines and during business jet operations in line with identified KPAs such as safety and human performance defined by the European ATM Master Plan.

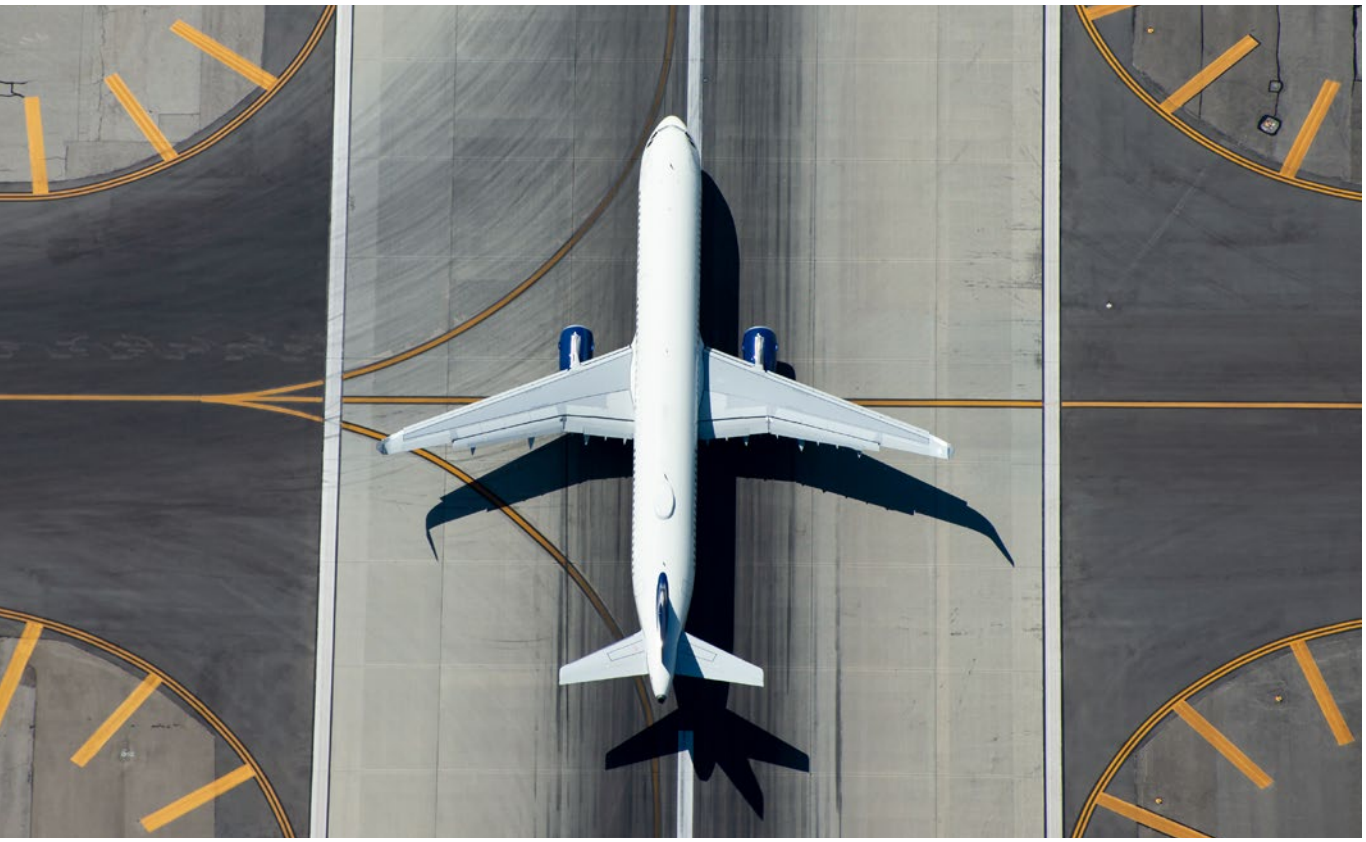
The project's specific objectives are:

- to support a controlled entry into service of SURF-A and SURF-ITA by demonstrating the required safety objectives for the certification of the new functions to the airworthiness authorities;
- to replay the collected data in fast-time simulations to further assess the performance of the new functions and fine-tune the related algorithms;
- to assess the quality of the collected ADS-B data, supporting the intention to establish a worldwide reference for ADS-IN quality on the ground;
- to ensure interoperability between the on-board safety nets provided by Solution PJ.03b-05 and those available to the other ATM stakeholders, in particular ATCOs providing tower ANS.

In 2020, the work of the project focused on planning the demonstration activities, from the operational, technical and regulatory perspectives. However, the impact of the COVID-19 outbreak and changes in Airbus's business priorities led to the need to fine-tune the specific set-up of the demonstration activities, with the intention of preserving the overall project objectives and ambition. At the time of writing of this report, the SESAR JU and the consortium members were assessing the impact of such changes on the project.

Project VLD03-W2, SORT, 'safely Optimised runway throughput', kicked off in July 2020. It aims to demonstrate the operational and technical readiness of the following mature SESAR Solutions to transition to industrialisation and deployment:

- PJ.02-01-01, 'Optimised runway delivery on final approach',



- PJ.02-01-04, 'Wake turbulence separations (for arrivals) based on static aircraft characteristics',
- PJ.02-01-07, 'Reduction of wake turbulence risk considering acceleration of wake vortex decay in ground proximity',
- PJ.02-03, 'Minimum-pair separations based on required surveillance performance',
- PJ.02-08-01, 'Trajectory-based integrated runway sequence',
- PJ.02-08-02, 'Trajectory-based integrated runway sequence',
- PJ.02-08-03, 'Increased runway throughput based on local runway occupancy time characterisation'.

In 2020, the project team started planning the demonstration activities, from the operational, technical and regulatory perspectives. Live and shadow mode trials were initially planned at several major airports, each addressing specific aspects:

- demonstration in live operations at London Heathrow Airport of the operational concept of pairwise separation in the ROT component of a time-based separation system, and assessment of the benefits and issues arising from the use of the concept,
- demonstration in live operations at Vienna Airport of the operational concept of a wake decay-enhancing device to increase safety by reducing the number of wake encounters, and assessment of the benefits and issues arising from the use of the concept, focusing on technical and regulatory constraints,
- demonstration in live operations at Zurich Kloten Airport of the operational concept of reducing the surveillance separation minimum for in-trail pairs on final approach, including revised ROT categorisation (ROCAT) and assessment of the benefits and issues arising from the use of the concept,
- demonstration in shadow mode, at Stockholm Arlanda Airport, of the operational concept of an integrated AMAN–DMAN (departures manager) runway sequencer, and assessment of the benefits and issues arising from the use of the concept.

However, the COVID-19 pandemic has affected Skyguide and Zurich Airport in such a way that the demonstration initially planned for Zurich is no longer feasible. At the time of writing of this report, the consortium members and the SESAR JU were working on a mitigation plan that would preserve the project scope and level of ambition as much as possible with the aim of integrating the Zurich exercise objectives into the Heathrow demonstration. An assessment of the demonstration technique (i.e. live trials or shadow mode) was also ongoing.

1.5.1.4. Status of the VLD Open 2 call (H2020-SESAR-2020-1)

The VLD Open 2 call for proposals with reference H2020-SESAR-2020-1 [28] was defined using the priorities set out in the European ATM Master Plan, and in particular in the EOCs set out in the 2020 edition of the European ATM Master Plan (see also subparagraph 1.1.2.3, 'Delivery of VLD activities'). It also considers the operational and technical measures that need to be implemented in the very short term (2020–2025), as outlined in the Airspace Architecture Study transition plan. The open call was opened at the end of January 2020 and the call deadline was postponed to the end of June because of COVID-19. The total budget of the call was EUR 21 933 376. Following the evaluation process, which took place in September, a main list and a reserve list were drawn up. Grant agreements for all six projects on the main list had been signed by December 2020. The projects will deliver their results in 2021 or 2022. Two additional projects from the reserve list proceeded to the grant agreement phase in December, and grants are expected to be signed by February 2021.

[28] Call conditions were set in the 2019 work programme paragraph of the SESAR JU's SPD 2019–2021. The all documentation is available on the Funding and Tenders Portal.

The call content is structured in a number of topics.

- Taking into consideration traffic hotspots identified in the Airspace Architecture Study transition plan, the VLDs aim to demonstrate optimised and coordinated organisation of airspace activations and reservations, able to support optimised traffic flows in a free route environment as well as other uses of airspace (e.g. military).
- The demonstration activities may also include initial dynamic airspace configuration and application of advance flexible use of airspace (AFUA) and ATFCM and showcase initial strategies to delegate ATS among ATSUs and capacity-on-demand arrangements and gradual transition towards higher levels of automation.
- The VLDs should aim to demonstrate, in a consolidated and integrated manner, the real-time synchronisation of trajectory information among all involved stakeholders.
- The demonstration activities may also extend to free routing operations in cross-border environments; automated support for adapting capacity to evolving demand; cross-border interoperability of mission trajectory elements; enhanced integration of AU trajectory definition and network management processes; enhanced network traffic prediction and shared complexity representation; ATM data service provision; and air–ground and ground–ground connectivity.
- U-space capabilities and services to enable UAM refers to the provision of mobility services in an urban environment using air vehicles. These vehicles encompass everything from manned helicopters, as currently flown, through small inspection and delivery drones, to 'flying taxis', with or without a pilot. As this important and growing domain evolves, it is clear that new operational concepts, regulations and standards will be needed, underpinned by existing and new technologies. The whole environment will need to integrate safely with manned aviation and ATC.
- The VLDs should aim to demonstrate ATM operations that mitigate aviation's environmental footprint and contribute significantly to the reduction of CO_2 emissions. Applicants are invited to promote and demonstrate 'zero CO_2 waste' trajectories. Projects are encouraged to explore options for protecting green flights from unnecessary deviations or constraints.

The following paragraphs provide information on the projects' activities in 2020.

The VLD project ALBATROSS , 'The most energy efficient flying bird', aims to explore the possibilities of implementing and supporting a 'Flight with zero waste of fuel and CO_2 emissions', and demonstrate, through a series of live trials, the feasibility of minimising the fuel consumption of flights in various operating environments. The aim is to achieve fuel consumption as close as possible to the theoretical optimum and as low as possible compared with the average historical fuel consumption of similar aircraft types operating on the chosen city pairs under similar operational conditions. The calculation of optimal flight trajectory to achieve, as far as possible, zero waste fuel and CO_2 emissions will take into consideration weather conditions information available during the planning and execution of the flight.

ALBATROSS follows a holistic approach by covering all flight phases, directly involving all relevant stakeholder groups (such as airlines, ANSPs, NMs, airports and industries) and addressing both operational and technological aspects of aviation and ATM. The project will demonstrate the complementarity of solutions, for example the use alternative aircraft fuel combined with improvements to ATM and AUs' operations on the ground, in the TMA and en route. To foster increased flexibility and scalability, the demonstrated approaches will also leverage cutting-edge technologies such as modern methods of air–ground connectivity and novel highly collaborative ATM.

The project has as its key objectives:

- to develop a coherent generic 'zero fuel and CO_2 emissions waste flight' ConOps (WP2), aligned with the SESAR,
- to undertake trial activities (WP3) to demonstrate the principles defined in the ConOps for preferred green flight, including flights adopting SESAR Solutions that enable fuel efficiency gains,
- to undertake identical performance assessments (WP4) of all demonstrations to ensure that single a methodology and common metrics can be developed for the analysis of all trials,
- to disseminate the results (WP5) of ALBATROSS to all interested stakeholders and target organisations, to foster their interest in the project, and to take into account their recommendations in the later stages of the project.

ALBATROSS will be a key element of the sustainability strategy of the SESAR JU, by demonstrating the environmental benefits of the applications of multiple solutions on the same flight, at large scale. Ideally, the project will trial the concept on approximately 1000 flights.

The ALBATROSS project started on 1 December 2020.

The VLD project **AMU-LED,** 'Air mobility urban – large experimental demonstrations', aims to design and deliver a detailed ConOps and definition of urban air missions followed by simulations and a large real-flight campaign composed of three demonstrations to verify and validate the concepts and to compare two UTM architectures. AMU-LED will allow UAM stakeholders to specify various use cases applicable to logistics and the urban transport of passengers, to integrate into the UAM environment, to demonstrate the UAS ground and airborne platforms and, finally, to assess safety, security, sustainability and public acceptance. The flight demonstrations will amount to more than 100 hours of flying in total, and flights will take place across Europe, in three different countries, and using various scenarios. The United Kingdom (Cranfield), the Netherlands (Amsterdam/Rotterdam) and Spain (Santiago de Compostela) have expressed interest in the project and have communicated their needs in terms of air logistics, transport and emergency services.

The SESAR JU kicked off AMU-LED in January 2021.

The VLD project **CORUS-XUAM**, 'Concept of operations for European U-space services – extension for urban air mobility', will demonstrate how U-space services and solutions could support integrated UAM flight operations, allowing eVTOLs/UAS and other AUs (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 activities will start with an update of the U-space ConOps, addressing the integration of UAM/UAS operations into the airspace and identifying new U3/U4 services. The project activities will continue with the preparation and execution of six challenging VLD campaigns in six different European locations. These VLD activities will be at the heart of CORUS-XUAM and will support integrated operations of UAS/UAM and manned aircraft and advanced forms of interaction through digital data exchange supported by integrated and advanced U-space services in urban, sub-urban, and inter-city scenarios as well as in and near ATM-controlled airspaces and airports. The VLDs will focus on different types of mission, such as passenger transport, logistic, delivery, emergency response and surveillance, using different U-space deployment architectures and state-of-the-art technologies. They will consider coordination between ATC and U-space, including interaction with ATCOs and pilots. The VLDs will combine flights by eVTOLs with other traffic and operations in the controlled traffic regions of major airports. Vertiport procedures, separation and data services will also be demonstrated. The main results will be used to further consolidate the ConOps at the end of the project. The project will also involve extensive consultation and communication initiatives with reference Authorities, U-space stakeholders and end-users.

The SESAR JU kicked off CORUS-XUAM in January 2021.

Project **GOF2.0**, 'Integrated urban airspace very large-scale demonstration', is a VLD project that will safely, securely and sustainably demonstrate the 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. The demonstrations focus on validation of the GOF2.0 architecture for highly automated real-time separation assurance in dense airspace including precision weather and telecom networks for air–ground communication and will significantly contribute to our understanding of how UAM and other commercial drone operations can be safely integrated into ATM airspace without degrading safety or security or disrupting current airspace operations.

The SESAR JU kicked off GOF2.0 in January 2021.

The vision of the VLD project **SAFIR-Med,** 'Safe and flexible integration of advanced U-space services focusing on medical air mobility', is to achieve safe, sustainable, socially accepted and socially beneficial UAM. Five unmanned UAV platforms (passenger eVTOL vehicles, hydrogen fuel cell vertical take-off and landing (VTOL) vehicles, automated external defibrillator medical drone, X8 medical transport) will be combined with manned aviation in real-life exercises validating technology in an authentic urban environment. The technologies of all partners will be leveraged to make use of the maximum number of U-space services, including an advanced DAA U-space service, with a view to achieving the highest possible operational safety level. The demonstrations will take place in the cities of Antwerp (Belgium), Aachen (Germany) and Heerlen (the Netherlands), leveraging the MAHHL (Maastricht, Aachen, Hasselt, Heerlen, Liège) trans-border region, following a full de-risking exercise at the DronePort beyond

visual line of sight (BVLOS) test facility in Belgium.

The demonstration results will be further virtually enhanced through large-scale simulations in order to test the maximum airspace capacity of the ConOps. The project results will then be further validated and made representable for the whole of the EU, by simulating demonstrations in additional locations in Europe, namely Athens, Greece, Prague, Czech Republic. Refinements to the current U-space architecture principles and measurable indicators for UAM will enable smart cities to include UAM in their transport roadmaps, supporting standardisation and, thereby, safety. Finally, SAFIR-Med will make an important contribution to the EU healthcare system, by ensuring that future generations will continue to have equitable access to the best care and treatments.

The SESAR JU kicked off SAFIR-Med in January 2021.

The VLD project **TINDAIR** 'Tactical instrumental deconfliction and in-flight resolution', aims to demonstrate the safe integration of UAM as an additional AU. Four missions/flights, with different operating methods, will take place, in coordination with all relevant partners, and will involve more VTOL platforms carrying human passengers and medical equipment to simulate the variety of possible U-space users in the near future. The demonstration flights will also include vehicles with full autonomous capabilities for automated safe procedures, as well as helicopters.

Flight demonstrations will address tactical conflict resolution and emergency landing, with a focus on pre-flight checks for possible conflicts in the strategic phase and in-flight checks to enable each VTOL vehicle operating in that airspace to rely on a DAA service. The DAA service will instruct the aircraft to change their speed, level or heading as needed or force them to make emergency landing at a pre-identified vertiport in the urban area.

The ultimate objective of this project is to deliver strategic and innovative technologies that can drive competitiveness and UAM growth using an impact-oriented approach and demonstrate the safe integration of UAM aircraft as additional AUs. The results of the TINDAiR project will help to:

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

The VLD project **Uspace4UAM,** 'U-space for urban air mobility,' aims to bridge the gap between development and deployment. The project will tackle issues of operational concepts, regulation and standards, while building confidence in a safe and orderly integration of UAM in everyday air traffic. A series of well-defined, iterative and multinational demonstrations involving both drones and UAM vehicles will be conducted. They will cover different use cases, including mixed operations, to allow the project to derive critical enablers for a wide set of UAM service applications that can be applied all over Europe.

Uspace4UAM will build on the CORUS project results and on operational and business experience already gathered in operational drone service implementations in Europe. It will study safety cases and their impact on system requirements, and look at how regulation and standardisation can be set up to support innovators to build a sustainable business case while operating safely in a multimodal transport network. In order to prove that this will be achieved, and that the project indeed has built a bridge between development and deployment, the project is set to deliver a number of commercial contracts for the provision of fully automated drone services, and present solutions to identified gaps to be addressed before fully autonomous urban air taxi services can be implemented.

The project **VLD2 VOICE,** 'Reduced separations and improved efficiency based on VHF communications over LEO satellites' explores the use of space-based infrastructure, which is a necessary step towards the provision of ATS in remote areas or big portions of airspace where they are not currently available owing to the geographical constraints of terrestrial-based systems. In such areas, the answer could be to improve the efficiency, safety and capacity of aviation to enable reduced separations minima in remote airspace based on satellite VHF voice and data communications systems. Other satellite-based technologies cannot provide a complete and integrated solution in terms of performances necessary to reduce separation.

The objective of VLD2 VOICE is to demonstrate that the use of satellite-based VHF systems providing voice and datalink allows ATS traffic in remote airspace to be handled in the same way as in a continental environment, and that current separation can be reduced without compromising safety. In addition, the project will perform some cross-border operations between adjacent flight information regions in different countries. The demonstration will cover operations in the Canarias and Sal Oceanic flight information regions, where ATCOs communicate in real time with aircraft at distances of more than 1 500 km.

1.5.1.5. Status of the Wave 3 call (H2020-SESAR-2020-2)

Concluding the Wave 3 call for proposals (see paragraph 1.4.3, 'Status of the Wave 3 call'), the following VLD projects were awarded funding: PJ37-W3, ITARO, and PJ38-W, ADSCENSIO.

The VLD project **PJ.37-W3, ITARO,** 'Integrated terminal manoeuvring area, airport and runway operations', the grant agreement for which was signed in December 2020, for a start date on 1 January 2021, addresses two topics of the Wave 3 call:

- IR activities topic 5, 'Collaborative management of terminal manoeuvring airport throughput' and
- Innovative action (IA) topic 6, 'Integrated runway throughput and terminal efficiency (VLD-like)'.

The project aims to:

- complement Wave 2 Solution PJ.07-W2-39, 'Collaborative framework managing delay constraints on arrivals', by performing validation activities on the collaborative process dealing with delay constraints on arrivals, feeding into Solution PJ.07-W2-39 V3 R & I activities;
- demonstrate the benefits of integrating the following SESAR Solutions:
  - PJ.01-05, 'Airborne spacing flight deck interval management',
  - PJ.02-01-01, 'Optimised runway delivery on final approach',
  - PJ.02-01-04 'Wake turbulence separations (for arrivals) based on static aircraft characteristics',
  - PJ.02-08-03, 'Increased runway throughput based on local ROT characterisation (ROCAT)',
  - #05, 'Extended arrival management horizon',
  - #11, 'Continuous descent operations using point merge'.
- complement Wave 2 Solution PJ.01-W2-08B, 'Dynamic extended terminal manoeuvring area for advanced optimised descent operations', by performing additional development and validation activities on the optimisation of the climb and descent phases of a flight, feeding into Solution PJ.01-W2-08B V2 R & I activities.

VLD project **PJ.38-W3, ADSCENSIO** 'ADS-C enables and supports improved air traffic management operations', relying on the general principle of TBOs, aims to improve various features of ATC by better anticipating how flights will behave. During the execution of a flight, the important information needed for accurate and reliable trajectory prediction, or alternative scenarios, can be provided by the aircraft itself. This information includes wind conditions and speed schedule or the trajectory prediction computed by the

aircraft navigation system itself, based on the four dimensions of horizontal and vertical positions, altitude and time (4D). Some aircraft operated by European airlines already have the capacity to send this information via a datalink communication application.

The objectives of the project are to demonstrate both the improvements that can be achieved in many common operational situations that ATCOs have to manage and the efficiency and robustness of a technological infrastructure to support the exchange of trajectory-related information between the aircraft and various ground consumers using datalink communications. More specifically, through operational demonstrations of the use of ADS-C and by evaluating the ability of the proposed infrastructure to convey and share ADS-C data, the project aims:

- to continue to collect ADS-C reports and related data sent by aircraft equipped with the technology to downlink flight trajectory information;
- to analyse the characteristics, performance and behaviour of ADS-C data from the operational and technical perspectives;
- to perform operational evaluations to demonstrate and characterise the benefit of integrating ADS-C data in ATC systems, with a specific focus on the integration of SESAR Solution #115 (ATM Master Plan reference) in the continuity of initial works performed in Wave 1 (in particular projects 10-2a and 18-6);
- to demonstrate the feasibility of an efficient distributed ADS-C service ('ADS-C common Service') on the ground; and
- to demonstrate the use of SATCOM link to complement VDL2 technology to ensure air–ground ATN connectivity (SESAR Solution #109 in the European Master Plan).

Project PJ.38-W3, ADSCENSIO started on 1 November 2020.

1.5.2. Activities carried out under other financial frameworks: status of the U-space call (CEF-SESAR-2018-1)

The EU, with SESAR, has developed a vision called U-space: the phased introduction of procedures and 'a set of services designed to support safe, efficient and secure access to airspace for large numbers of drones' to encourage the growth of the UAS industry and the use of these aircraft in Europe. These services and procedures rely on a high level of digitisation and automation of functions, whether they are on board the drone itself or are part of the ground-based environment. The intention behind U-space is that, when fully deployed, a wide range of drone operations will be possible thanks to a sustainable and robust European ecosystem that is globally interoperable.

In response to this delegation agreement, in 2020, the SESAR JU conducted the following activities in continuation of the activities carried out in 2018 and 2019 (see the delegation agreement implementation reports referred to in footnote 2).

- It supervised the delivery of six projects in execution following the conclusion of the call for proposals with reference CEF-SESAR-2018-1.
- It carried out grant management activities in accordance with the rules of the CEF programme.
- It planned and delivered communication and outreach activities in relation to the entrusted task.
- It carried out the financial implementation of the expenditure in relation to the entrusted task, in accordance with the principles of sound financial management, transparency and non-discrimination as detailed in Title VIII of the financial regulation ([29]).
- It closed each project, which included a maturity assessment of the project outcomes and consolidation at programme level (U-space brochure).

1.5.2.1. Operational implementation of the entrusted task

In 2020, six projects (referred to in this report by their short names: DIODE, DOMUS, SAFIR, EuroDrone, Vutura and GOF-Uspace) were in execution following the conclusion of the call for proposals with reference CEF-SESAR-2018-1.

These projects aim to demonstrate initial versions of U-space services through the early demonstration of U-space systems and procedures. The work complemented more conceptual SESAR ER U-space projects with real-world flight trials. The project had two aims. The first was to utilise commercial off-the-shelf and near-term technologies to investigate state-of-the-art but achievable U-space service solutions in tightly controlled experimental scenarios. The second was to take the outcomes from these experiments and use the valuable real world tested information to draw conclusions on maturity recommendations on initial achievable standardisation and to understand how the U-space framework as defined by the CORUS (Concept of operation for European UTM systems) project ([30]) refined, improved and progressed.

These projects are part of the SESAR 2020 programme. The SESAR JU followed the programme management framework set up since 2019 and tailored to the 19 U-space projects of the SESAR 2020 programme, including management and technical aspects, with the aim of collecting and consolidating the outcomes of the various projects at programme level. Under this programme management framework, all U-space projects had to produce their reports in compliance with specific SESAR JU guidance with the aim of delivering conclusions and recommendations that fit with the SESAR JU expectations.

In 2020, all these projects delivered their final study report, which included a description of project outcomes and, more importantly, any conclusions drawn or recommendations to be considered at programme level.

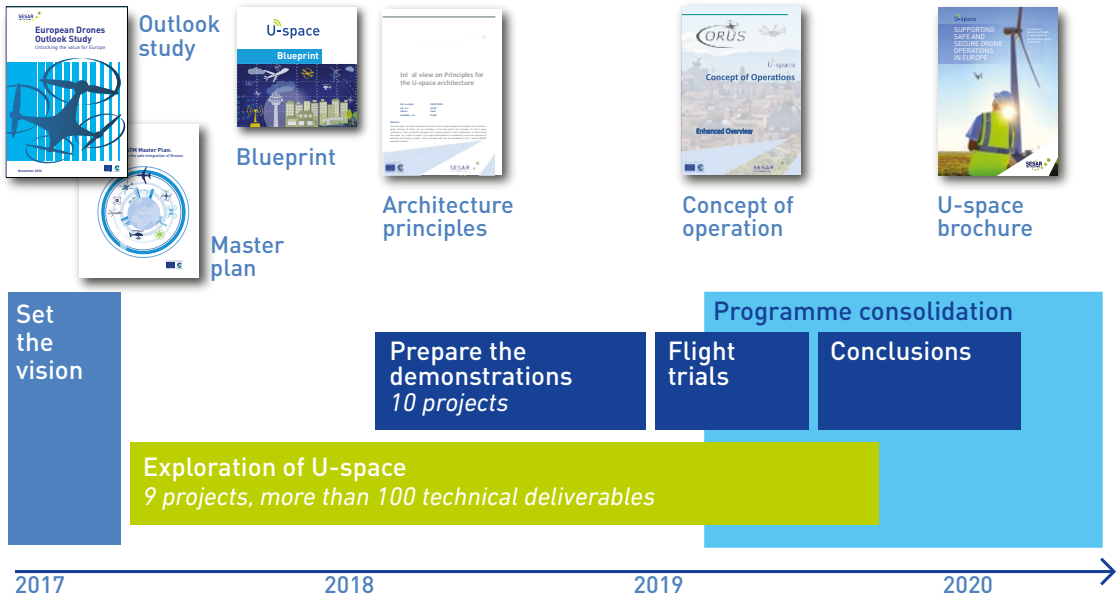
1.5.2.1.1. Supervision and leadership of the U-space projects under the Connecting Europe Facility by the SESAR JU

In 2020, SESAR JU partners completed research and demonstration projects. These projects followed a short but complex timeline, with almost all the activities performed in parallel with the production of a series of documents developed by the SESAR JU regarding the development of U-space (Figure 19).

([29]) Title VIII of Regulation (EU, Euratom) No 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014 and (EU) No 283/2014 and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012.

([30]) The CORUS project, part of the SESAR 2020 programme, is conducted under SESAR JU supervision through the H2020 framework.

FIGURE 19 SESAR DEVELOPMENT OF U-SPACE 2017–2020



After the completion of these projects, the SESAR JU reviewed all the reports and technical documentation produced by the project teams. In November 2020 the SESAR has published the U-space brochure, the summary of this consolidated review. The aim of the brochure is to make SESAR outcomes, and then CEF projects, accessible and easy to use.

The U-space brochure contains the latest available catalogue of the U-space services with descriptions extracted from the final edition of the U-space ConOps prepared by the project CORUS and notable requirements from the SESAR projects. This publication provides the readers with:

- a summary of the main SESAR findings, including a comprehensive view of the SESAR coverage and answering questions such as 'What did SESAR demonstrate or not?' and 'How mature is U-space?';
- facts and quotes from the flight trials performed in SESAR demonstration projects;
- a view of the needs for future research and development activities;
- a summary of the recommendations for standardisation and regulation activities;
- an overview of each project.

The content of this state-of-the-art review is based on various documents but especially on the final study reports and technical appendixes of the CEF projects reports.

1.5.2.1.2. Progress and development of the U-space projects

The projects were initiated in late 2018, and 2019 was given over to the design and execution of flight test campaigns and the presentation of initial findings. In 2020, the projects delivered their final conclusions and recommendations to the SESAR JU. The results from these projects show that we have made progress on the building blocks of U-space, with some project partners already reporting plans to start to deploy some elements of U-space work in their countries. At the same time, the projects also identified important gaps in the performance of certain technologies or the need for more research, especially in the area of UAM operations and the interface with manned aviation.

Another important outcome of the R & I has been the building up of the drone stakeholder community, with projects bringing together an unprecedented number and range of

actors from traditional aviation, but also new entrants, including start-ups, SMEs, research institutes, universities, drone operators as well as service providers, airports, local/city authorities, law enforcement agencies and civil aviation authorities.

The involvement of the EASA and the European aviation industry standards-developing body (Eurocae) ensures that the results of the project can be incorporated into ongoing drone standardisation and regulatory work.

The following paragraphs present the specific developments of each project.

DIODE (D-flight internet of drones environment)

Drones operate across multiple sectors, including medicine, agriculture, mapping, deliveries, inspection and emergency services. They range over different terrains and display different characteristics. The DIODE project focused on demonstrating technologies to safely manage multiple drones flying in VLL airspace at the same time, while accomplishing multiple tasks and missions. The project worked on the assumption that each aircraft (manned and unmanned) will report its positions, in other words that all aircraft cooperate with the system, thereby reducing is overall complexity.

DIODE is a consortium of Italian companies that conducted 11 missions in Rieti, a small province close to Rome, in several different types of terrain: rural, mountainous, remote, industrial, urban and semiurban. The demonstrations covered a wide range of operations: parcel delivery; road traffic patrol; professional photography; railway and power lines surveillance; search and rescue, airport operations; interaction with general aviation; and firefighting. The flights were carried out in combination with manned flight and took account of third parties on the ground.

The demonstrations adopted a risk-based approach to the provision of initial and advanced U-space services aligned with the expectation of drone operators. The drones were monitored using D-flight, a dedicated platform that provides e-registration, e-identification and static geofencing in compliance with European regulations. The risk assessment followed the specific operations risk assessment methodology used for complex drone operations and looked at new competences and technology to support the growth of drone services.

DIODE demonstrated that emerging and mature capabilities on board drones can support the deployment of a risk-based and an operation-centric concept of U-space. The project considered a huge range of drones and highlighted opportunities where the drone market can also contribute to development of more advanced U-space services.

DOMUS (demonstration of multiple U-space suppliers)

Ensuring that drones operate safely alongside all other AUs calls for advanced conflict detection between flight paths and reliable communications with the ATM system. By integrating already developed technologies and concepts around a federated architecture, members of the DOMUS consortium showed that initial and some advanced U-space services, including tactical deconfliction, are possible.

DOMUS demonstrations involved three service providers interacting with one ecosystem manager, and several drone operators using drones from different manufacturers, during tests in Andalucía, Spain. In this set-up, the ecosystem manager is the principal U-space

service provider and provides data integrity to the system as a single point of truth, thus ensuring safety, security, privacy and secrecy, and easing the entrance of new service providers to the system. It also provides a single interface with ATM. The service providers operate in parallel to deliver U-space and added-value services to the various drone operators, who need to exchange data to carry out their operations. Such data includes optimum operation profiles, fleet management, log records and additional flight information. During the flights conducted by DOMUS partners, three service providers connected to the ecosystem manager and simultaneously provided services to five different drone operators, in close proximity and at a distance, in two different locations: Lugo and Jaen, Spain. In one example, integration with manned aviation was also demonstrated.

Thanks to the ecosystem manager, DOMUS demonstrated some of the initial services detailed in U1 and U2 definitions of U-space, including e-registration, e-identification, geofencing, flight planning, tracking, dynamic flight management and interfaces with ATC. Some U3 services, such as tactical deconfliction between two drones and dynamic geofencing – for example around manned aircraft – in collaboration with ATM, were also tested. Activities included mapping, normal and urgent deliveries, building inspections and integration of recreational flights. The project also demonstrated the feasibility of connecting U-space operations to the smart city platform. The live trials showed how a federated architecture can support multiple service providers under the management of an ecosystem manager for efficient deployment of U-space services. This is possible using current technology and interoperable U-space services provided by different service providers and different drone operators.

SAFIR (safe and flexible integration of Initial U-space services in a real environment)

To safely integrate drones into the airspace, the U-space SAFIR consortium conducted a series of demonstrations to show how technology can support the safe deployment of a multitude of drones in a challenging airspace environment. Three U-space service providers and one ANSP integrated their services to control the airspace collaboratively. The test scenarios included parcel delivery flights, aerial survey, medical inter-hospital flights and emergency prioritisation supported by leading operators in these domains.

The use cases were first successfully tested at DronePort in Sint-Truiden, Belgium, a secure test environment for manned and unmanned aircraft, before transferring to Antwerp City (urban area), Antwerp Airport terminal area and the Port of Antwerp to test the viability of the use cases in a realistic environment. In addition, SAFIR tackled the issue of unregistered drones and their impact on legal drone operations and manned aviation. A specialised radar developed by the CLASS project was deployed to detect rogue drones in critical areas and provide a live feed for the

U-space service providers. SAFIR's federated model enabled information-sharing between multiple interoperable services, categorised according to their function.

SAFIR proved the ability of drones to safeguard critical areas, such as an international port or an urban environment. It was demonstrated that the Port of Antwerp could request a drone to inspect a certain area should there be reason for concern, as well as create no-drone zones to manage safety in the port. The project also showed how multiple U-space service providers can operate in the same geographical area at the same time as UTM systems are interoperable.

SAFIR demonstrated full availability of the following services: e-identification; pre-tactical, tactical and dynamic geofencing; strategic and tactical deconfliction; and tracking and monitoring. The project successfully tested initial, advanced and full U-space services and made recommendations for further research. For example, it concluded that tracking data sourced from different places needs to be fused; full integration is needed between UTM and drone operators on the ground; and interaction with ATC is important, preferably in an automated way. Flight authorisation is complex and SAFIR expects European regulation to help clarify drone categories. It also found satellite mobile connectivity performed well, but 4G degrades at higher altitudes and would benefit from a dedicated 4G drone overlay network, particularly relevant to beyond visual line of sight operations.

SAFIR findings will contribute to the EU regulatory process and deployment of interoperable, harmonised and standardised drone services across Europe.

EuroDrone (A European UTM testbed for U-space)

The safe integration of drones into manned airspace requires a universal platform connecting various stakeholders (drone operators, regulators, law enforcement agencies and product developers) and providing interoperability between different systems in a unified environment. EuroDrone tested different concepts, technologies and architectures to promote the cooperation of the relevant stakeholders in a U-space environment. By using cloud software and hardware, the research experimented with U-space functionalities ranging from initial services to more advanced services such as automated DAA. A series of demonstration flights in Missolonghi, Greece, helped to identify the technology, architecture and user requirements necessary for U-space.

EuroDrone conducted highly automated unmanned flights using a cloud-based UTM system connected to a miniature, intelligent transponder processing board that is fully capable of flight mission planning. The tests used an innovative vehicle-to-infrastructure link, integrated to a self-learning UTM platform, with the capability to share flight information in real time. The flights demonstrated end-to-end UTM applications focusing on both visual and BVLOS logistics and emergency services. Among the main activities, the project identified key user needs and regulatory challenges, and compared the results with the ConOps. The findings were used to define a practical, automated cloud-based UTM system architecture, and to validate this architecture using simulation and live demonstrations.

In conclusion, the project demonstrated robust end-to-end UTM cloud operations, including BVLOS medical deliveries over 10 km in coordination with ATC and commercial operation. It also demonstrated innovative vehicle-to-infrastructure and vehicle-to-vehicle communications, equipped with operational DAA algorithms. The flights were able to demonstrate high levels of autonomy using cloud-based infrastructure, as is envisaged for an advanced UTM environment. The demonstrations took place over the sea, countryside and urban environments, and tested LTE communications links.

Vutura (validation of U-space by tests in urban and rural areas)

Drones will need to adhere to rules of the air to operate safely alongside manned aviation. This is especially important in urban environments. Demonstrations carried out by members of the

Vutura consortium looked at the new digital smart cities, and how unmanned vehicles can become a part of this interconnected world.

Vutura focused on four major goals: validating the use of shared airspace between existing, manned AUs and drones; validating more than one U-space service provider providing U-space services in a specific airspace and the procedures needed to support drone flights; ensuring alignment of regulation and standardisation between SESAR developments and U-space service providers; and increasing the pace at which European cities and companies exploit emerging technologies related to drones. The goal was to improve the quality of life in cities, create concrete socioeconomic outcomes and help European companies to take a leading position in the new smart city market.

The consortium conducted BVLOS demonstration flights involving multiple U-space service providers in rural, urban and smart city environments. Each scenario featured two service providers coordinating their services, and interoperability was a major focus. Manned aviation, different levels of automation, commercial and leisure drones and off-the-shelf drones as well as custom-made ones all featured in the scenarios. Information was shared, allowing all stakeholders to access the data via a web interface. In the tests, drones autonomously gave way to high-priority drones, for example medical deliveries, and the U-space service providers facilitated the drone traffic deconfliction using interoperable systems.

The work done by Vutura demonstrated that commercial drone traffic can safely co-exist with traditional air traffic in different kinds of environments and the technology to safely manage drone traffic is feasible, scalable and interoperable. It also flagged up areas in need of further research. This includes closer alignment of flight planning activity by U-space service providers and a set of procedures for cross-border flight planning; a common interface for exchanging information and acceptable transmission delay; and reliable DAA capability. Among its key findings, Vutura concluded that before the industry can move closer to supporting UAM, AUs need to be registered in order to share airspace, to be identifiable and to meet geofencing requirements.

GOF Uspace (Finnish–Estonian 'Gulf of Finland' very large U-space demonstration)

The safe operation of multiple drones in the same airspace relies on collaboration and data exchange between many different actors. A basic function of U-space is to bring situational awareness to all users and bridge the gap between manned and unmanned aviation by linking ATM information with unmanned traffic information, thus allowing operators and pilots access to common flight information. A flight information management system (FIMS) makes this possible by creating an interoperability architecture using standard protocols to exchange data.

The GOF Uspace partners established a pre-operational authority FIMS by creating an interoperability architecture for integrating existing solutions from three U-space service providers to showcase U-space in all phases of drone operations. Specifically, the GOF Uspace architecture enabled data exchange between two ANSPs (in Finland and Estonia), several U-space service providers, eight drone operators and two manned aircraft operators. The technology was demonstrated in seven flight trials during summer 2019 involving parcel deliveries, police operations, flights in dense urban airspace, forestry inspection BVLOS, airport operations, maritime search and rescue, and a manned taxi demonstration in Helsinki International Airport.

The GOF Uspace architecture integrated U-space service provider microservices and enabled collective and cooperative management of all drone traffic in the same geographical region. A microservice-oriented data exchange layer provided standard protocols to connect various U-space services from different service providers and the capabilities of service provision were demonstrated during the trials. Integration between FIMS and U-space service providers, between FIMS and FIMS, and between U-space service providers and ground control services was established, with a link to receive data from the ATM systems, demonstrating interoperability between systems.

The demonstrations showed commercial off-the-shelf UTM components to be fit for purpose to demonstrate all phases of drone operations with a focus on pre-flight and flight execution. The exercise proved that service providers and operators can connect to the open platform to access FIMS and ATM data, while noting the need for additional work to develop tracking solutions and improve resilience to poor mobile network coverage. The project demonstrated the need for single truth – where all AUs can access one source of reliable airspace and aeronautical information – and common standards for communication between systems.

In conclusion, 2020 was a very busy and successful year for these demonstration projects. Their findings, together with those of other SESAR 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 and, ultimately, full integration with manned aviation. Stakeholders in the CEF projects, such as DIODE, DOMUS, GOF U-space and SAFIR, are already working with the authorities in their countries to exploit solutions to deploy U-space. In addition, initial deployments that reflect the findings from these U-space projects are planned or are in execution in a number of states across Europe.

1.5.2.2. Grant management activities in relation with the entrusted tasks in 2020

In 2020, the SESAR JU signed eight amendments with U-space beneficiaries.

In 2019, the SESAR JU received three requests for amendments from beneficiaries. The signature of two amendments was postponed until 2020 because the beneficiaries were late in submitting the relevant documentation. These two amendments were related to:

- SESAR JU/LC/0340-GA DIODE action: request for a change in the consortium composition due to a partial succession of rights of one of the beneficiaries,
- SESAR JU/LC/0343-GA GOF Uspace action: request related to:

- a change in the consortium composition owing to the universal transfer of rights and obligations from one of the beneficiaries to a new entity, and
- the addition of two affiliates to another beneficiary.

Pursuant to Article II.23.2.1d of the delegation agreement regarding the conditions of submission of the financial statements accompanying the delivery of the final report, a consortium is obligated to provide a certificate on the financial statements, 'if: (i) the cumulative amount of payments the consortium requests as reimbursement of actual costs as referred to in Article 3(a)(i) (and for which no certificate has yet been submitted) is EUR 325 000 or more'.

After cross-checking against the original provisions in the CEF model grant agreement and carrying out a technical assessment of the impact of such a provision, it became evident that the EUR 325 000 threshold relates to the cumulative value of payments to the beneficiary, as per the CEF model grant agreement and the same practice under H2020, rather than to the consortium.

This provision was corrected in all U-space grant agreements before the closure of the projects to avoid beneficiaries unnecessarily requesting the services of external audit firms and incurring costs that would be disproportionate to the efforts of the beneficiaries.

1.5.2.3. Communication activities

In 2020, the SESAR JU raised the visibility of the U-space demonstrations through a range of activities and communications channels. These activities aimed to show how Europe and its industries are making progress with the integration of drones into the airspace in a safe and secure manner.

Under the umbrella of the SESAR Digital Academy, four webinars (Table 5) were organised to highlight the work being carried out under the programme (see also subparagraph 1.6.3.1, 'Events and conferences', below). The webinars provided an overview of the results of individual projects as well a consolidated view of the results of all work carried out under the programme.

TABLE 5 EVENTS ORGANISED IN RELATION TO U-SPACE PROJECTS IN 2020

Date	Topic	Number of participants
28 April 2020	U-space from concept to reality	898
28 April 2020	Taking up the U-space challenge	750
30 April 2020	Demonstrating U-space	858
12 November 2020	SESAR U-space consolidated results	468

In addition, in 2020, the SESAR JU published two reports on the results of the U-space projects: *Supporting safe and secure drone operations in Europe – A preliminary summary of SESAR U-space research and innovation results* and *Supporting safe and secure drone operations in Europe – Consolidated report on SESAR U-space research and innovation results*. Further detail on these publications can be found in subparagraph 1.6.3.2, 'Publications', below.

Finally, in 2020, the SESAR JU developed social and multimedia material to promote U-space, including:

- Twitter and LinkedIn posts:
  - https://twitter.com/SESAR_JU/status/1255773767550357504,
  - https://twitter.com/SESAR_JU/status/1326803352978677760,
  - https://www.linkedin.com/feed/update/urn:li:activity:6732587316193370112,
- video summarising project results: https://youtu.be/qQh5Ps-QpgE (Figure 20).

FIGURE 20 SCREENSHOT OF THE U-SPACE VIDEO SUMMARISING PROJECT RESULTS

1.5.2.4. Expenditures incurred in 2020 under this delegation agreement

Budget

According to the delegation agreement, the maximum EU contribution to the implementation of the entrusted task is EUR 10 000 000. The EU contribution shall:

- reimburse expenditure incurred in the implementation of the entrusted tasks and accepted by the Commission;
- remunerate the SESAR JU for the implementation of the entrusted tasks.

The remuneration of the SESAR JU shall be up to 5 % of the final amount of the EU contribution.

Budget implementation – revenues

The SESAR JU had received a first pre-financing of EUR 4 000 000 in December 2017. A second pre-financing (final payment) of EUR 6 000 000 was submitted and paid to the SESAR JU in January 2020.

Budget implementation – expenditure

The abovementioned budget was implemented through commitments and payments from 2018 to 2020. As this report is the last implementation report on the delegation agreement, this subparagraph provides a comprehensive view of the budget implementation operations carried out over that period.

2018

In 2018, external experts evaluated the proposals. The SESAR JU made related payments of EUR 14 207.55.

Following the award decision, during 2018, six commitments for a total value of EUR 9 402 331.74 were created and five payments relating to pre-financing requests were executed, amounting to EUR 2 000 583.43 in total.

2019

The SESAR JU executed five payments relating to second pre-financing requests and completed one payment relating to a first pre-financing request. The total value of the second pre-financing payments for projects in 2019 amounted to EUR 1 092 388.87.

In addition, in 2019, the SESAR JU made a payment of EUR 284.94 related to the U-space blueprint.

Finally, the SESAR JU committed EUR 65 272 for a U-space video and for a U-space virtual-augmented reality (VR) experience.

2020

The SESAR JU executed the final payments for the six projects and two payments related to the completion of the U-space video, VR experience and brochure. The total value of the payments in 2020 amounted to EUR 4 398 317.96, covering the final payments to the grant beneficiaries and the payment for communication activities.

Following the final payments, outstanding appropriations of EUR 1 977 099.40 were decommitted.

Table 6 presents the cumulated budget implementation figures (commitments, total payments and resulting decommitments) at the end of 2020.

TABLE 6 **CUMULATED BUDGET IMPLEMENTATION IN RELATION WITH THE DELEGATION AGREEMENT AT THE END OF 2020**

Local key	User reference	Committed amount (in 2018 and 2019)	Consumed amount (payments in 2018, 2019 and 2020)	Decommitted amount (in 2020)
SES.2779	USPACE GA CEF-SESAR-2018-1 GOF USPACE SESAR JU/LC/0343-CTR	1 617 098.00	1 109 992.80	507 105.20
SES.2780	USPACE GA CEF-SESAR-2018-1 SAFIR USPACE SESAR JU/ LC/0344-CTR	1 328 441.00	1 328 441.00	–
SES.2781	USPACE GA CEF-SESAR-2018-1 DIODE USPACE SESAR JU/ LC/0340-CTR	1 978 443.00	1 092 247.78	886 195.22
SES.2783	USPACE GA CEF-SESAR-2018-1 DOMUS USPACE SESAR JU/ LC/0341-CTR	1 989 400.21	1 826 909.97	162 490.24
SES.2785	USPACE GA CEF-SESAR-2018-1 EURODRONE USPACE SESAR JU/ LC/0342-CTR	1 400 000.00	1 284 187.48	115 812.52
SES.2786	USPACE GA CEF-SESAR-2018-1 VUTURA USPACE SESAR JU/ LC/0345-CTR	1 088 949.53	783 453.31	305 496.22
SES.2760	EXPERTS CALL EVALUATION U-SPACE	14 207.55	14 207.55	–
SES.2869	USPACE VIDEO & VR	65 272.00	65 272.00	–
SES.2805	USPACE BLUEPRINT & BROCHURE	1 070.86	1 070.86	–
Total		**9 482 882.15**	**7 505 782.75**	**1 977 099.40**

The aforementioned commitments and payments were done following standard SESAR JU procedures, fully in line with the SESAR JU financial rules.

1.5.2.5. Audit activities

Following the completion of the activities implementing this delegation agreement in 2020 and the related final payments carried out during the second half of 2020, the project *ex post* audits will take place during 2021.

1.5.2.6. Next steps

The projects delivered their final study reports and related technical appendices by the end of February 2020 and were closed in March 2020.

Nevertheless, there is still much to be done. The findings have made it clear that, although much has been achieved over the past two years, more work is needed on developing and validating drone capabilities and U-space services to ensure safe and secure drone operations. For the U3 concept to be realised, complex issues, which these SESAR JU projects have started to address, need to be resolved, including DAA, command and control (C2) link, geoawareness, contingency procedures and dynamic interface with ATM.

These issues must continue to be addressed in cooperation with international partners, including the ICAO, and the traditional manned aviation community, whose operations are affected by the rapid appearance of drones.

In addition, the scope of the U-space projects needs to be widened to include UAM operations, extension of U-space services beyond the VLL limit, U-space interoperability with ATM, including the development of a collaborative decision-making process between urban operations, ATM and city authorities, higher levels of automation, including ML and AI, and fundamental aviation tenets, such as airspace classification and the rules of the air.

Further demonstration activities dedicated to U-space and UAM are planned by the SESAR JU in preparation for the future Digital European Sky. These activities will address the R & I needs identified by the CEF projects.

1.6. Strategic area of operation 5: delivery of SESAR Outreach

The SESAR JU met all its objectives related to SESAR Outreach in 2020, as set out in Paragraph III of the SPD 2020–2022. This includes the following achievements and results.

- Strengthen global interoperability activities aligned with the European Commission's expectations, especially towards the ICAO, in close collaboration with the US Federal Aviation Administration (FAA)/NextGen and other ATM modernisation initiatives. Activities were carried out in accordance with the plan. The SESAR JU participated in ICAO groups on drones and iCNSS and reprioritised activities under the EU–US MoC;
- Strengthen links with standards-making organisations such as Eurocae and RTCA, with the involvement of SESAR JU members and make available SESAR material in support of standardisation. Liaison with standardisation bodies took place in accordance with the plan.
- Strengthen dissemination of SESAR Solutions / demonstrations / ER activities and results through SESAR publications, workshops and communications events. Dissemination activities were carried out in accordance with plan. The cancellation of major events (e.g. the World ATM Congress, the Berlin Air Show) due to COVID-19 was compensated by investment in extensive online events (Digital Academy webinars, Digital Sky vodcasts).
- Active cooperative arrangements with all European (Member States and regions), international actors and other modernisation initiatives in aviation relating to SESAR definition and development phases. The cooperation activities took place in accordance with the plan.

SESAR Outreach plays an integral role in engaging with the wider aviation community and informing them about the SESAR JU's work and results. The Outreach also encourages wider international commitment to the SESAR approach to ATM modernisation, and contributes to maintaining the momentum around SESAR R & I.

For 2020, the following key messages were the focus of the SESAR JU's outreach activities:

- the unique SESAR JU public–private partnership is delivering solutions that drive aviation performance, in support of EU transport and mobility policy objectives;
- the SESAR JU model pools resources and expertise from Europe's aviation community and beyond to deliver efficient and value-for-money R & I;
- embracing new trends and opportunities through cutting-edge R & I is a prerequisite for maintaining Europe's global leadership and competitiveness in aviation.

1.6.1. Cooperation with third countries and international organisations

The SESAR JU's strategy for cooperation with third countries and/or international organisations, pursued in the framework of the EU Aviation Strategy and in close coordination with the European Commission, aims to secure SESAR's position as a global leader in ATM modernisation in support of the ICAO's global air navigation plan (GANP), promoting SESAR Solutions for global interoperability and harmonisation, and

thereby supporting EU industrial leadership and competitiveness. The SESAR JU's ability to pursue these objectives during 2020 was badly affected by the situation created by the COVID-19 pandemic, which resulted in many countries, as well as the ICAO, focusing attention on addressing the crisis affecting aviation and the essential task of promoting recovery. International travel was effectively stopped from March 2020 and, therefore, the SESAR JU's engagement with international partners was severely curtailed.

It was originally expected that 2020 would see the commencement of work to follow up on discussions at the 40th ICAO Assembly through ICAO's newly created GANP Study Group, of which the SESAR JU is a member, but in the event the group's work was postponed until 2021. The SESAR JU did remain actively involved in supporting the ICAO in a number of areas. The SESAR JU actively participated in the ICAO UAS Advisory Group, helped to organise ICAO's annual Drone Enable event and contributed significantly to the development of the ICAO's UAS Framework Document, building on experience gained in SESAR U-space projects, as well as participating in the ICAO UAS Flight Rules Task Force, led by the International Air Transport Association (IATA). The SESAR JU also participated in the newly created ICAO Integrated Communications, Navigation, Surveillance and Spectrum Task Force, which aims to evolve the CNS systems roadmap and frequency spectrum access strategy in a performance-based and service-oriented manner.

The SESAR JU also contributed to ICAO's technical work, through its Committee on Aviation Environmental Protection (CAEP), on the exploration of the feasibility of a long-term global aspirational goal for international civil aviation CO_2 emissions reductions. The European Commission nominated the SESAR JU to act as co-lead of the operations subgroup of CAEP's Long-Term Aspirational Goal Task Group, and this work focused during 2020 on collecting the relevant information on operational measures that may contribute in the short, medium and long terms to reductions in CO_2 emissions from international aviation, including those being developed through the SESAR innovation pipeline.

The SESAR JU's cooperation with the US FAA and its NextGen programme, under the EU–US MoC on Air Traffic Management Modernisation, Civil Aviation Research and Development, and Global IOP, was effectively on hold during 2020 pending a review of activities and priorities to be undertaken by the MoC's Executive Committee, co-chaired by European Commission and FAA. The SESAR JU worked with its counterparts in the FAA to

develop proposals for future focus areas, and it is expected that these will be considered by the Executive Committee in early 2021.

Other bilateral contacts with international partners during 2020 were limited as a result of the pandemic situation, as mentioned above. Detailed and highly constructive discussions took place with the Civil Aviation Authority of Singapore (CAAS) in February 2020 on possible future areas of research cooperation under the MoC between the SESAR JU and CAAS. However, these discussions were put on hold for the remainder of the year.

The SESAR JU participated in a limited number of international events during 2020, including the iCNS conference, which took pace online in October, and the ICAO Global Symposium on the Implementation of Innovation in Aviation in December.

1.6.2. Stakeholder engagement

1.6.2.1. European Union Aviation Safety Agency

Cooperation and coordination between the EASA and the SESAR JU under the MoC signed in 2016 was strengthened in 2020. As a result of close cooperation between the two organisations, the European ATM Master Plan and the European Aviation Safety Plan, which are the focus of the activities of the SESAR JU and the EASA, respectively, were brought into alignment.

The coordination on drone/U-space activities was also fully achieved by issuing the report of the consolidated SESAR U-space R & I results.

In order to further deepen the cooperation at technical level, the EASA and the SESAR JU worked on establishing an interinstitutional service-level agreement (SLA) between the two agencies, with implementation expected in 2021.

1.6.2.2. European Defence Agency

In Europe, military aviation encompasses hundreds of military areas and dozens of military airfields. An estimated 30 % of military flights adhere to GAT rules, while the remainder operate as operational air traffic. Military flights are carried out for a wide variety of reasons, including as training exercises, to ensure homeland security (including sovereignty missions) and for the management of cross-border crises management operations. Such missions often require immediate access to airspace, as they are frequently launched at short notice. This means that, by default, military use of airspace is immediate and unpredictable, necessitating dynamic ATM arrangements if efficient military operations are to be secured without a negative impact on the efficient overall flow of air traffic. For this reason, widespread military involvement in SESAR Solutions has been, and still is, paramount to enable that effective military missions and airspace use can be integrated with other uses of airspace across Europe.

The SESAR JU and the EDA have been engaged in close dialogue since 2011, and this relationship continued in 2019, especially on military matters and inputs to the SESAR

research and innovation programme. The EDA now serves as the main interface between SESAR 2020 and SESAR JU activities and military aviation and ATM and it responsible for coordinating military views with regard to the Single European Sky and SESAR.

The cooperation under the MoC in 2019 focused on securing military inputs into the update of the European ATM Master Plan as well as technical advice on project evaluations and the SESAR programme in general. In particular, the SESAR JU has harmonised its RPAS research programme with that of the EDA to reduce duplication and to benefit from military efforts in this domain. During project execution, the SESAR JU participates in reviews, discussions and events relating to EDA RPAS activities, and EDA reciprocates in SESAR ER and IR projects, notably PJ.13. This cooperation supports a harmonised approach to RPAS standardisation and operational integration.

1.6.2.3. SESAR Deployment Manager (SESAR DM)

During 2020, collaboration under the 2015 memorandum of understanding (MoU) between the SESAR JU and SESAR DM continued with regular meetings.

1.6.2.4. Standards-making organisations

Collaboration between the SESAR JU and the standard-making organisations is part of the mitigation of risks recognised in the coordination of the ATM Master Plan.

1.6.2.4.1. Eurocae

The SESAR JU continued to ensure ongoing alignment between SESAR work and proposed standards developments and the Eurocae working arrangements and planning through its active participation in the Eurocae Council and Technical Advisory Committee, and under the terms of the 2012 MoC between the SESAR JU and Eurocae. This included specifically drafting parts of the Eurocae Technical Work Programme to ensure alignment with SESAR planning and needs.

During 2020, SESAR deliverables were made available to several Eurocae working groups to support the development of standards relating to several key areas of the SESAR 2020 programme and the SESAR JU also coordinated with the equivalent special committees of the RTCA.

Eurocae published standards in 2020 with contributions from and of direct relevance to SESAR Solutions.

1.6.2.4.2. The European Air Traffic Management Standards Coordination Group

In 2020, the SESAR JU continued as an active participant in the European Air Traffic Management Standards Coordination Group (EASCG), with the objectives of coordinating standardisation activities, identifying their links with the R & I activities and providing a forum for discussion. The SESAR standardisation roadmap is a major input into the European ATM Standardisation Rolling Development Plan, and not only provides the reference for ATM standardisation needs in European (including SESAR specific needs),

but also serves as the basis for the European input into both the process and content of the ICAO standardisation roadmap development.

1.6.2.4.3. The European UAS Standards Coordination Group

In 2020, the SESAR JU continued as an active participant in the European UAS Standards Coordination Group, with the objective of coordinating UAS-related standardisation activities and needs.

1.6.2.5. Civil airspace users

Civil AUs comprise a wide range of undertakings and carry out a wide spectrum of activities, including scheduled and charter flights, cargo flights, business and general flights and rotorcraft operations.

AUs are directly integrated within the programme through four framework contracts and related specific contracts reflecting the specific interests and skills of different categories of AUs (lot 1, European scheduled airlines; lot 2, global airlines; lot 3, business aviation; and lot 4, general aviation and rotorcrafts). Their expertise is recognised as key to the overall success of SESAR 2020 activities.

In 2020, despite the COVID-19 crisis, the AUs supported the SESAR JU in the monitoring and steering of SESAR 2020 projects, using their substantial expertise to review and comment on solution projects' deliverables through the delivery of technical analyses, priority analyses and gap analyses, participation in maturity gate meetings and validation exercises and the provision of technical advice. AUs' input played a key role in assuring robust assessment of the quality of SESAR Solutions and the benefits expected from their implementation. AU support to the programme was particularly important in 2020, as AUs contributed to the preparation of the SRIA by reviewing the document and contributing to dedicated workshops with the PJ.20 project team.

1.6.2.6. Professional staff organisations

In 2019, the SESAR JU collaborated, under a new framework contract, governing new specific contracts, with the following PSOs: the International Federation of Air Traffic Controllers' Associations (IFATCA), the European Cockpit Association, the International Federation of Air Traffic Safety Electronics Associations (IFATSEA), the European Transport Workers' Federation (ETF) and the Air Traffic Controllers European Union Coordination (ATCEUC).

In 2020, PSOs continued to provide expertise and direct support to the SESAR JU, and thereby the SESAR 2020 programme, with a large number of licensed and operational controllers, pilots and engineers of all nationalities providing relevant and cross-border operational and technical knowledge of direct relevance to the successful delivery of SESAR results and solutions.

In 2020, four quarterly coordination meetings were held to coordinate activities, with priorities defined in a work programme agreed between the SESAR JU and the PSOs in relation to ATM modernisation. Although engagement was affected by the COVID-19 crisis and the immaturity of SESAR 2020 Wave 2 projects, the PSOs provided direct support to specific research programmes and virtual events. Of particular note was the continued detailed contribution by the PSOs in the complex remote tower research, which is of particular concern to the PSOs, and participation in RPAS projects. This fruitful cooperation has been of immense value to both the PSOs and the SESAR programme, and is set to grow as Wave 2 projects start to conduct their validation activities.

1.6.2.7. Airports Council International Europe

Recognising the need for further airport integration, the SESAR JU works closely with Airports Council International (ACI) Europe to raise awareness of SESAR among its airport partners, which include airport operators beyond those represented the SESAR European Airports Consortium (SEAC 2020).

In 2020, the close cooperation between ACI Europe and the SESAR JU continued, in the form of an efficient and constructive relationship, exemplified by a new specific contract implementing the framework contract established in 2016. Through this contract, the following main activities were performed.

- ACI Europe carried out a study to assess the current state of implementation of the delivered (i.e. V3 mature) SESAR solutions at European airports. Despite the severe impact of the COVID-19 pandemic on the European airports, the study results showed relatively good uptake of the available SESAR solutions. The study also highlighted the need to better explain the solutions and their benefits to the airport community, adapting the message and communication approach to the targeted airport categories.
- ACI Europe supported the SESAR JU in the following communication activities.
  - Several SESAR-related news items and three articles were published in ACI Europe's newsletters and magazine.
  - SESAR JU communication campaigns relevant to airports were promoted on ACI Europe's social media accounts.
  - As the co-organiser of the 2019 Digital Sky Challenge, ACI Europe participated in the SESAR Academy webinar 'Nurturing young talent: look back to the Digital Sky Challenge' in June 2020.
  - Jost Lammers, ACI Europe's President and the chief executive officer of Munich Airport, participated in the SESAR Digital Sky vodcast 'How can ATM innovation help airlines and airports in the recovery?' in July 2020.
  - A SESAR JU-sponsored Digital Transformation Award was presented to Istanbul Airport at ACI Europe's 30th Annual Congress & Assembly, recognising Istanbul Airport's digitalisation strategy and uptake of a wide range of SESAR Solutions.
  - In November 2020, the SESAR JU took part in a panel at the ACI Europe Annual Assembly & Congress in a working session entitled 'Build back better: decarbonisation and sustainability. This was an opportunity for the SESAR JU to highlight the important role of redefining airspace organisation in relation to trajectories as well as to traffic flow, and to refine procedures to focus on sustainability.
- ACI EuropeE, in close coordination with the SESAR JU, developed an augmented reality-based airport gaming tool that can be used by both organisations to promote SESAR innovations for airports at organisation events. As such events could not take place in 2020 because of the COVID-19 pandemic, a web-based version of this tool was also developed (see https://www.sesarju.eu/sesar-gaming-tool).
- ACI Europe, under the leadership and guidance of the SESAR JU, delivered a project management plan describing the steps to be taken in order to organise a new Digital Sky Challenge. Again, because of the restrictions on travel anedevents resulting from the COVID-19 pandemic, this new edition was planned as an online/virtual event.

1.6.2.8. National authorities

In 2020, despite the COVID-19 crisis, the SESAR JU continued cooperation arrangements with national supervisory authorities (NSAs). The main objective of the cooperation with NSAs is to secure their early involvement in the definition and development activities to minimise the risks inherent to the transition between SESAR development and deployment activities.

Under a bilateral MoC signed with the SESAR JU in 2017, each of the 16 NSAs had the opportunity to attend bilateral meetings on a quarterly basis in order to discuss in detail the main activities for inclusion in an agreed work plan. The main areas of interest to NSAs were the steps needed to establish the future SESAR 3 JU, U-space activities and the overview of key 2021 validation and demonstration projects in SESAR 2020.

In addition to the quarterly meetings with all NSAs, the SESAR JU conducted only one bilateral meeting in February due to the

pandemic restrictions with the Bulgarian NSA accompanied by the national ANSP to provide an update on SESAR and strengthen the cooperation.

1.6.2.9. European Network Manager

Network Manager nominated by the European Commission

During 2020, the SESAR JU participated in the European Continuous Climb Operations / Continuous Descent Operations (CDO/CCO) NM Task Force. The SESAR JU facilitated presentations of SESAR projects to the task force. The presentations showed the potential of relevant mature SESAR Solutions to improve vertical profiles, as well as the relevance of ongoing related research. In addition, the SESAR JU actively participated in the development of the European CDO/CCO Action Plan, including in particular the inclusion of mature SESAR Solutions with the potential to provide benefits in this area. The SESAR JU also took a leading role in the drafting of the 'Future Developments' appendix of the Action Plan, which lays out the challenges in the area of vertical flight profile optimisation that are currently being addressed by R & I or will need to be addressed by R & I in the future. The European CDO/CCO Action Plan was published in November 2020, and is now the European CDO/CCO reference.

1.6.2.10. Space

1.6.2.10.1. European Space Agency

The European ATM Master Plan clearly identifies the need for space-based positioning for navigation and communication services in support of time-based and trajectory-based operations, as well as for improved operations at less well-equipped airports or airports with differently equipped vehicles.

Within the context of an MoC signed between the ESA and the SESAR JU in 2016, coordination between the two organisations has progressed well, particularly in relation to ESA/Inmarsat Iris activities and SESAR JU project PJ.14 on satellite communications. This activity allowed the development of a shared view on the value chain and interdependencies between the programmes. Ultimately, this coordination with ESA and the finalisation of the Iris system are key to enabling 4D operations worldwide.

1.6.2.10.2. European GNSS Agency

European Global Navigation Satellite Systems Agency

Informal coordination with GSA continued during 2019. This included in-depth coordination in the context of the update of the European ATM Master Plan, in particular to highlight the role of EGNOS and Galileo in the future multifrequency, multiconstellation GNSS.

1.6.2.11. Clean Sky 2 Joint Undertaking

Clean Sky 2 JOINT UNDERTAKING

In 2019, cooperative arrangements with the Clean Sky 2 Joint Undertaking (the Clean Sky 2 JU) [31] continued under the MoC signed in December 2015. Cooperation in 2019 focused on identifying synergies and complementarities in the two organisations' programmes.

[31] Council Regulation (EU) No 558/2014 of 6 May 2014 establishing the Clean Sky 2 Joint Undertaking (OJ L 169, 7.6.2014, p. 77).

1.6.2.12. Communications, Navigation and Surveillance Advisory Group

The high-level group on SES implementation agreed principles and provided guidelines for an optimal CNS infrastructure implementation. It subsequently established a CNS Advisory Group to develop recommendations to ensure the best possible organisation, management and implementation of a CNS infrastructure based on these principles.

The CNS Advisory Group started its work in June 2020, under the chairmanship of the European Commission. SESAR JU subject matter experts contributed to this CNS Advisory Group by bringing an R & I perspective.

The approach has been to further develop the conclusions of the CNS symposium organised by EUROCONTROL in October 2018 by identifying key issues and assessing their root causes, the interdependencies among them and their consequences. Based on this work and the lessons learned from the current CNS context, the group is proposing a set of recommendations and concrete actions to take them forward. This work is still in progress.

1.6.3. Communications

1.6.3.1. Events and conferences

Over the course of 2020, the SESAR JU events schedule was impacted by the COVID-19 social distancing restrictions, with the result that the majority of events in which the SESAR JU had intended to participate were cancelled or postponed until 2021. Despite these challenges, the SEAR JU maintained visibility by providing a speaker at over 20 online events and/or conferences.

SESAR Digital Academy webinar series

In order to maximise visibility and outreach in 2020, the SESAR JU organised a series of technical webinars aiming to provide an overview of SESAR 2020 achievements and provide a flavour of concrete benefits that ATM modernisation is starting to bring to the entire aviation ecosystem and exploring what still needs to be done and, in particular, how technology can bring about fundamental changes to the way we manage air traffic in European airspace.

Over the course of the year, 18 webinars, each lasting 90 minutes, were held under the banner of the SESAR Digital Academy. A number of key stakeholders and partners were invited to present their success stories, and the webinars were moderated by SESAR JU ATM experts. The webinars attracted, on average, over 400 participants, amounting to a global audience of over 3 700 participants throughout the course of the year.

The webinars featured content from SESAR projects and related ATM context. Each webinar included three or four technical presentations followed by a moderated Q & A session; in addition, effort was made to facilitate interaction with the audience by providing a fully transparent live chat facility throughout each webinar; all questions and answers were made visible to the live audience. The webinar format has made the content of the SESAR programme accessible to the European public in a way that had never been possible before. After each webinar, all material, (presentations, a webinar replay link and full live Q & A file) was made available online, constituting a permanent and invaluable educational online resource library for the future.

A summary of the webinars and playback links is provided in Table 7.

TABLE 7 WEBINARS HELD BY THE SESAR JU IN 2020

Title	Date	More info	Replay
Smart and sustainable solutions for greener ATM – en route	14/12/2020	More info	Replay
Smart and sustainable solutions for greener ATM – Greener arrivals and departures	4/12/2020	More info	Replay
Smart and sustainable solutions for Greener ATM – Airport domain	19/11/2020	More info	Replay
SESAR U-space consolidated research results	12/11/2020	More info	Replay
Exploring the future vision and technological innovations in CNS	22/10/2020	More info	Replay
A holistic approach towards CNS	6/10/2020	More info	Replay
Virtualisation – Virtual Centre	29/09/2020	More info	Replay
Virtualisation - Remote Towers	15/09/2020	More info	Replay
Artificial Intelligence (part 2)	24/07/2020	More info	Replay
Artificial Intelligence (part 1) 22/07/2020		More info	Replay
European ATM Master Plan in a nutshell	30/06/2020	More info	Replay
Recognising excellence with the SESAR Young Scientist Award	29/06/2020	More info	Replay
Nurturing young talent: Look back at the Digital Sky Challenge	30/06/2020	More info	Replay
Exploring the boundaries of ATM: ATM & CNS	23/06/2020	More info	Replay
Exploring the boundaries of ATM: Enabling trajectory-based operations	15/06/2020	More info	Replay
U-space: From concept to reality	28/04/2020	More info	Replay
Taking up the U-space challenge	28/04/2020	More info	Replay
Demonstrating U-space	30/04/2020	More info	Replay

SESAR vodcasts

There can be no denying that the COVID-19 pandemic has changed aviation fundamentally. To date, the focus has been on surviving the crisis and the sudden plunge in traffic. However, as the situation stabilises it is time to turn to thinking through the deeper implications for European aviation. The SESAR Joint Undertaking is committed to driving that conversation and over the course of 2020 convened a series of senior leaders of the industry to discuss these issues in the format of vodcasts.

The vodcasts were extremely popular, attracting an average of 360 participants.

An overview of these conversations can be found below:

- **Vodcast 1: Is COVID-19 a game changer for ATM?** The first vodcast brought together the Director-General for Transport, Henrik Hololei, and the Director-General of EUROCONTROL, Eamonn Brennan, to discuss with the Executive Director of the

SESAR JU the top-level implications of the pandemic on European aviation and ATM in particular. The discussion identified a number of key themes and signposts for the way forward.

- **Vodcast 2: How can ATM innovation help to reboot aviation sustainably?** This vodcast brought together Marylin Bastin, Head of Aviation Sustainability at EUROCONTROL and Marc Hamy, Vice President, Corporate Affairs, Sustainability and the Environment, of Airbus, to discuss with Florian Guillermet, Executive Director of the SESAR JU, the issue of sustainable aviation and the role that ATM can play. Given the COVID-19 crisis, is sustainability still an issue? Does the downturn give the ATM industry time to regroup and reconsider its obligations to sustainability?
- **Vodcast 3: How will digital transformation build resilience in ATM?** This vodcast brought together Klaus Meier, Chief Technology Officer, Skyguide, Ramon Tarrech, ATM Strategy Development Director, Indra, and Marc Baumgartner, SESAR Coordinator, IFATCA, to discuss with Florian Guillermet, Executive Director of the SESAR JU, the issue of digital transformation in ATM for a more resilient aviation.
- **Vodcast 4: How can ATM innovation help airlines and airports in the recover?** This vodcast brought together Jost Lammers, Chief Executive Officer, Munich Airport, and President of ACI Europe, and Alain-Hervé Bernard, Chief Operating Officer, Air France, to discuss with Florian Guillermet, Executive Director of the SESAR JU, the issue of digital transformation in ATM and how it can help airlines and airports in the recovery.
- **Vodcast 5: Deploying in a time of COVID.** This vodcast turned its attention to how the pandemic has changed what we are doing in ATM and, more importantly, what we need to deploy in the new normal. Tanja Grobotek, Director Europe Affairs, Civil Air Navigation Services Organisation, and Nicolas Warinsko, General Manager, SESAR Deployment Manager, joined Florian Guillermet, the Executive Director of the SESAR JU, to discuss the issues of most concern.
- **Vodcast 6: The economics ATM post COVID.** The COVID pandemic is having an unparalleled economic impact on ATM, calling into question the viability of the business model and the long-term sustainability of the industry. On 10 November, Brian Pearce, Chief Economist, IATA, and Adriaan Heerbaart, Director Central Route Charges Office (CRCO) and Finance, joined Florian Guillermet, the Executive Director of the SESAR JU, to explore how making ATM more resilient and scalable could open up opportunities for more sustainable and flexible service provision.

- **Vodcast 7: Building a better future.** A green and technologically positive recovery for aviation is non-negotiable. That was core message from guests during the Digital Sky Vodcast on 17 November. Moderated by Andrew Charlton, Managing Director of Aviation Advocacy, participants Grazia Vittadini, Chief Technology Officer, Airbus, Patrick Ky, Executive Director, EASA, and Florian Guillermet, Executive Director, SESAR JU, discussed what needs to be done to build back better in order to make aviation climate neutral for the generations to come.

Engage SESAR Summer School 2020

The second Engage SESAR Summer School took place between 21 and 25 September as a virtual event (more about the Engage project can be found in paragraph 1.2.1, 'Contributions from the transversal steering projects'). Among the participants were 10 Engage-funded PhD students, as well as two EUROCONTROL-funded PhD students, each of whom presented their PhD topic and the findings obtained thus far. A large number of applications were received from not only European countries, but also the USA, China and Vietnam. The virtual format enabled all applicants to be accommodated, and as a result 86 participants from 18 countries were able to take part in the summer school, more than double the number in 2019. This led to a nicely sized and structured final group of participants with varied backgrounds but having in common a strong interest in ATM. Over five days, industry experts gave seven presentations and five tutorials aligned with the needs of or requests from Engage PhD students. Lecturers included SESAR JU experts, who provided a SESAR programmatic perspective on how the academic topics of cybersecurity and tactical versus strategic ATC link to the Master Plan vision and policy objectives. The event achieved the objective of establishing a forum for the exchange of ideas between industry and academia, thereby fulfilling an educational purpose as well as supporting the uptake of academic research by the ATM industry. The lecture materials have been made publicly available on the Engage website (https://engagektn.com/summer-school-2020/) and constitute a valuable educational resource for the future.

AeroDays, 25–26 November 2021

The SESAR JU was proud to be part of the 2020 European Aeronautics Days (#AeroDays2020), the leading event in aviation R & I.

The event adapted to the COVID-19 situation by adopting a hybrid format: an on-site programme, with speakers on stage in Berlin, was combined with an online offering, via a streaming platform, for virtual participants. The aim of the event was to explore the future of aviation and the implementation of EU policy priorities, such as the European Green Deal, with leading representatives from the aviation industry and research community.

On 26 November, the SESAR JU organised a panel event looking at digital solutions for automated ATM. The panel, which was moderated by Peter Hotham, SESAR JU's Deputy Executive Director, comprised a selection of SESAR JU members and partners:

- Helmut Többen, Director, AT-One, and Head of Management Services, DLR,
- Michael Holzbauer, Director European Affairs, Frequentis,
- Olivier Delain, R & I Unit Manager, Group ADP–DOAA,
- Koen Meuleman, Regulatory Affairs Officer, Unifly,
- Jan-Christian Schraven, Senior Director, Business Development, Swiss International Air Lines
- Csaba Gergely, Senior ATM Advisor, Hungarocontrol.

Panel members showcased their SESAR success stories, in increasing connectivity and mobility, advancing the digitalisation and virtualisation of ATM, enabling greener aviation and ensuring the safe integration of new types of aircraft, in particular unmanned aircraft.

The SESAR JU was also part of the #Aerodays2020 virtual exhibition, which allowed participants to connect virtually with SESAR JU representatives to learn about our latest achievements and upcoming activities.

SESAR Innovation Days, 7–10 December, virtual

SESAR Innovation Days are the main vehicle for the SESAR JU to share progress and disseminate the results of its exploratory research programme. Unlike other scientific events in ATM research, SESAR Innovation Days focus explicitly on long-term and innovative research.

The 10th edition of SESAR Innovation Days took place between 7 and 10 December 2020, but, sadly, because of COVID-19 and its impact on travel and gatherings, it was necessary to move the event to a virtual format.

As in other years, scientific papers and presentations shaped the 2020 event. These papers were selected from the responses to an open call for contributions published in May 2020 on the SESAR Innovation Days website, and promoted through emails, SESAR newsletters and the Engage website. The selection process was managed by the Engage network, which was selected as part of the third SESAR 2020 ER call in order to inspire new researchers and help to facilitate the transfer of results of fundamental and applied research to industrial research.

Contributions were reviewed by the Programme Committee, including members of the SESAR Scientific Committee and the SESAR JU. In total, 30 papers (out of 48 contributions, an acceptance rate of 62 %) and 21 posters (out of 23 contributions) were selected, which is in line with the previous editions. Attendees, numbering 1060 in total, came mainly from European research and development centres and universities, but also included international guests and Programme Committee members). No more than 400 participants attended at any one time. Participation was consistently greater in the technical sessions than in the plenary sessions, with participation gradually decreasing between the first and last days.

In addition, 750 people downloaded and used the event app, an average of 250+ participants attended the technical sessions (with a peak of 370) and an average of 120 participants attended the virtual networking and the virtual social activities.

The Global Panel on Higher Airspace Operations was attended by 444 participants and rated positively by SESAR Innovation Days participants. Organised together with the ICAO and ATCA, this event attracted a wealth of excellent speakers from both sides of the Atlantic; a similar panel could not easily have been organised as a physical event at the SESAR Innovation Days. This illustrates one of the benefits of on-line conferencing.

Keynote speeches, plenary talks and discussion panel took place in plenary sessions, while technical sessions were conducted in parallel.

All relevant information including the call for papers, submission instructions and, at a later stage, programme and conference registration were available via the SESAR Innovation Days website. All posters and papers are available for download from the website, together with the presentations. As reported above, a dedicated smartphone app was also available. This included relevant information and allowed users to comment and engage in dialogue, and in this edition was the primary way for attendees to contact each other.

During the closing remarks, the SESAR JU ED announced the 2021 edition of SESAR Innovation Days, which, if the COVID-19 pandemic allows, will be held in Budapest.

All content was recorded, ensuring that the presented material has a longer 'shelf life', and creating valuable online content for the SESAR Digital Academy. The material can be found at https://www.sesarju.eu/node/3556

More information about content of SESAR Innovation Days and the benefits they bring is provided in subparagraph 1.3.4.1, 'SESAR Innovation Days'.

1.6.3.2. Publications

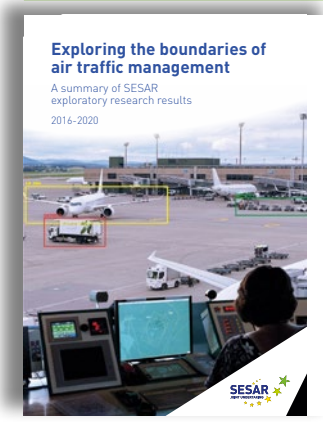
A number of documents were published throughout the year (Table 8) and were promoted on online channels and at key events.

TABLE 8 KEY PUBLICATIONS OF THE SESAR JU IN 2020

Supporting safe and secure drone operations in Europe: a preliminary summary of SESAR U-space research and innovation results

Over the two-year period from the end of 2017 to the end of 2019, SESAR JU and its partners completed 19 research and demonstration projects addressing a wide range of topics, including ConOps for drone operations, critical communications, surveillance and tracking, and information management to aircraft systems, ground-based technologies, cyber-resilience and geofencing. The results of these projects are summarised in this brochure and will be fully detailed in a comprehensive report due for publication in the second half of 2020.

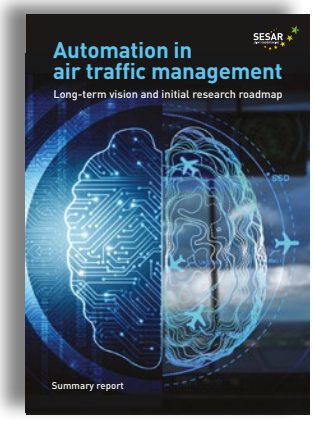
View publication



Exploring the boundaries of air traffic management: a summary of SESAR exploratory research results

This brochure summarises the results of 36 completed ER projects that investigated innovations and technologies coming out of not just aviation and ATM, but also other sectors, such as the automotive, robotics and system engineering sectors, as well as other safety-critical industries, such as the nuclear and space industries. The projects brought together over 100 academic and industry partners, including universities, SMEs, research centres, airlines, manufacturers and ANSPs from across the EU and EU Associated Countries.

View publication



Automation in air traffic management: long-term vision and initial research roadmap

Higher levels of automation to reduce ATCO workload and stress is key to a futureproofed ATM system. This publication summarises a report by the SESAR 2020 Scientific Committee Automation Task Force, detailing a long-term vision and research roadmap for automation in ATM, as a basis for the definition and coordination of future research activities.

View publication

Supporting safe and secure drone operations in Europe: consolidated report on SESAR U-space research and innovation results

The report consolidates the findings from 19 SESAR research and demonstrations projects, including an analysis of the coverage and level of maturity of each U-space service, and identifies areas requiring further research. The consolidated findings from SESAR JU research activities support the definition of required standards, protocols and regulations. 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.

View publication

Strategic Research and Innovation Agenda for the Digital European Sky

The SRIA details the R & I 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 to 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 R & I Programme (2021–2027).

View publication

1.6.3.3. Press

In 2020, the SESAR JU continued its outreach to trade press and member/partner media channels, with more than 15 feature articles and interviews published in a range of magazines and online media:

- trade or specialised press, including *Airport Business*, *AIR*, *ATC Network* and *AeroSafety World*;
- member/partner media, CORDIS, CEAS, *Skyguide Blueprint*, ILA and Air France inflight magazine,
- EUROCONTROL's *Skyways*
- SESAR JU website provides an overview of 2020 coverage: https://sesarju.eu/newsroom/press-coverage.

1.6.3.4. Online communications

1.6.3.4.1. Website and e-news

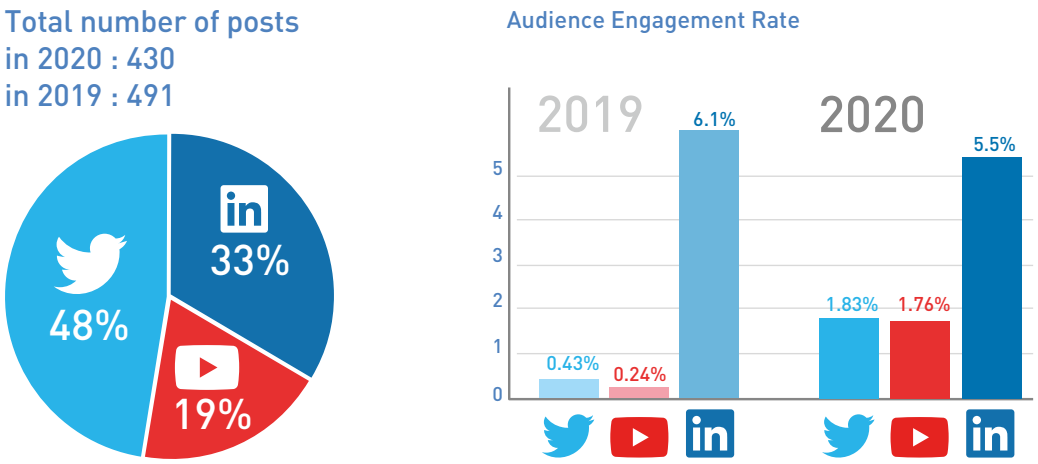
The SESAR JU updated its website with information on the newly launched projects over the course of 2020, resulting in the creation of more than 50 new web pages and the publication of numerous news stories and updates.

A monthly e-news was sent to nearly 6 000 external contacts (all compliant with the general data protection regulation). In addition, over 50 dedicated event mailshots and press releases were distributed, attracting further traffic to the SESAR JU website. Among the most popular website content were the U-space and drone developments, the home page, news, projects, SESAR Innovation Days and vacancy notices.

1.6.3.4.2. Social media

In 2020, SESAR JU social media communication achieved positive results in the majority of its KPIs, such as the growth rate, SESAR JU own activity and engagement. SESAR JU social media engagement in 2020 amounted to 430 posts, retweets, shares or comments (Figure 21), compared with 1 039 in 2019 – the drop can be explained by the cancellation of physical events that usually generate a lot of content and engagement. However, the number of posts on YouTube doubled between 2019 and 2020.

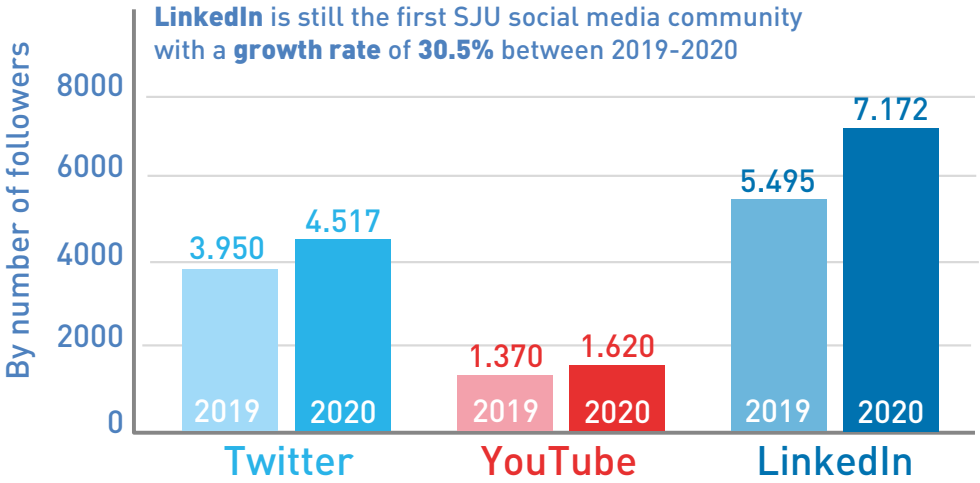
FIGURE 21 THE SESAR JU ON SOCIAL MEDIA



All SESAR social media channels saw an improvement in their engagement rate between 2019 and 2020. The posts that generated the most engagement were on LinkedIn (Figure 22).

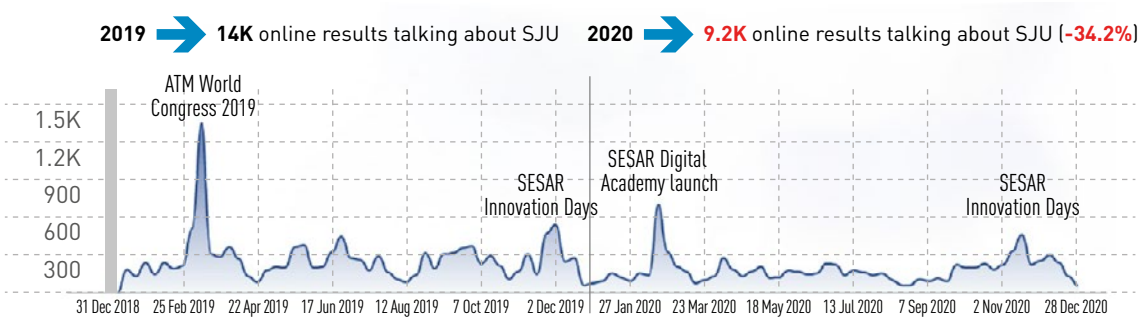
In terms of enlarging the online community, the SESAR JU saw an increase in the number of followers, especially on LinkedIn. This may be the result the work done internally to encourage staff to become ambassadors for the SESAR JU on LinkedIn, as well as increased engagement with SESAR 2020 project beneficiaries.

FIGURE 22 THE SESAR JU'S ONLINE COMMUNITIES BY SOCIAL MEDIA PLATFORM



On both channels engagement rate and views peaked at the time of launch of the SESAR Digital Academy webinar series and SESAR Innovation Days, a result of the increased number of posts by the SESAR JU and their multiplier effect.

FIGURE 23 THE SESAR JU'S PEAK ENGAGEMENT



1.7. Strategic area of operation 6 (transversal activity): delivery of effective financial, administrative and corporate management

The SESAR JU met all its objectives related to effective financial, administrative and corporate management in 2020, as set out in Paragraph III of the SPD 2020–2022. This includes the following achievements and results.

- Implement the calls for proposals and grants management framework. Two calls for proposals (VLD Open 2 and Wave 3) were launched in accordance with the plan. All grant agreements (26) had been signed by the end of 2020.
- Ensure full compliance with programming and reporting requirements: SPDs were developed and submitted on time, as per requirements. The upcoming SPDs will include elements required by the new guidelines issued by the Commission in April 2020. The CAAR 2019 was adopted and submitted on time, in accordance with requirements.
- Monitor Exception and Non-Compliance Events Register (target within 1 %). Three exceptions were recorded in 2020: two linked to COVID-19 (electronic signature workflows put in place for legal documents commitments and financial workflow) and one linked to the extension of the Scientific Committee. One non-compliance event (payment of 2020 fees for Directorate-General Budget services) was entered in 2020. All information was registered in accordance with the policy and process.
- Monitor the efficiency and effectiveness of the SESAR JU's legal and procurement activities. Activities were carried out in accordance with the plan agreed with the requestor and with the SPD 2020–2022 procurement plan.
- Monitor the efficiency and effectiveness of the SESAR JU's project audit activities. Project audit activities were carried out in accordance with the plan. The issue identified by the Common Audit Service (CAS) and reported in CAAR 2019 is still to be resolved.
- Monitor the efficiency and effectiveness of the SESAR JU's corporate and management activities. Actions in relation to compliance requirements were taken in accordance with the plan.
- Balance payments to members and beneficiaries. The 2020 execution rate was 95.4 % in commitment appropriations and 90 % in payment appropriations;
- Deliver infrastructure services to enable teams and the SESAR JU to operate smoothly. Services were delivered in line with plans. Business continuity measures were implemented, and infrastructure services proved to be effective in this regard.
- Define and prepare for the future of SESAR. The SESAR JU delivered the SRIA and supported the Commission in the preparatory steps of the future ATM R & I partnership for ATM, by contributing to the impact assessment study and the high-level partnership proposal.
- Ensure effective and efficient SESAR JU governance activities. Meetings and procedures took place as planned.

This chapter outlines the activities that were carried out to deliver the objectives of the SESAR JU related to financial, administrative and corporate management. These objectives are associated with relevant indicators and 2020 targets.

1.7.1. Implementation of calls for proposals and grant management framework

In 2020, the SESAR JU managed 36 grants already in execution at the beginning of the year, following five calls for proposals procedures conducted in previous years. All these projects and the related grants were managed in accordance with the applicable programme rules: H2020 for 30 grants and CEF for the six U-space demonstration projects.

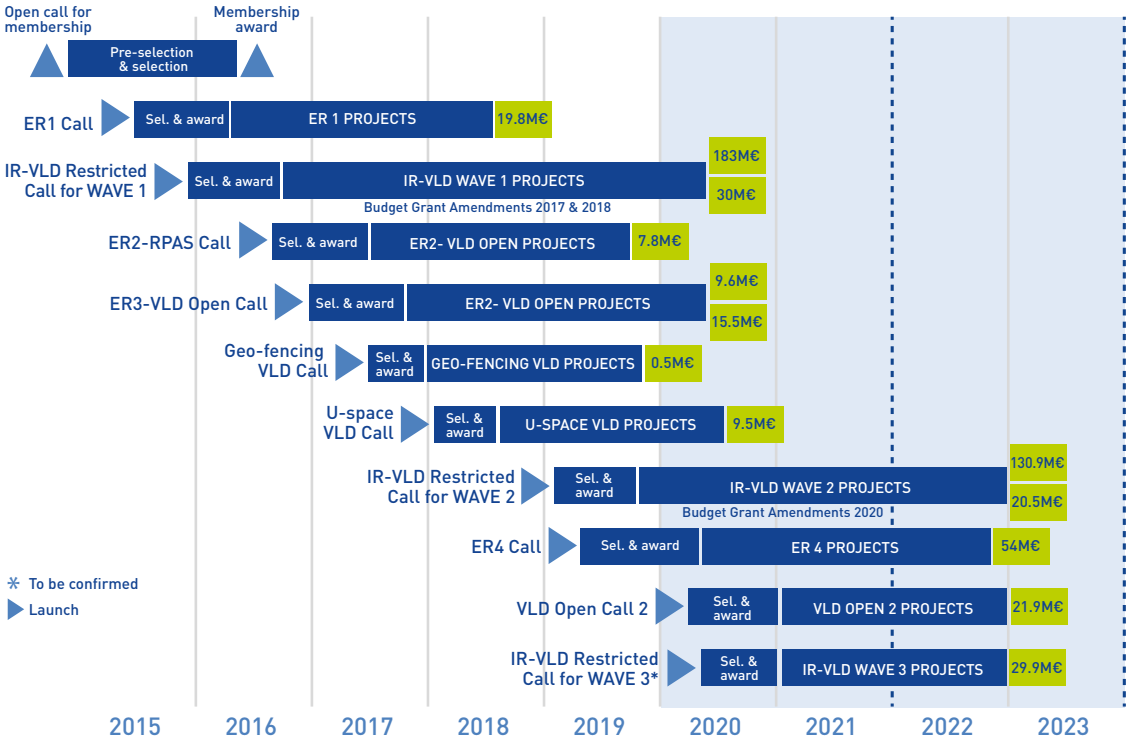
In addition, two calls for proposals under the H2020 framework were launched in 2020: the VLD Open 2 call with reference H2020-SESAR-2020-1 (see subparagraph 1.5.1.4, 'Status of the VLD Open 2 call (H2020-SESAR-2020-1)') launched in January and closed in June 2020, and the restricted IR-VLD Wave 3 call with reference H2020-SESAR-2020-2 (see paragraphs 1.4.3, 'Status of the Wave 3 call (H2020-SESAR-2020-2)' and 1.5.1.5, 'Status of the Wave 3 call (H2020-SESAR-2020-2)') launched in March and closed in June 2020. The call management and evaluation process was as follows.

- The SESAR JU received 12 proposals in response to the VLD Open 2 call, for a total amount of EUR 40 584 548.91 (207 % of the maximum call amount).
  - As part of the evaluation of the proposals, and in accordance with the H2020 rules, the SESAR JU ran admissibility, eligibility, operational and financial capacity checks, which resulted in the rejection of one proposal.
  - Scientific evaluation of the remaining 11 proposals, took place between 3 July and 11 September 2020, with the assistance of six external experts. The evaluation concluded with the submission of the evaluation report to the Executive Director, who followed the recommendation of the panels and approved the invitation to the grant agreement preparation phase of six projects.
  - The grant agreement preparation phase was concluded in Q4 2020 for the six projects on the main list, representing a total value of EUR 21 933 376.
- The SESAR JU received seven proposals in response to the IR-VLD Wave 3 call, for a total amount of EUR 30 275 774.86 (100.9 % of the maximum call amount).
  - As part of the evaluation of the proposals, and in accordance with the H2020 rules, the SESAR JU ran admissibility, eligibility, operational and financial capacity checks, which resulted in the rejection of two proposals.
  - Scientific evaluations of the five remaining proposals took place between 3 July and 11 September 2020, with the assistance of three external experts. The evaluation concluded with the submission of the evaluation report to the Executive Director, who followed the recommendation of the panels and approved the invitation to grant preparation phase of five projects.
  - The grant agreement preparation phase was concluded in Q4 2020 for all projects, representing a total value of EUR 29 925 862.

Furthermore, the SESAR JU set up specific measures to mitigate the adverse effects of the COVID-19 crisis on the aviation sector. Taking into account the amount available for project funding under the operational budget, the reserve list that was drawn up following the ER4 call for proposals (with reference H2020-SESAR-2019-2) and the objective of optimising the use of available funds, an additional budget of up to EUR 15.4 million was made available for new projects under the ER4 call for proposals, thus allowing the award of 12 additional grants to projects on the reserve list (six for work area 1 and six for work area 2); the grant agreement preparation phase concluded in December 2020 with the signature of all grant agreements and the launch of the projects in execution.

The sequence of all SESAR 2020 calls for proposals from 2015 to 2023, with results at the end of 2020, is shown in Figure 24.

FIGURE 24 SESAR 2020 CALLS FOR PROPOSALS AND THEIR RESULTS AS AT THE END OF 2020



1.7.2. Financial management

The primary focus in the area of financial management was the implementation of the budget. The results of this activity can be found in chapter 2.3, 'Budget and financial management', below.

The SESAR JU further strengthened its finance function with the arrival of the new Chief Financial Officer in January 2020.

The financial team concentrated their efforts on providing financial support to the members confronted with the COVID-19 crisis. Following the introduction of lock-down measures in EU Member States, a series of measures were drawn up and presented to the Administrative Board in May 2020. These included increased pre-financing rates, delayed and reduced financial contributions, and optimised use of available operational funds, funded by a significant reduction in SESAR JU running costs.

Furthermore, despite legal provisions not allowing any repayment of the remaining cash left unused from the SESAR 1 programme (EUR 30.8 million) until the winding-up of the Joint Undertaking, the European Court of Auditors in its report on the accounts 2019 stressed that this amount should be repaid as soon as possible. The decision to reimburse the cash remaining from the SESAR 1 programme was submitted to the Administrative Board of the SESAR JU on 7 May 2020, and was finally adopted on 8 October 2020 following a positive opinion given by the Commission on the same day. Less than three months later, on 31 December 2020, all but three payments had been disbursed, amounting to EUR 30 474 585.55 (out of EUR 30 767 098.22, i.e. 99 %). This involved a period of intense activity, including complementary payments from two members and the signature of bilateral agreements with all members other than the EU.

Other achievements in the area of financial management are presented in chapter 2.3, 'Budget and financial management'.

1.7.3. Human resources management

The SESAR JU approved 2020 staff establishment plan allows for 39 temporary or contract agents and three seconded national experts (SNEs), as set out in the 2020–2022 SPD.

The staff establishment plan and its realisation are presented in Annex IV.

The effective allocation of staff resources also remained a priority for the SESAR JU during 2020. Efforts were focused on the professional and career development of its staff, in addition to ensuring that allocated staff resources are used in the most economic, efficient and effective way.

In 2020, the SESAR JU conducted its career development review exercise, and was able to conduct the reclassification, which, as a result, seven temporary agents were reclassified.

The vacancy rate at the end of 2020 was 10 %. It should be noted that, as the SESAR JU Staff Establishment Plan only has 39 positions plus three SNEs positions, each move in staff counts for more or less 2.5 %.

During the final quarter of 2020, the selection processes (internal and external) for the vacant positions of 'facility coordinator and planning and reporting officer' were launched in order to create reserve lists. The contract with the successful candidate for the post of facility coordinator was signed in February 2021 (for this position, filled externally, the recruitment process was completed in March 2021 with the arrival of the selected candidate). The new planning and reporting officer, also an external recruit, is expected to join the organisation in June 2021.

SYSPER for Agencies, the HR management system developed by the European Commission, was successfully implemented in the SESAR JU during 2020. This HR system is based on the Commission's HR management rules, in particular on the Staff Regulations and the Conditions of

Employment of Other Servants of the EU [32], the General Implementing Provisions thereto and the related business processes. The first phase of the implementation of SYSPER for Agencies was completed in November 2020 through the deployment of the initial modules:

- identity management,
- organisation management (organisation chart, job quotas),
- employee personal data management,
- time management (including work patterns, leave rights, absences, flexitime).

Training sessions were made available to staff throughout the organisation to support the deployment of these modules.

1.7.4. Legal support to operations

In 2020, the SESAR JU paid particular attention to:

- the regularity and legality of all SESAR JU's binding agreements, contracts, H2020 [33] and non-H2020 grants [34] related amendments, SESAR JU decisions, processes and measures,
- respecting the partnership principles agreed with SESAR JU members (in the membership agreement) and their development (including the signature and management of two secondment agreements) and
- respecting the agreements concluded with SESAR JU's founding members (delegation agreements with the Commission, the SESAR JU-EUROCONTROL agreement, SLAs, etc.).

Of particular relevance with regard to legal aspects in 2020 were also the following elements:

- preparation for the withdrawal of the United Kingdom from the EU through an internal transversal working group to assess the impact of possible changes on the SESAR JU's procurements, grants and membership as well as to identify, analyse, prioritise and schedule actions that will be required as a result of this withdrawal,
- the financial closure of SESAR 1 with the early repayment of the excess financial contributions received from SESAR JU members under SESAR 1 (see paragraph 1.7.2, 'Financial management'),
- management of the impacts of the COVID-19 crisis on on-going programme actions,
- support to the European Commission during the preparation of the legislative act setting a new joint undertaking to repeal and replace the current SESAR JU under the Horizon Europe programme (SESAR 3 Joint Undertaking) and from 2021 until 2031.

Furthermore, during 2020, the SESAR JU processed a continuously increasing number of applications for public access to documents. In compliance with the applicable rules [35], legal expertise was provided in the

[32] As last amended by Regulation (EU, Euratom) No 1023/2013 of the European Parliament and of the Council of 22 October 2013 amending the Staff Regulations of Officials of the European Union and the Conditions of Employment of Other Servants of the European Union (OJ L 287, 29.10.2013, p. 15).

[33] Mainly for topics related to Force Majeure, EDES, consortium composition changes and intellectual property rights.

[34] Mainly U-space with eight amendments to CEF grants.

[35] Article 15(3) of the Treaty on the Functioning of the European Union, Article 42 of the Charter of Fundamental Rights of the EU, Regulation (EC) No 1049/2001 of the European Parliament and the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents and Article 19 of the SESAR JU Statutes. These practical arrangements for public access to the documents of the SESAR JU are governed by Decision ADB(D)-12-011 of the Administrative Board of the SESAR Joint Undertaking 'Concerning the transparency and public access to the documents of the Joint Undertaking' and by further internal rules of the SESAR JU (Executive Director's Decision SESAR JU/ED/683).

management of 16 requests ([36]) for access to documents made by the public. As a result of the case-by-case basis analysis of each request received, the SESAR JU granted full access on seven occasions and partial access on 11 occasions; two requests for access to documents were refused ([37]). Granting only partial access was justified by invoking Article 4(1)(b) ([38]), 4(2) ([39]) or 4(1)(a) ([40]) of Regulation (EC) No 1049/2001 ([41]). So far, no sensitive documents have been recorded in the SESAR JU's public register (as required by Article 11 of the regulation).

In response to an increase in the number of requests processed by the SESAR JU, up by 18 % compared with the previous year (covering 87 documents in total), the SESAR JU took several initiatives in the field of public access to documents.

- It created an internal Public Access to Documents Register.
- It updated its internal rules regarding public access to documents (i.e. ED Decision ref. SESAR JU/ED/683 defining implementing rules for the application of Decision ADB(D)-12-011 'concerning the transparency and public access to the documents of the Joint Undertaking').
- An additional process of consultation with the European Commission on receipt of requests from third countries was defined.

1.7.5. Procurement activities

During 2020, the SESAR JU effectively implemented its procurement plan (as per Annex IX of the 2020–2022 SPD).

While the SESAR JU dealt with fewer procurement procedures than in 2019, the number of contracts signed remained relatively stable, at approximately 28, including one framework service contract, one direct service contract and 22 specific contracts implementing SESAR JU framework contracts and interinstitutional agreements.

In the interest of sound financial management, the SESAR JU continued, as far as possible, to reinforce its involvement in interinstitutional procedures with the signature of 10 MoUs for interinstitutional procurement procedures and one SLA, most of which were with the European Commission or other EU institutions.

In 2020, there were six procurement procedures: one negotiated procedure without prior publication of a contract notice (point 11.1(a) to (f) of Annex 1 of the financial regulation (FR) and Article 74(10) FR), one public contest and four very low-value procedures (leading to the award and signature of one direct contract and three purchase orders). In addition, the SESAR

([36]) Article 17 of Regulation (EC) No 1049/2001 states that 'each institution shall publish annually a report for the preceding year including the number of cases in which the institution refused to grant access to documents, the reasons for such refusals and the number of sensitive documents not recorded in the register'.

([37]) It should be noted that one request was in fact two requests from the same applicant and that the outcome of each disclosure does not necessarily correspond to the number of requests received, as some documents may be partially, fully or not disclosed at all under a single request.

([38]) Access has to be refused if its disclosure would undermine the protection of privacy and the integrity of the individual, in particular in accordance with EU legislation regarding the protection of personal data in accordance with Article 4(1)(b) of Regulation (EC) No 1049/2001.

([39]) Access has to be refused if disclosure would undermine the protection of commercial interests of a natural or legal person, including intellectual property.

([40]) Access has to be refused if its disclosure would undermine the protection of the public interest as regards public security, defence and military matters, international relations and the financial, monetary or economic policy of the Community of a Member State. Accordingly, the disclosure of the requested documents is prevented by the exception to the right of access laid down in the abovementioned article, which application of such article was confirmed by the European Commission consulted by the SESAR JU on this matter. Moreover, refusal of access to documents was also justified by invoking Article 4(2) of Regulation (EC) No 1049/2001 regarding public access to European Parliament, Council and Commission documents, pursuant to which access has to be refused if its disclosure would undermine the protection of commercial interests of a natural or legal person, including intellectual property.

([41]) Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents. OJ L 145, 31.5.2001, p. 43.

JU signed five amendments to its contracts, specific contracts and SLA.

All procedures were carried out in compliance with the SESAR JU's financial rules to ensure respect for transparency, fair competition among suppliers and the most efficient use of SESAR JU funds. The procurement procedures supported the SESAR JU objectives transversally.

In addition, and in order to promote automation and decentralisation of very low-value procedures, but with procurement maintaining a verification role, the procurement team developed new tender documentation for these procedures and delivered specific training to the OIAs.

Last, the remote working triggered by the COVID-19 crisis accelerated the move towards electronic approval cycles and contract signature, as explained in chapter 2.6. 'Strategy for efficiency gains' below. The procurement team actively supported this transition with the development of specific routing slips, related user manual and electronic signature (the latter not replacing though the blue ink signature due to its certification level). This development has been welcomed by the entire organisation, which appreciates the reduced duration of the approval cycles.

1.7.6. Corporate planning and reporting

Corporate programming documents and corporate planning

In 2020, following prescribed written procedures, the SESAR JU made three amendments to the 2020–2022 SPD that were adopted by the Administrative Board: the re-inscription of unused 2018 appropriations and 2019 into the 2020 budget. The first amendment, revision of the annual budget for 2020 to face the COVID-19 crisis and an increase in the maximum budget of the ER4 call, was adopted through decision of the SESAR JU Administrative Board ADB(D)03-2020). The second amendment, increase in payment appropriations to cover

the ER4 call amount and the increase of the budget of the VLD Open 2 call, which is explained in section 1.7.1, 'Implementation of calls for proposals and grant management framework', was adopted through decision of the SESAR JU Administrative Board ADB(D)07-2020. The third amended version was adopted through decision of the SESAR JU Administrative Board ADB(D)12-2020).

Furthermore, in accordance with requirements of the framework financial regulation, the SESAR JU further developed its 2021–2023 SPD, which was adopted by the Administrative Board on 17 December 2019 (ADB(D)14-2020). This adoption included the approval of the 2021 annual work programme, the financing decision of the adoption of the 2021 budget, the approval of the staff establishment plan for 2021 and the approval of the procurement plan for 2021.

The SESAR JU also began drafting the 2022–2024 SPD, as this document (in draft version) is due to be submitted to the authority by 31 January 2021.

Furthermore, following revision of the framework FR, and seeking to implement its Article 32, the SESAR JU participated in the working group of the EU Agencies Network on proposals for the revision of the corporate planning documents template and guidelines (42).

Corporate reporting

In 2020, the SESAR JU released its 2019 CAAR, which the Administrative Board approved through written procedure on 25 June 2020 (ADB(D)8-2020).

Moreover, the SESAR JU prepared and submitted implementation reports for 2019 in response to the three delegation agreements referred to in paragraph 1.1.1, 'Overview of calls and grants up to 2020' (footnote 19), namely on CEF U-space demonstrations, on geofencing demonstration and on the Airspace Architecture Study.

The SESAR JU reported on its activities to the Administrative Board on a quarterly basis.

Furthermore, following the revision of the framework financial regulation, and seeking to implement its Article 48, the SESAR JU participated in the working group of the EU Agencies Network on proposals for the revision of the corporate reporting documents template and guidelines (43).

Leverage effect

Building on the clarifications on the leverage effect calculation methodology in the 2018 CAAR (Part I, paragraph 2.6.5, pages 144 and 145), the SESAR JU uses three methods to present the leverage of the SESAR JU:

1. The method used by the European Commission in the context of the interim evaluation;
2. A method that is a refinement of the interim evaluation method but also includes all activities of the SESAR JU;
3. The method used by Horizon 2020.

Some readers also expect to see a leverage that describes the contribution of the beneficiaries of SESAR 2020 grants against that of the Union. As the industrial programme is only a part of the responsibility and work undertaken by the SESAR JU this must be calculated differently to be meaningful, a Partnership leverage is also calculated and will be consistently reported upon in this and future reports.

(42) This working group provided the European Commission with advice and feedback that was subsequently incorporated in new guidelines on the establishment of the SPD (Annex I to Commission communication C(2020) 2297 final on the strengthening of the governance of Union Bodies under Article 70 of the Financial Regulation 2018/1046 and on the guidelines for the Single Programming Document and the Consolidated Annual Activity Report).

(43) This working group provided the European Commission with advice and feedback that was incorporated in new guidelines on the establishment of the CAAR (Annex II to Commission communication C(2020) 297 final on the strengthening of the governance of Union Bodies under Article 70 of the Financial Regulation 2018/1046 and on the guidelines for the Single Programming Document and the Consolidated Annual Activity Report).

The set of leverage targets, the raw data and calculation methods used are shown in Table 9.

TABLE 9 CUMULATIVE LEVERAGE FOR THE PROGRAMME AND THE SESAR JU

		Cumulative Leverage (Reporting)				Forecast Leverage
Partnership Leverage (SESAR Programme)		**2017 Adopted**	**2018 Adopted**	**2019 Reported**	**2020 Estimated**	
1	Gross In-Kind Contribution by Members	€126.547.889,00	€264.133.070,00	€370.110.780,00	€491.812.075,46	€706.311.697,71
2	Co-Financing requested by Members	€70.472.006,00	€147.843.953,00	€208.815.125,39	€276.528.488,45	€395.560.424,70
3	**Net In-Kind Contribution of Members**	**€56.075.883,00**	**€116.289.117,00**	**€161.295.654,61**	**€215.283.587,01**	**€310.751.273,01**
4	Gross In-Kind Contribution by Founding Member EUROCONTROL	€60.547.899,00	€122.744.297,00	€185.625.399,66	€248.657.581,37	€370.857.581,37
5	Co-financing requested by Founding Member EUROCONTROL	€945.174,00	€1.977.073,00	€3.057.148,98	€4.407.932,80	€5.007.932,80
6	**Net In-Kind Contribution of Founding Member EUROCONTROL**	**€59.602.725,00**	**€120.767.224,00**	**€182.568.250,68**	**€244.249.648,57**	**€365.849.648,57**
7	**Net In-Kind Contribution by Founding Member EU**	€0,00	€0,00	€0,00	€0,00	
8	**SJU Commitment Appropriations for Co-financing**	€180.610.284,00	€180.610.284,00	€211.872.274,37	€280.936.421,25	€400.568.357,50
	of Members & Founding Member					
	Calculation Partnership Leverage = [(3)+(6)+(7)]/(8)	**0,64**	**1,31**	**1,62**	**1,64**	**1,69**
	Calculation Partnership Leverage = [(3)+(6)+(7)+(8)]/(8)	**1,64**	**2,31**	**2,62**	**2,64**	**2,69**

Union Body Leverage (SESAR JU)		**2017 Adopted**	**2018 Adopted**	**2019 Reported**	**2020 Estimated**	
1	**Net Contribution of Members (inc. cash)**	**€58.713.893,00**	**€121.565.137,00**	**€167.890.679,61**	**€223.197.617,01**	**€329.377.029,01**
2	**Net Contribution of EUROCONTROL(inc. cash)**	**€67.290.326,41**	**€132.638.367,78**	**€196.412.507,54**	**€260.022.504,36**	**€390.733.383,36**
3	**Net In-Kind Contribution by Founding Member EU**	**€0,00**	**€0,00**	**€0,00**	**€0,00**	**€0,00**
	Finance Available for ER Open calls					
	Finance Available for VLD Open calls					
	Total Finance available for Open calls					
	5% contribution to Running Costs					
	Maximum Finance available for Open Calls					
	Forecast overall funding rate					
4	**Net In-Kind Contribution from Open calls (ER+ VLD-Open)**	**€14.147.995,00**	**€14.147.995,00**	**€12.630. 784,14**	**€17.440.689,39**	**€27.971.433,97**
5	**Total EU Commitment Appropriations available to the SJU**	**€236.148.000,00**	**€348.711.000,00**	**€461.329.000,00**	**€585.000.000,00**	**€585.000.000,00**
6	**EU Commitment Appropriations available to the SJU for ER**					
	Target Leverage by Regulation = [(1)+(2)+(3)]/(5-6)					
	Target Leverage by Interim Evaluation = [(1)+(2)+(3)]/(5)	**0,53**	**0,73**	**0,79**	**0,83**	**1,23**
	Calculation of SJU Union Body Leverage = [(1)+(2)+(3)+(4)]/(5)	**0,59**	**0,77**	**0,82**	**0,86**	**1,28**
	Calculation of SJU Union Body Leverage = [(1)+(2)+(3)+(4)+(5)]/(5)	**1,59**	**1,77**	**1,82**	**1,86**	**2,28**

It should be noted that the figures in Table 9 are estimates and that the final figures will be added in Q2 2021 in line with the Wave 1 RP4 and Wave 2 RP1 reports received from SESAR JU members.

Table 9 shows that, as reported last year, the actual leverage of the SESAR JU and the SESAR 2020 programme regularly progresses towards the targets.

1.7.7. Internal control, risk management and audit

1.7.7.1. Internal control and quality management

In 2020, in continuation of the activities of previous years, the SESAR JU continuously reviewed and improved its quality management system (QMS) in response to the SESAR JU's evolving business needs and to improve efficiency (see also chapter 2.6, 'Strategy for efficiency gains', below).

Upgrades in 2020 included the addition of new processes to the QMS, especially those related to finance and to the activities carried out under the SESAR JU–EUROCONTROL agreement.

Continuous improvement also included the further alignment of the QMS with the requirements of the European Commission's ICF, in particular the definition of the SESAR JU's internal control strategy, which was adopted by the Quality, Information and Communication Technology (QICT) Committee at the end of the year. The internal control strategy clarifies how the QMS will be used to implement the European Commission ICF and was summarised in the 2021–2023 SPD, as set out in the Commission's new requirements for SPDs (referred to in paragraph 1.7.6, 'Corporate planning and reporting'). As observed by the European Court of Auditors during the preliminary phase (fieldwork) of the audit on the SESAR JU's 2020 accounts, for the annual self-assessment and monitoring of the effectiveness of the control activities required by the ICF, the JU developed relevant indicators for all internal control principles and related characteristics. These indicators were submitted for approval to the corporate management team at the end of the year, and will be used in CAARs from next year onwards, once data for a full year have been collected. As regards 2020, the results of the assessment against the ICF described in chapter 4.1, 'Effectiveness of internal control systems', below, were obtained using the same method as used in previous reports.

A final contributor to continuous improvement and efficiency gains at the SESAR JU is the development of a workflow-based approach for certain processes and transactions. In this approach, some critical processes related to the review and approval of financial, legal and administrative transactions are supported by electronic routing slips within the information and document management service (IDMS). This is further detailed in chapter 2.6, 'Strategy for efficiency gains,' below.

1.7.7.2. Risk management

Risk management aims to enable an organisation to fulfil its mission and objectives in the most efficient and effective way by ensuring the timely and adequate identification, assessment (analysis and evaluation), management (treatment and escalation as required), monitoring and controlling of risks and opportunities.

In 2020, owing to the COVID-19 crisis, only one risk management workshop took place in 2020, in October. The risk management team reviewed the four categories of risks identified in the SESAR JU's risk management policy (for further detail, see the Corporate Activity Plan for 2018), namely strategic risks, internal risks, Master Plan risks and programme risks. In accordance with the agency's policy, most focus was put on critical risks. Following the work the risks and the related actions outlined in the risk management policy were update and an additional risk, related to the impacts of the COVID-19 crisis on the SESAR programme and on the SESAR JU activities and resources, was identified and documented. A dedicated action plan was defined. This built on a specific report that the SESAR JU sent to the Commission in June 2020 in response to a request on an analysis of COVID-19-related risks.

As a result of these activities, the SESAR JU updated its corporate risk register and froze it on 31 October 2020. The updated information on risk management was incorporated in the 2021–2023 SPD.

The status of risk management presented in part III is the status of the SESAR JU corporate risk register at the end of 2020.

1.7.7.3. Audit

Actions related to audit are addressed in Part III of this report.

1.7.7.4. Anti-fraud

The SESAR JU financial rules state that, for the purposes of the implementation of the budget of the SESAR JU, the SESAR JU shall apply internal control at all levels of management designed to provide reasonable assurance of achieving *inter alia* the objective of prevention, detection, correction and follow-up of fraud and irregularities ([44]).

To this end, the SESAR JU Administrative Board adopted the first SESAR JU anti-fraud strategy ([45]) in 2016. This first SESAR JU anti-fraud strategy addressed 2016–2019 and had a strong focus on risks related to the SESAR 1 programme. Therefore, an update of this first SESAR JU anti-fraud strategy was required.

As reported in the 2019 CAAR, the SESAR JU carried out a fraud risk assessment in November 2019. The results of this risk assessment served as the basis for the revision of the anti-fraud strategy. This update was drafted over the course of December 2019 and January 2020. The updated version builds on the anti-fraud actions performed by the SESAR JU from 2016 to 2019 and sets out a new set of objectives and actions to address current risks, including H2020-specific risks. The SESAR JU Administrative Board adopted the updated anti-fraud strategy in March 2020 ([46]).

The SESAR JU updated anti-fraud strategy includes the following elements:

- the background and context of the anti-fraud strategy, including how this strategy aligns with the European Commission and how it addresses the internal control principles,
- fraud definitions,
- the results of the anti-fraud risk assessment which was carried out as a stand-alone exercise

([44]) SESAR JU Administrative Board decision No ADB(D)-21-2019 adopted on 9 October 2019 of the Financial Rules, Article 29, particular Articles 31, 38, 44, 47, 84 and 106 thereof.

([45]) SESAR JU Administrative Board Decision No ADB(D) 4-2016 signed on 18 March 2016 of the anti-fraud Strategy 2016–2019.

([46]) SESAR JU Administrative Board Decision No ADB(D)04-2020, signed on 12 March 2020, referring to the updated 2020–2022 anti-fraud strategy.

in November 2019 and which underlies the strategy,

- an overview of the means and staff resources that the SESAR JU has at its disposal to tackle fraud and to mitigate identified risks, including an overview of policies and processes the SESAR JU has enforced since 2008 in the area of conflict of interest and anti-fraud,
- the three main objectives of the anti-fraud strategy:
  - objective 1: maintain a culture of integrity
  - objective 2: build capacity through training and guidance
  - objective 3: prevent and detect external fraud,
- an overview of the indicators that will be used to report on the anti-fraud strategy in the CAAR
- a detailed action plan which outlines the specific actions that the SESAR JU will undertake from 2020 to 2022 to address the three objectives of the anti-fraud strategy.

In this context, an 'Anti-fraud implementation report 2020' was submitted to the Executive Director in April 2021. The report provides an overview of the anti-fraud activities which were carried out by the SJU in 2020. It notably describes specific training sessions which were set-up in the field of ethics and anti-fraud in Q4 2020. These training sessions covered the following topics: fraud definitions; red flags; reporting of serious irregularities; conflict of interest; outside activities; gifts and favours, EDES, double funding and plagiarism.

A total of four sessions were arranged and took place in the form of web conferences in view of the mandatory COVID-19 teleworking rules that were in place in Q4 2020.

The training sessions were mandatory for all staff, including European Commission staff members, EUROCONTROL staff members, SNEs, trainees and temporary staff and contractors working in the SESAR JU offices. A total of 86 staff members were invited to participate.

The training sessions were attended by 93 % of staff members. An additional session will be arranged in 2021 for those staff members who could not attend in 2020.

1.7.8. Information and communication technologies management

SESAR JU operations are supported by an information and communications technology (ICT) system composed of the following elements:

- infrastructure and services acquired through EUROCONTROL under Schedule 4 of the SESAR JU – EUROCONTROL agreement, for instance the network, support services, e-mail system, etc.,
- tools and services acquired through the European Commission, such as ABAC for finance, SyGMa-COMPASS for grant management, SYSPER for Agencies for HR management, etc,
- direct contracts set up by the SESAR JU or that form part of joint acquisitions with other EU agencies.

In 2020, faced with the COVID-19 crisis, and the extraordinary measures required, the JU's ICT system was tested to the maximum and proved really effective. The teleworking measures that were adopted in March 2020, in full alignment with the instructions of the Commission, continued throughout the year, and, at the time of writing, are still ongoing. These measures had many implications for ICT: not only was the unified communication system, including web conferencing tools and telephony, widely used, but it was essential that the security of information was not compromised by teleworking measures.

The ICT system was central to the continuity of the SESAR JU's operations. To assess this, and in preparation for the deployment of general teleworking measures, the SESAR JU ICT team assessed the agency's ability to implement teleworking measures and ran a stress test session on 11 March 2020. All SESAR JU staff was asked to telework that day. The results were summarised and shared with the QICT Committee on 19 March 2020.

The successful provision of ICT services was enabled by implementing the provisions of Schedule 4 of the SESAR JU– EUROCONTROL agreement and agreements with the European Commission for the provision of ICT services. Continuous process improvements and strong working relationships between the SESAR JU ICT and its suppliers, combined with new initiatives for transformation, innovation and risk mitigation, all helped to ensure that a high-quality support service was delivered throughout the year while keeping the cost of the support service stable and under control (about –4.58 % compared with the previous year).

Transformation projects, all of which were approved by the SESAR JU QICT Committee, which includes representatives from all SESAR JU sectors, focused particularly on guaranteeing continuity of the service and minimising the risk of system failure in the event of disasters or major incidents. To this end, some outdated equipment, such as laptops, was replaced, redundancy was added to some systems with single points of failure, and remote monitoring capabilities were reinforced.

All the transformation projects planned for 2020 were delivered during the course of the year and a list of candidate transformation projects to be carried out in 2021 was submitted to the QICT Committee by the end of the year for information. The list of transformation projects was drawn up in consultation with service providers and will be subject to a prioritisation exercise early in 2021.

1.7.9. Facilities management

In 2020, work continued on a number of initiatives in the SESAR JU's premises in Brussels to maintain the productivity, safety and efficiency of the working environment and facilities offered to SESAR JU staff.

In particular, as a result of the COVID-19 pandemic, the facilities team was tasked with ensuring that the premises were safe for staff to use when lockdown regulations permitted. The team successfully implemented the

measures and tools necessary to ensure the safety of staff members and others physically present on the premises. The facilities team members acted as the OIA in the procurement of masks and other protective equipment for staff. In addition, together with the data protection officer (DPO) in charge of the privacy notices, members of the facilities team created a COVID-19 booking system to ensure that social distancing was maintained when staff were allowed to return to the office voluntarily.

The JU's insurance policies and requirements were assessed to determine if they provided the maximum possible coverage and reassurance. As a result, a new building and contents insurance policy, and covering damage due to terrorism, was taken out under the OIB framework contract. All premiums were paid on time, time providing the maximum possible coverage and reassurance.

Finally, following the recommendations of the security audit carried out in 2019, two actions were taken.

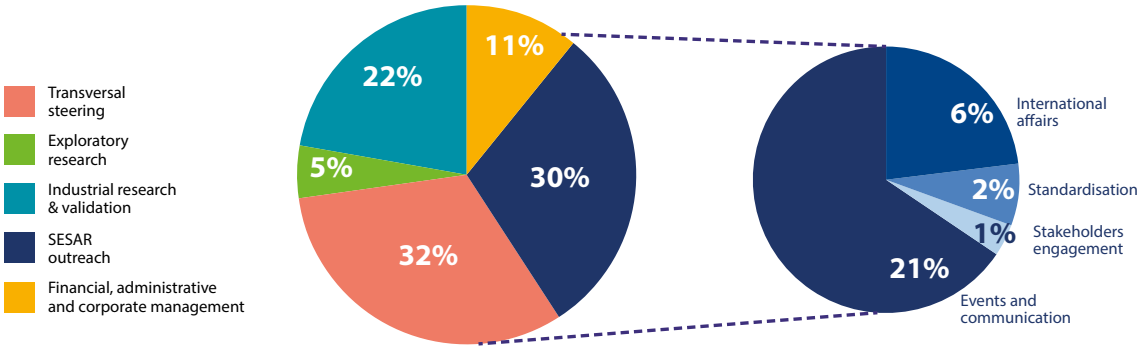
- With the LSO leading the process, a physical security policy was drafted, approved and published. This has brought together all rules and guidelines related to physical security and provided clarity to the organisation.
- A key management process was drafted (and added to the physical security policy) and a cabinet for the secure storage of all SESAR JU keys was purchased.

1.7.10. Travel coordination

In 2020, as a result of the COVID-19 crisis and the severe restrictions on travel in Europe and globally, the number of missions performed by SESAR JU staff dropped by 80 %, to 82 (not including missions related to the activities managed by the Programme Management Unit under the SESAR JU–EUROCONTROL agreement), from 244 in 2019. More than 90 % of the missions (75) took place before lockdown.

Of the 82 missions in 2020, 26 (32 %) were related to transversal steering activities (Strategic Area of Operation 1), and 25 (26 %) to SESAR Outreach (Strategic Area of Operation 5). The split by strategic area of operation, and within Strategic Area of Operation 5 by topic, is shown in Figure 25.

FIGURE 25 BREAKDOWN OF SESAR JU MISSIONS IN 2020 BY STRATEGIC AREA OF OPERATION



Mission management was executed on time and in line with the rules of the European Commission's Mission Guide.

1.7.11. Data protection

In addition to consolidating several initiatives in the area of data protection and continuing its regular work in the field, the SESAR JU overcame two major challenges during 2020:

- the management of the unexpected COVID-19 pandemic and
- the impacts of the 'Schrems II' case law in the field of international data transfer.

The COVID-19 outbreak was a key challenge in 2020 and raised numerous questions concerning data protection and privacy issues. The SESAR JU took care to assess and document all tools used or procedures implemented in a response to the situation generated by the sanitary crisis ([47]), focusing on maintaining transparency and data quality and the trust of data subjects.

Further to the 'Schrems II' judgment of the Court of Justice of the EU, the European Data Protection Supervisor (EDPS) asked the EU institutions, bodies, offices and agencies to ensure and monitor the compliance of their ongoing and future international transfers of personal data with the judgment in relation to transfers of personal data to third countries, and in particular the United States. To this end, the SESAR JU carried out a mapping exercise and impact assessment of all its processing operations and ongoing contracts involving data transfers to third contracts ([48]). The SESAR JU carried out this exercise in close cooperation with EUROCONTROL and took advantage of this exercise to document all the processing operations conducted under the SESAR JU–EUROCONTROL agreement.

In parallel, the SESAR JU continued to demonstrate its compliance with the data protection regulation ([49]) on several levels.

- A data protection central register, populated with approximately 25 records, was created, following a three-level workflow ([50]), and published on the SESAR JU website. This initiative was a major achievement, and the support of SESAR JU senior management was necessary to ensure that the activities of every department complied with the data protection regulation ([51]). This achievement was recognised by the EDPS, which – following an audit of the register under Article 31(5) of the regulation – assessed the SESAR as 'largely compliant'.
- The SESAR JU cooperated closely with the EDPS, issuing specific reports on the use of social media, the register of records and international transfers, and notified a data breach to the EDPS on 27 July 2020.
- Several SESAR JU policies, such as 'Rules on restrictions of access to rights from data subjects' and 'Implementing rules of the data protection officer', were drafted in cooperation with the other JUs.
- Dissemination and outreach activities included an information session on the 'Use of images and videos'. The session focused particularly on the documentation of processing of personal data in the area of

([47]) Mainly the business continuity plan, webinars, a COVID-19 pandemic booking system to manage staff presence at the SESAR JU premises and systems to encourage social interaction among staff.

([48]) As a result of this exercise, the SESAR JU did not identify any transfer not based on any transfer tool, based on a derogation under Article 50 of the regulation or 'high-risk transfers' to the United States in the light of the judgment. 'High-risk transfers' are transfers to any entity clearly subject to Paragraph 702 of the Foreign Intelligence Surveillance Act or Executive.Order.123338 and involving large-scale processing operations; or complex processing operations or sets of operations; or processing of sensitive data or data of a highly personal nature. Only two specific processing operations involving international transfers (outside the EU/EEA) were identified, one to the United States and the other to New Zealand.

([49]) Regulation (EU) No 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC.

([50]) Each record was first drafted (by the person(s) internally responsible for the processing activity), then verified (by the DPO) and, finally, approved (by the SESAR JU controller).

([51]) Executive Director decision ref. SESAR JU/ED/716 on the delegation of the approver role for the publication of records of processing activities in the GDPR central.

communication, for example during events or meetings and on social media.

- SESAR JU staff received advice on the use of new software, grant agreements, interpretation of contracts, etc.
- The organisation cooperated extensively with other stakeholders in the area of joint controllership, for example by participating in the drafting working group on co-controllership of Commission services and agencies research family, the documentation of all processing operations conducted under the SESAR JU–EUROCONTROL agreement and the revision of various SLAs for the use of European Commission systems (e.g. ABAC, SYSPER).

1.7.12. Participation in support and coordination groups in 2020

In 2020, SESAR JU staff participated in a number of H2020 coordination groups, as follows:

- Common Implementation Centre (CIC) (four meetings, amounting to eight hours in total),
- Grant Management Steering Committee (two meetings, amounting to two hours in total),
- Grant Management Key User Group (five meetings),
- Proposal Submission and Evaluation Steering Committee (two meetings),
- CORDA Steering Committee and Key User Group (three meetings),
- Expert Management Steering Committee and Key User Group (four meetings),
- H2020 Legal Mechanism Issue Group (nine meetings),
- CIC Executive Committee (three meetings, amounting to seven hours in total),
- other CIC group (five meetings, amounting to 10 hours in total).

In addition, SESAR JU staff regularly participate in meetings of the EU agencies' networks:

- Heads of Agencies (two meetings, amounting to 15 hours in total),
- Heads of Admin (two meetings, amounting to 20 hours),
- Network of Agencies' Procurement Officers (one meeting),
- Inter-Agency Legal Network (two meetings),
- Network of DPOs (Data Protection Officer) of EU Institutions and Bodies (two meetings).

The SESAR JU also maintained a regular relationship with the Commission's Directorate-General for Mobility and Transport/Directorate-General for Energy Shared Resource Directorate.

1.8. Overall risk level

As reported in subparagraph 1.7.7.2, 'Risk management', in 2020 the SESAR JU executed its risk management process and implemented its risk management policy. This process requires the SESAR JU to focus on critical risks affecting the achievement of the SESAR JU objectives. A risk should be considered significant if its impact falls within at least one of the following categories.

- It jeopardises the achievement of strategic goals or the effective implementation of the mandate of the SESAR JU.
- It causes serious damage to SESAR JU's stakeholders or partners.
- It results in critical intervention at political level (e.g. Council/Parliament) regarding the SESAR JU's performance.
- It results in the infringement of laws or regulations.
- It results in significant material and/or financial loss.
- It jeopardises the safety of staff.
- It seriously damages the SESAR JU's image and reputation.

TABLE 10 SESAR JU CORPORATE RISKS AND RESPONSE PLAN SUMMARY AS AT THE END OF 2020

The information on the SESAR JU's critical risks is not public and may be made available on request in case of justified need.

Part IIa.
Management evaluation

2.1. Administrative Board

In 2020, the Administrative Board of the SESAR JU held three remote plenary meetings and maintained a similar pace in the adoption of decisions as in previous years, adopting 17 decisions through written procedures (Table 11). The main focus of the Administrative Board was to follow up the achievement of the SESAR JU's work programme for 2020 (as described in Part I of this document) and to adopt a number of decisions related to Implementing Rules of the Staff Regulation.

In this regard, the Administrative Board adopted the following decisions in 2020:

TABLE 11 ADMINISTRATIVE BOARD DECISIONS IN 2020

Subject	Type of decision	Date of adoption
Approval of the Internal Audit Capability Annual Audit Plan 2020	Written procedure	3/2/2020
Approval of the draft 2021–2023 SPD	Written procedure	30/1/2020
Adoption of the first amended 2020–2022 SPD	Written procedure	1/4/2020
Adoption of the 2020–2022 anti-fraud strategy	Written procedure	20/3/2020
Voting rights allocations	Written procedure	6/5/2020
Appointment of Vice-Chair	ADB 049	7/5/2020
Adoption of the second amended 2020–2022 SPD	Written procedure	3/7/2020
2019 CAAR	Written procedure	25/6/2020
Repayment of SESAR 1cash contributions	Written procedure	8/10/2020
Opinion on 2019 annual accounts	Written procedure	30/6/2020
Non-application of maximum duration of non-permanent staff in the Commission services	Written procedure	
SPD – amendment 3	Written procedure	23/11/2020
2019 annual accounts	Written procedure	
2021–2023 SPD	ADB 51	15/12/2020
HR amending Commission decision on leave	Written procedure	14/12/2020
HR amending decision on pension rights	Written procedure	14/12/2020
HR – updated 2020 organisation chart	Written procedure	

2.2. Major developments: facing the COVID-19 crisis

As reported in Part I, 'Achievements of the year', the SESAR JU met all its objectives in 2020. This was achieved in spite of the COVID-19 pandemic, which constituted an unprecedented crisis for the aviation sector and for the economy worldwide, and which also challenged traditional ways of working and the work relationships between people and organisations.

The SESAR JU took prompt action to provide financial support to stakeholders in the aviation sector severely affected by the crisis, as reported in paragraph 1.7.2, 'Financial management'. The SESAR JU was also quick to introduce teleworking and the ICT infrastructure necessary to support it. Teleworking was mandatory for all staff as from March 2020 and throughout the year. This is further explained in paragraph 1.7.8, 'Information and communication technologies management', subparagraph 1.7.7.1, 'Internal control and quality management', and in chapter 2.6, 'Strategy for efficiency gains, below'. An ICT infrastructure able to support effective and efficient business processes and agile solutions to manage processes electronically were key to continuity of operations in 2020.

Two further important areas to address were the organisation of management and staff well-being. The SESAR JU rapidly set up a crisis management team with members from all critical business areas. The team initially met every week, and still meets bimonthly today. In addition, an exercise to identify the risk presented by the COVID-19 pandemic was carried out (see chapter 1.8, 'Overall risk level').

To support staff during the COVID-19 pandemic, the Executive Director held five briefings for all staff, and which included time for staff questions. To support social interaction, informal remote meetings, open to all staff members, were held weekly. The SESAR JU also organised 'chat roulette', in which staff members are randomly matched with another with whom they can have an informal social conversation. This initiative was highly appreciated, strengthening contacts across teams and welcoming and bringing onboard of newcomers.

Furthermore, in October 2020 – together with the staff of six other JUs (Fuel Cells and Hydrogen, Clean Sky, Electronic Components and Systems for European Leadership, Innovation Medicines Initiative, Bio-based Industries and Shift2Rail) – SESAR JU staff were invited to participate in a training course on resilience, 'Coping in a time of COVID', facilitated by a professional certified coach. The course included breakout sessions to allow the staff of all participating JU to exchange views on the working conditions. The training was highly appreciated by participants and, because it was so successful, the executive directors of the JUs agreed to create up to three working groups to discuss on subjects of interest to the staff

of all JUs (well-being, effective teleworking and digital literacy).

The SESAR JU also carried out two staff surveys on teleworking, one in March 2020 and one in July 2020. The latest survey found that:

- 83 % (up seven percentage points compared with March 2020) of staff had not encountered significant IT issues while 17 % (down seven percentage points compared with March 2020) had done so;
- 19 % of staff considered teleworking much more efficient than working in the office, 22 % considered it slightly more efficient, 36 % considered the efficiency of teleworking and working in the office to be the same, 22 % considered teleworking to be slightly less efficient and no-one considered teleworking much less efficient.

The SESAR JU took on board the results of the surveys and implemented initiatives to further support the staff during the COVID-19 pandemic.

All initiatives were supported by the managers and the staff, which has allowed the SESAR JU to progress its work as planned despite the difficult situation it faced during the year.

2.3. Budgetary and financial management

2.3.1. Annual budget for 2020

The 2020 budget was adopted through the adoption of the 2020–2022 SPD in December 2019 and then modified through three amendments to the 2020–2022 SPD (see paragraph 1.7.6, 'Corporate planning and reporting').

- The first amendment authorised the re-inscription of unused appropriations.
- The second amendment authorised the agency to take exceptional financial measures in the face of the COVID-19 measures.
  - Pre-financing rates were increased from 20 % to 40 % for projects under the VLD 2 Open call and from 60 % to 80 % for projects under the Wave 2 (pre-financing of second instalments) and Wave 3 calls.
  - The exceptional reduction in cash contributions from members other than the EU and EUROCONTROL to cover the SESAR JU's running costs, which fell by 50 % in 2020, was compensated by a reduction in the SESAR JU's running costs for 2020 of EUR 2.3 million (21 %) .
  - The overall budget for the ER4 call was increased by EUR 15.4 million, and the additional money was used to fund the highest ranked proposals on the reserve list of projects.
- The third amendment was for an additional amount of EUR 13 million additional payment appropriation for Title 3 and for the increase of the VLD Open 2 call amount.

The 2020 budget, as modified through the three amendments to the 2020–2022 SPD, established an amount of EUR 153 491 122 in commitment appropriations and of EUR 169 461 158 in payment appropriations, representing a 1.9 % increase in commitment appropriations and a 0.2 % decrease in payment appropriations (–9.8 % for running costs only) in comparison with the 2019 budget (Table 12).

TABLE 12 **2020 BUDGET FIGURES IN COMPARISON WITH 2019**

Commitment appropriation	2019	2020	
Title I	6.044.372	5.454.684	-9,8%
Title II	3.612.935	3.022.095	-16,4%
Title III	140.901.014	131.630.939	-6,6%
Title IV	0	13.383.404	
Total	**150.558.321**	**53.491.122**	**1,9%**

Payment appropriation	2019	2020	
Title I	6.044.372	5.544.647	-8,3%
Title II	3.612.935	3.164.888	-12,4%
Title III	160.199.891	160.751.623	0,3%
Title IV	0	0	
Total	**169.857.198**	**169.461.158**	**-0,2%**

The 2020 budget included revenue (cash forecasted to be received, additional appropriations coming from carry-overs and internal assigned revenues) of EUR 153 491 122 (SESAR 2020 only) and payment appropriations (cash forecasted to be spent) of EUR 169 461 158 [52] (of which EUR 30 767 098 was for SESAR 1, for the reimbursement of excess financial contributions for the SESAR 1 programme, and EUR 138 694 060 was for SESAR 2020).

In terms of expenditure, the budget presented total available commitment appropriations of EUR 163 189 459 [53] (of which EUR 405 400 was for SESAR 1 and EUR 162 784 059 for SESAR 2020) and total payment appropriations of EUR 179 159 495 [54] (of which EUR 31 172 498 was for SESAR 1 and EUR 147 986 997 for SESAR 2020), made up as follows:

- initial commitment appropriations of EUR 134 993 503, amending budgets for EUR 16 322 402, carry-overs and assigned revenue for an amount of EUR 11 873 554,
- initial payment appropriations of EUR 127 267 702, amending budgets for EUR (7 769 502), carry-overs and assigned revenue for an amount of EUR 59 661 295.

[52] The amount of EUR 122 145 352 was inscribed in ABAC knowing that unused appropriations from previous years: (EUR 47 315 805) would be deducted from the previous year's revenue payment appropriations (when uploading the amending budgets, C2 inscriptions are posted only in expenditure and are deducted from revenue from previous years).

[53] Including initial budget, amending budgets, transfers and additional appropriations (carry-overs and assigned revenue).

[54] Including initial budget, amending budgets, transfers and additional appropriations (carry-overs and assigned revenue).

2.3.2. Implementation of the budget for 2020

2.3.2.1. Revenue

SESAR 2020

The total revenue received in 2020 (for SESAR 2020 programme) amounted to EUR 123 445 245, made up of an EU contribution, a contribution from the European Free Trade Association (EFTA), financial contributions from the other members and other contributions:

- EU contribution:EUR 109 083 059, of which:
  - administrative: EUR 3 268 071
  - operational: EUR 105 814 988,
- EFTA contribution: EUR 2 628 902,
- other contributions: EUR 5 733 284, of which:
  - EUROCONTROL: EUR 1 137 244
  - other members: EUR 1 303 103
  - other contributions ([55]): EUR 3 292 937.

In addition, the SESAR JU received EUR 6 000 000 in assigned revenue corresponding to the delegation agreement for U-space.

SESAR 1

Total revenue received was negative in 2020, EUR (30 393 021), owing to the financial closure of the SESAR 1 Programme and the reimbursement of excess financial contributions (for details, see subparagraph 2.3.2.1, 'Revenue: SESAR 2020'):

- EU contribution reimbursement: EUR (23 897 454), of which:
  - administrative: EUR (1 968 687)
  - operational: EUR (21 928 767),
- other contributions: EUR (6 495 567), of which:
  - EUROCONTROL reimbursement: EUR (4 778 826)
  - other members: EUR (1 798 305) (recovery of due cash contribution for EUR 325 836 and reimbursement for EUR (2 122 141))
  - other contributions: EUR 81 564.

The revenues established (recovery orders issued) amount to EUR 93 863 595 (61 % of the approved budget and of which EUR 111 711 961 is the EU contribution under the H2020 programme) and revenue actually received to EUR 93 052 223 (76 % of the approved budget, of which EUR 111 711 961 is the EU contribution).

It should be noted that the overall implementation rate (61 % in commitment appropriations and 76 % in payment appropriations) is highly influenced by the 'technical' operations needed to close the SESAR 1 programme.

Indeed, after consultation with the Directorate-General for Budget, the following operations were implemented in order to ensure the closure of the SESAR 1 programme:

- 1. 'hors budget' payment request (without consumption of payment appropriations inscribed in the 2020 budget of EUR 30 767 098),
- 2. regularisation of this 'hors budget' payment request through a regularisation recovery order to post the negative budget revenue on the income line(s) that were used for the initial contributions.

As a result of this approach, the aggregated (for all years) budget revenue and expenditure of the SESAR 1 programme will be corrected.

This means that the payment appropriations foreseen for the SESAR 1 programme (and for the reimbursement of the excess financial contributions) were 'consumed' by the negative revenue:

([55]) Such as reimbursements from the H2020 Guarantee Fund, recoveries after ex ante audits on projects, late interest, etc.

SESAR 1 Programme

Local Key	Comm. Credi.	Comm. Cons.	Pay. Credits	Pay. Cons.	Pay. Credits Avail.	Consumption	Description	Member
CSAR-I2020-2100	0,00	0,00	0,00	0,00	0,00	-4.778.826,05	CONTRIBUTION EUROCONTROL	EUROCONTROL
CSAR-I2020-3100	0,00	0,00	0,00	0,00	0,00	-2.122.140,74	CONTRIBUTION OTH MEMBERS	OTHER MEMBERS
CSAR-I2020-1100	0,00	0,00	0,00	0,00	0,00	-11.709.752,58	7TH RESEARCH AND DEV-EU contribution	EU
CSAR-I2020-1200	0,00	0,00	0,00	0,00	0,00	-12.187.701,67	TRANS-EUROPEAN NETW-EU contribution	EU
CSAR-B2020-3300	4.127,50	4.127,50		4.127,50		4.127,50	Ex-post audit desk review	OTHER MEMBERS
CSAR-B2020-3300	81.564,25			81.564,25		81.564,25	Positive ex-post audit	OTHER MEMBERS
CSAR-B2020-3300	323.835,49			323.835,49		323.835,49	Reimbursement 2 Other Members	OTHER MEMBERS
CSAR-B2020-3300								
					Total	**-30.388.893,80**		
						23.897.454,25	Paid to EU	
						4.778.826,05	Paid to EUROCONTROL	
						-323.835,49	Recover from 2 Members	
						2.122.140,74	Paid to Other Members	
						30.474.585,55		
						Still to be paid in 2021		
						292.512,67	30 Other Members	
						30.767.008,22	SESAR 1 closure Final	

Table 13 provides a breakdown of revenues by source (56) (for SESAR 1 and SESAR 2020 combined, then for SESAR 2020 and SESAR 1 separately).

TABLE 13 2020 BUDGET REVENUE BY REVENUE SOURCE

SESAR 1 + SESAR 2020

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8
Type of revenue	Commitment appropriations (*)	Actual Revenues established/ carried over	*% of budget*	Payment appropriations (**)	PA execution	*% of budget*	Outstanding (from 2019 only)	Outstanding (Total)
Contribution from the European Union	123.671.000	87.814.506	*71,0%*	135.609.415	87.814.506	*64,8%*	0	143.353.345
Assigned Revenues	0	6.000.000	*0,0%*	6.809.359	6.000.000	*88,1%*	0	0
Contribution from Eurocontrol	1.036.000	(3.641.583)	*-351,5%*	5.814.826	(3.641.583)	*-62,6%*	0	10.143.346
Contributions from other Members	1.319.005	(479.300)	*-36,3%*	3.409.823	(495.202)	*-14,5%*	15.902	11.886.933
Other sources of contribution and revenue	27.465.117	4.169.971	*15,2%*	17.817.735	3.374.502	*18,9%*	795.470	0
C2 inscriptions (*)	(2.175.217)			(47.315.805)				
TOTAL REVENUE	**151.315.905**	**93.863.595**	***62,03%***	**122.145.352**	**93.052.223**	***76,18%***	**811.372**	**165.383.625**

(*) EUR 151 315 905 were inscribed in ABAC knowing that unused appropriations from previous years: EUR 2 175 217 were deducted from previous years revenue payment appropriations (when uploading the amending budgets, C2 inscriptions are only posted in expenditure and are deducted in revenue from previous years).
(**) EUR 122 145 352 were inscribed in ABAC knowing that unused appropriations from previous years: EUR 47 315 805 were deducted from previous years revenue payment appropriations (when uploading the amending budgets, C2 inscriptions are only posted in expenditure and are deducted in revenue from previous years)

SESAR 1

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8
Type of revenue	Commitment appropriations	Actual Revenues established/ carried over	*% of budget*	Payment appropriations	Actual Revenues received	*% of budget*	Outstanding (from 2020 only)	Outstanding (Total)
Contribution from the European Union		(23.897.454)	*0,0%*	23.897.454	(23.897.454)	*-100,0%*		
Contribution from Eurocontrol		(4.778.826)	*0,0%*	4.778.826	(4.778.826)	*-100,0%*		
Contributions from other Members		(1.798.305)	*0,0%*	2.090.818	(1.798.305)	*0,0%*		
Other sources of contribution and revenue		81.564	*0,0%*		81.564	*0,0%*		
TOTAL REVENUE	**0**	**-30.393.021**	***0,0%***	**30.767.098**	**-30.393.021**	***-98,78%***	**0**	**0**

SESAR 2020

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8
Type of revenue	Commitment appropriations	Actual Revenues established/ carried over	*% of budget*	Payment appropriations	Actual Revenues received	*% of budget*	Outstanding (from 2020 only)	Outstanding (Total)
Contribution from the European Union	123.671.000	111.711.961	*90,3%*	111.711.961	111.711.961	*100,0%*		143.353.345 (*)
Assigned Revenues	0	6.000.000	*0,0%*	6.809.359	6.000.000	*88,1%*		0
Contribution from Eurocontrol	1.036.000	1.137.244	*109,8%*	1.036.000	1.137.244	*109,8%*		10.143.346
Contributions from other Members	1.319.005	1.319.005	*100,0%*	1.319.005	1.303.103	*98,8%*	15.902	11.886.933.
Other sources of contribution and revenue	27.465.117	4.088.407	*14,9%*	17.817.735	3.292.937	*18,5%*	795.470	
TOTAL REVENUE	**153.491.122**	**124.256.616**	***81,0%***	**138.694.060**	**123.445.245**	***89,01%***	**811.372**	**165.383.625**

(*) only in payment appropriations - The EU commitment appropriation was recei1.ed in its totality (EUR 585 million)

(56) In commitment appropriations: EUR 2 175 217 (reinscription of unused appropriations from previous years) is deducted from the previous year's commitment appropriations. In payment appropriations: EUR 47 315 805 (reinscription of unused appropriations from previous years) is deducted from the previous year's payment appropriations.

2.3.2.2. Expenditure

In C1 appropriation, the 2020 execution rate is 95.4 % in the case of commitment appropriations and 90.0 % in the case of payment appropriations (Table 14).

TABLE 14 2020 BUDGET IMPLEMENTATION IN COMMITMENT APPROPRIATIONS AND IN PAYMENT APPROPRIATIONS

C1 appropriation	Commitment appropriation	Committed	
Title 1	5.454.683,74	5.196.247,68	95,3%
Title 2	3.022.095,34	2.728.288,80	90,3%
Title 3	129.455.721,26	123.677.185,03	95,5%
Total	**137.932.500,34**	**131.601.721,51**	**95,4%**

C1 appropriation	Payment appropriation	Paid	
Title 1	5.544.646,75	5.192.405,38	93,6%
Title 2	3.164.888,43	2.945.853,91	93,1%
Title 3	110.788.664,84	99.465.008,45	89,8%
Total	**119.498.200,02**	**107.603.267,74**	**90,0%**

The reason for the commitments rate of 90.3 % under Title 2 is the low rate of execution (58 %) under 'Realisation of publications', with an unexecuted amount of EUR 169 000.

In payments, the rate of 89.8 % corresponds to an amount of EUR 11.3 million unspent, mainly because agreements for two VLD Open 2 projects with a pre-financing amount totalling EUR 2.9 million have not yet been signed and an amendment to a Wave 2 project for EUR 1.2 million has not yet been signed.

In terms of expenditure, total commitments amounted to EUR 141 761 861 (86.87 % of the total available appropriations budget), of which 87.09 % was for SESAR 2020 available appropriations and 0.00 % for SESAR 1 available appropriations. The total payments executed amount to EUR 121 207 122, that is 67.65 % of the total available budget, of which EUR 4 128 was for SESAR 1 (0.01 % of the total available appropriations) and EUR 121 202 995 for SESAR 2020 (81.90 % of the total available appropriations).

The low rate of payments implementation is due to the anticipated reimbursement of remaining financial contributions, as agreed by the Administrative Board on 8 October 2020.

The projects of the SESAR 1 programme were closed by 31 December 2016. Following ex post audit corrections, the financial and administrative closure of the programme was finalised in December 2019 (with the exception of an amount of EUR 71 422 to be recovered).

Following closure of the programme, it was calculated that the SESAR JU had received from its members excess financial contributions to SESAR 1 amounting to EUR 30 959 396. According to Article 13 of the SESAR JU's basic act, SESAR JU's members can expect reimbursement of their excess contributions only on dissolution of the JU, which will take place on 31 December 2024, unless the JU's Administrative Board decides before this to propose to the Commission the dissolution of the SESAR JU. However, the European Commission, respecting the principles of equality and sound financial management, has recommended that the financial contributions that the JU received in excess of actual needs should be reimbursed JU members as soon as possible.

To ensure that the agency has sufficient budget to execute the repayments, the Administrative Board has instructed the SESAR JU to record a cumulated budget out-turn of EUR 30 959 396 in the statement of revenue and in the statement of expenditure in the budget under chapter 3.3, 'Other members' operating expenditure S1'.

Following ex post audit corrections of the SESAR 1 programme, an amount of EUR 81 564 was recovered in May 2020 (instead of EUR 71 422). In addition, an amount of EUR 4 128 was paid for the ex post audit desk review in May 2020.

The amount of EUR 30 959 396 initially determined to be the excess financial contributions received from SESAR JU members for the SESAR 1 programme needs to be adjusted to EUR 30 767 098 (this budget out-turn is the result of all transactions done under the SESAR 1 programme, including recoveries resulting from ex post audit adjustments).

To ensure that the agency has sufficient budget to execute the repayments, the Administrative Board instructed the SESAR JU to record a cumulated budget out-turn of EUR 30 767 098 (this budget out-turn was confirmed by the Court of Auditors during its audit mission to the SESAR JU at the beginning of 2020) in the statement of revenue and in the statement of expenditure in the budget under chapter 3.3, 'Other members' operational expenditure S1'. After consulting the Directorate-General for Budget, the following operations were implemented.

- 1. A 'hors budget' payment request was entered (without consumption of payment appropriations inscribed in the 2020 budget of EUR 30 767 098).
- 2. This 'hors budget' payment request was regularised through a regularisation recovery order to post the negative budget revenue on the income line(s) that were used for the initial contributions. As a result of this approach, the aggregated (for all years) budget revenue and expenditure of SESAR 1 will be correct.

This means that the payment appropriations foreseen for the SESAR 1 programme (and for the reimbursement of the excess financial contributions) were 'consumed' by the negative revenue (as explained in subparagraph 2.3.2.1, 'Revenue').

As the SESAR JU is a multiannual programme (with a limited lifetime and fixed total budget ceilings), unused payment appropriations at the end of one budgetary year are not cancelled but inscribed as budget result in the revenues of the subsequent budget. The budget result for 2020 (i.e. total revenue received of EUR 93 052 223 minus total payments of EUR 121 207 122 minus exchange rate differences of EUR 3 990) amounts to a deficit of EUR 28 158 889 (a surplus of EUR 2 238 260 for SESAR 2020 and a deficit of EUR 30 397 149 for SESAR 1). The 2020 cumulative surplus that remains within the JU amounts to EUR 22 081 501 (of which EUR 21 788 989 for SESAR 2020 and EUR 292 513 for SESAR 1 ([57])).

Table 15 provides a breakdown of expenditures by Title (for SESAR 1 and SESAR 2020 combined, then for SESAR 2020 and SESAR 1 separately):

([57]) A total of EUR 292 513 remained to be reimbursed at the end of 2020. The final three members were reimbursed in January and February 2021 (see paragraph 2.3.2.1, 'Revenue').

TABLE 15 2020 BUDGET EXECUTION

SESAR 1 + SESAR 2020

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8	9
Type of expenditure	**Final Commitment appropriations**	**Commitments**	***% of budget***	**Payment appropriations *Budget 2020***	**Payments**	***% of budget***	**Commitments still to be paid**	**Payments (against commitments of the year)**	**Payments (against previous years' commitments**
Staff Expenditure	5.474.531	5.196.248	*94,9%*	5.564.494	5.192.405	*93,3%*	19.847	5.192.405	0
Administrative Expenditure	**3.022.920**	**2.728.289**	***90,3%***	**3.165.713**	**2.945.854**	***93,1%***	**825**	**2.945.854**	**0**
Operating Expenditure	154.692.007	133.837.324	*86,5%*	170.429.288	113.068.863	*66,3%*	1.287.343	103.320.463	9.748.400
1. Providing strategic steering to the SESAR programme	*4.675.499*	*574.000*	*12,3%*	*1.259.948*	*662.116*	*52,6%*	*0*	*662.116*	*0*
2. Deliver exploratory research	*12.984.449*	*12.984.449*	*100,0%*	*22.921.541*	*22.131.719*	*96,6%*	*0*	*18.113.501*	*4.018.218*
3. Deliver industrial research and validation	*95.636.895*	*93.815.943*	*98,1%*	*76.475.807*	*67.874.616*	*88,8%*	*1.287.343*	*62.144.434*	*5.730.182*
4. Deliver very large-scale demonstration activities	*25.551.360*	*24.861.497*	*97,3%*	*36.834.494*	*21.236.021*	*57.7%*	*0*	*21.236.021*	
5. Deliver SESAR outreach	*2.055.000*	*1.601.435*	*77,9%*	*1.765.000*	*1.160.263*	*65,7%*	*0*	*1.160.263*	*0*
Unused Appropriations not required in current Year	13.383.404								
SESAR 1 Programme	405.400	0	*0,0%*	31.172.498	4.128	*0,0%*	405.400	4.128	0
TOTAL EXPENDITURE	**163.189.459**	**141.761.861**	***86,87%***	**179.159.495**	**121.207.122**	***67,65%***	**1.713.415**	**111.458.722**	**9.748.400**
TOTAL REVENUE					**93.048.233 (*)**		**1.713.415**		
BUDGET RESULTS					**(28.158.889)**		**0**		

SESAR 2020

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8	9
Type of expenditure	**Final Commitment appropriations**	**Commitments**	***% of budget***	**Payment appropriations *Budget 2020***	**Payments**	***% of budget***	**Commitments still to be paid**	**Payments (against commitments of the year)**	**Payments (against previous years' commitments**
Staff Expenditure	5.474.531	5.196.248	94,9%	5.564.494	5.192.405	93,3%	19.847	5.192.405	
Administrative Expenditure	3.022.920	2.728.289	90,3%	3.165.713	2.945.854	93,1%	825	2.945.854	
Operating Expenditure	140.903.204	133.837.324	95,0%	139.256.790	113.064.735	81,2%	1.287.343	103.316.336	14.024.378
1. Providing strategic steering to the SESAR programme	*4.675.499*	*574.000*	*12,3%*	*1.259.948*	*662.116*	*52,6%*		*662.116*	
2. Deliver exploratory research	*12.984.449*	*12.984.449*	*100,0%*	*22.921.541*	*22.131.719*	*96,6%*	*0*	*18.113.501*	*4.018.218*
3. Deliver industrial research and validation	*95.636.895*	*93.815.943*	*98,1%*	*76.475.807*	*67.874.616*	*88,8%*	*1.287.343*	*62.144.434*	*5.730.182*
4. Deliver very large-scale demonstration activities	*25.551.360*	*24.861.497*	*97,3%*	*36.834.494*	*21.236.021*	*57,7%*		*21.236.021*	*4.275.979*
5. Deliver SESAR outreach	*2.055.000*	*1.601.435*	*77,9%*	*1.765.000*	*1.160.263*	*65,7%*		*1.160.263*	
Unused Appropriations not required in current Year	13.383.404					0,0%			
TOTAL EXPENDITURE	**162.784.059**	**141.761.861**	***87,09%***	**147.986.997**	**121.202.995**	***81,90%***	**1.308.015**	**111.454.595**	**14.024.378**
TOTAL REVENUE					**123.441.254**		**1.713.415**		
BUDGET RESULTS					**2.238.260**		**0**		

SESAR 2020

All figures in EUR	1	2	3=2/1	4	5	6=5/4	7	8	9
Type of expenditure	**Final Commitment appropriations**	**Commitments**	***% of budget***	**Payment appropriations *Budget 2020***	**Payments**	***% of budget***	**Commitments still to be paid**	**Payments (against commitments of the year)**	**Payments (against previous years' commitments**
Staff Expenditure			*0,0%*			*0,0%*			
Administrative Expenditure			*0,0%*			*0,0%*			
Operating Expenditure			*0,0%*			*0,0%*			
1. Studies/Development conducted by the SJU	*405.400*		*0,0%*	*31.172.498*	*4.128*	*0,0%*	*405.400*	*4.128*	*0*
2. Studies/Development conducted by other Members	*405.400*		*0,0%*	*31.172.498*	*4.128*	*0,0%*	*405.400*	*4.128*	
TOTAL EXPENDITURE	**405.400**	**0**	***0,0%***	**31.172.498**	**4.128**	***0,1%***	**405.400**	**4.128**	**0**
TOTAL REVENUE					**(30.393.021)**				
BUDGET RESULTS					**(30.397.149)**				

TABLE 16 NUMBER AND VALUE OF BUDGET TRANSFERS

Transfers Commitment appropriations

		Credit Local Key	Credit Central Key	Credit User Reference	Acceptance Date	TAMC
11-0	C1	SES.26631	CSAR20203720000244	TRANSFER 2020 FROM BUDGET LINE CSAR-B2020-1101-C1-SESAR202 T0 BUDGET LINE CSAR-B2020-1220-C1-SESAR2020 (INTERIM STAFF)	09-11-2020	-32.526,70
11-0						32.526,70
12-0	C1	SES.26631	CSAR20203720000244	TRANSFER 2020 FROM BUDGET LINE CSAR-B2020-1101-C1-SESAR202 T0 BUDGET LINE CSAR-B2020-1220-C1-SESAR2020 (INTERIM STAFF)	09-11-2020	-32.526,70
12-0						32.526,70
21-0	C1	SES.26642	CSAR20203720000252	TRANSFER FROM BL 2170 SECURITY MAINTENANCE AND BL 2820 LEGAL SUPPORT TO BUDGET LINE 2710 IT SYSTEM MAINTENANCE	25-11-2020	21.315,72
	C1	SES.26658	CSAR20203720000267	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	-0,60
21-0						21.315,12
22-0	C1	SES.26637	CSAR20203720000249	TRANSFER FROM BL 2730 HARDWARE TO BUDGET LINE 2720 SOFTWARE	16-11-2020	3.068,83
	C1	SES.26642	CSAR20203720000252	TRANSFER FROM BL 2170 SECURITY MAINTENANCE AND BL 2820 LEGAL SUPPORT TO BUDGET LINE 2710 IT SYSTEM MAINTENANCE	25-11-2020	-6.995,71
	C1	SES.26658	CSAR20203720000267	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	-2.004,29
22-0						-5.931,17
23-0	C1	SES.26619	CSAR20203720000234	TTRANSFER FROM BL 2170 TO BL 2830 TO COVER BAKER TILLY CONTRACT	16-10-2020	32.500,36
	C1	SES.26637	CSAR20203720000249	TRANSFER FROM BL 2730 HARDWARE TO BUDGET LINE 2720 SOFTWARE	16-11-2020	-3.068,83
	C1	SES.26658	CSAR20203720000267	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	0,00
23-0						29.431,53
24-0	C1	SES.26658	CSAR20203720000244	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	3.069,32
24-0						3.069,32
25-0	C1	SES.26658	CSAR20203720000244	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	-1.064,03
25-0						-1.064,03
27-0	C1	SES.26619	CSAR20203720000234	TTRANSFER FROM BL 2170 TO BL 2830 TO COVER BAKER TILLY CONTRACT	16-10-2020	-32.500,36
	C1	SES.26642	CSAR20203720000252	TRANSFER FROM BL 2170 SECURITY MAINTENANCE AND BL 2820 LEGAL SUPPORT TO BUDGET LINE 2710 IT SYSTEM MAINTENANCE	25-11-2020	-14.320,01
27-0						-46.820,37
28-0	C1	SES.26658	CSAR20203720000267	TRANSFER TO COVER EUROCAE (BL2630), VANBREDA (2640) & ICT SUPPORT CONSULTING (2750) FOR A TOTAL OF EUR CA 3.069,32 & PA EUR 25.915,87	14-12-202	-0,40
28-0						-0,40

2.3.3. SESAR 2020 multiannual budget execution

The execution rate, in terms of revenues committed (revenues established and recognised), was 98.0 %, while 75.3 % of payments were executed.

Validated in-kind contributions ([58]) amounted to EUR 347 477 097 (46.9 % of total estimated in-kind contributions based on SESAR JU membership agreement). This in-kind contribution validation concerns activities performed by the SESAR JU members other than the Union from the end of 2016 until the end of 2019:

([58]) Out of EUR 46 238 402 (reporting period 3 in-kind contributions), EUR 10 833 945 was validated at the beginning of 2021 and EUR 264 013 will be validated in reporting period 4.

Multi-annual revenues

all figures in EUR	1	2						3	4=2-3
			Revenues/Contributions actually received ('Payments')						
I. CASH CONTRIBUTIONS	SESAR 2020 Programme Maximum	Total Entitlements ('Commitments')	2016	2017	2018	2019	2020	Total 2016-2024	Open Entitlements still to be reached
EUROPEAN UNION CONTRIBUTION H2020 funds	585.000.000	585.000.000	56.519.225	75.497.292	84.184.652	113.733.525	111.711.961	441.646.655	0
EUROPEAN UNION CONTRIBUTION Assigned revenue	11.300.000	11.300.000		650.000	4.000.000	402.657	6.000.000	11.052.657	0
CONTRIBUTION FROM EUROCONTROL	25.000.000	14.856.654		6.682.000	5.189.144	1.137.244	1.137.244	14.145.631	10.143.346
CONTRIBUTION FROM OTHER MEMBERS	18.466.056	6.579.123			2.546.435	2.729.585	1.303.103	6.579.123	11.886.933
OTHER REVENUE	0	9.280.307		24.704	18.968	5.148.227	3.292.937	8.484.837	795.470
Total CASH Contributions	639.766.056	627.016.084	56.519.225	82.853.996	95.939.199	123.151.238	123.445.245	481.908.903	22.825.749
Cumulative Budget implementation rates (of Prog. Max.):		98,0%						75,3%	
II. IN-KIND CONTRIBUTIONS IKC (validated by the SJU)									
IKC from EUROCONTROL	433.418.444	186.250.536			59.602.725	66.067.916	60.579.895	186.250.536	247.167.908
IKC from OTHER MEMBERS	307.372.404	161.226.562			54.234.818	60.753.342	46.238.402	161.226.562	146.145.842
Total IN-KIND Contributions	740.790.848	347.477.097	0	0	113.837.543	126.821.258	106.818.296	347.477.097	393.313.750
Cumulative Budget implementation rates (of Prog. Max.):		46,9%						46,9%	
III. TOTAL CONTRIBUTIONS (I.+II.)	1.380.556.904	974.493.181	56.519.225	82.853.996	209.776.742	249.972.496	230.263.541	829.386.000l	416.139.4991
Cumulative Budget implementation rates (of Prog. Max.):		70,6%						60,1%	

(*) out of EUR 46.238.402 : EUR 10.833.945 were validated beginning of 2021 and EUR 264.013 will be validated with reporting period 4

On expenditure side, the commitments made reach 94 % of the total programme forecasts and payments made 72 % of the total programme's forecasts:

Multi-annual expenditure

all figures in million EUR	1	2						3	4=2-3
			Revenues/Contributions actually received ('Payments')						
I. Expenditure Budget Titles:	SESAR 2020 Programme Maximum	Total Commitments made	2016	2017	2018	2019	2020	Total 2016-2024	Open Commitments (RAL)
Running Costs *(Titles 1 & 2)*	585.000.000	585.000.000	56.519.225	75.497.292	84.184.652	113.733.525	111. 711.961	441.646.655	0
Operational Expenditure Non-Members *(Title 3)*	11.300.000	11.300.000		650.000	4.000.000	402.657	6.000.000	11.052.657	0
Operational Expenditure Members *(Title 3)*	25.000.000	14.856.654		6.682.000	5.189.144	1.137.244	1.137.244	14.145.631	10.143.346
TOTAL Expenditure:	639.766.056	601.035.450	49.919.493	62.361.177	76.785.510	150.619.397	121.202.995	460.888.572	147.784.132,38
Cumulative Budget implementation rates (of Prog. Max.):		93,9%						72,00%	
II. Budget Results									
Cash Contributions *(see Multi-annual revenues)*	639.766.056	627.016.084	56.519.225	82.853.996	95.939.199	123.862.261	123.441.254	482.615.936	144.400.148
Budget Result *(Revenues .I. Expenditure)*	0	25.980.633	6.599.732	20.492.819	19.153.689	-26.757.136	2.238.260	21.727.364	3.383.984

2.3.4. Financial closure of the SESAR 1 programme

Reimbursement of excess financial contributions

The decision to reimburse the cash remaining from the SESAR 1 programme was submitted to the Administrative Board of the SESAR JU on 7 May 2020, and was adopted on 8 October 2020 following a positive opinion from the Commission on the same day.

Airbus and DFS were asked to pay the balance that they still owed within the general balance between Members (other than the EU and EUROCONTROL). The payment from DFS was cashed on 1 December 2020 and the one from on 10 December 2020.

The SESAR JU reimbursed the EU on 4 December 2020 through two separate payment orders: one for the share corresponding to the Trans-European Transport Network (TEN-T) programme and one for the share corresponding to the Seventh Framework Programme (FP7).

The bilateral agreements resulting from the Administrative Board decision and to be signed with all members other than the EU (and Airbus and DFS) were sent to members on 23 November 2020. Payments were made once the signed agreements had been received. EUROCONTROL was paid on 9 December 2020. All but three other members (other than the EU and EUROCONTROL) that had signed their bilateral agreements were paid on 29 December 2020.

On 31 December 2020, all but three payments had been processed, for an amount of EUR 30 474 585.55 (out of EUR 30 767 098, i.e. 99%).

Overview of SESAR 1 programme execution

The final overall programme execution rate was 90.0 %, and for Title 3 only it was 92.8 % (Table 17).

TABLE 17 BUDGET EXECUTION FOR THE SESAR 1 PROGRAMME

	Commitment made	Payments made	Total programme	% Payments execution
Title 1	40.596.071	40.596.071	55.000.000	73,8%
Title 2	24.838.991	24.838.991	42.824.089	58,0%
Title 3	737.729.330	737.729.330	795.000.000	92,8%
Total	**803.164.392**	**803.164.392**	**892.824.089**	**90,0%**

At the end of 2020, the cash situation was as follows:

	Revenue received in 2020	Cash used during the year 2020	Cash at year end 2020
			30.689.661
Ex-post audit	81.564,25	(4.127,50)	
Reimbursement of excess of financial contributions	323.835,49	(30.798.421,04)	
EU		(23.897.454,25)	
EUROCONTROL		(4.778.826,05)	
Other Members	323.835,49	(2.122.140,74)	
Balance 01/01/2021	**405.399,74**	**(30.802.548,54)**	**292.513**

The final reimbursements of excess financial contributions, to three members, were executed in January and February 2021. The SESAR 1 programme is therefore totally closed.

	Revenue received in 2020	Cash used during the year 2020	Cash at year end 2020	2021 movements
			30.689.661	
Ex-post audit	81.564,25	(4.127,50)		
Reimbursement of excess of financial contributions	323.835,49	(30.798.421,04)		(292.513)
EU		(23.897.454,25)		
EUROCONTROL		(4.778.826,05)		
Other Members	323.835,49	(2.122.140,74)		(292.513)
Balance 01/01/2021	**405.399,74**	**(30.802.548,54)**	**292.513**	

2.3.5. In-kind contributions for the SESAR 2020 programme

During 2020, we assessed the in-kind contributions of SESAR JU members other than the EU for the third reporting period (covering activities performed in 2019), which amounted to EUR 106 818 296 (of which EUR 95 720 339 was validated in 2020, EUR 10 833 945 was validated in early 2021 and EUR 264 013 is still to be validated). For reporting periods 1, 2 and 3, a total of EUR 347 213 085 has been validated and an amount of EUR 264 013 is still undergoing validation. This validation is subject to the submission of certificates for the valuation of in-kind contributions certifying the actual costs incurred from the starting date of H2020-SESAR-2015-2 projects until the end of 2019.

		Reporting Period 1	Reporting Period 2	Reporting Period 3	All reporting period	Total		Reporting Period 4	Total	
MEMBERS	Total Net IKOP EUR (Total for SESAR2020) (a)	Net in-kind contribution validated 2018	Net in-kind contribution validated RP2 2019	Net in-kind contribution validated RP 2020	Net in-kind contribution still to be validated	Net in-kind contribution	% Total for SESAR2020	Estimates reported in January 2021	Net in-kind contribution	% Total for SESAR2020
AIRBUS	25.093.735	8.456.750	6.745.919	4.488.737		19.691.406	78,47%	1.110.735	20.802.140	82,90%
AT-ONE Consortium	11.867.806	2.182.055	2.462.078	2.438.023		7.082.157	59,68%	1.041.109	8.123.266	68,45%
B4 Consortium	1.985.379	191.414	624.579	446.221	6.421	1.268.635	64,22%	155.813	1.424.448	71,75%
COOPANS Consortium	8.676.061	1.488.668	1.851.508	710.548		4.050.724	46,69%	661.194	4.711.918	54,31%
DASSAULT Aviation	4.956.639	196.712	295.271	331.679		823.661	16,62%	185.837	1.009.498	20,37%
DFS	7.810.987	2.770.809	3.066.617	2.100.348		7.937.774	101,62%	1.341.566	9.279.339	118,80%
DSNA	9.190.202	2.027.338	2.026.127	1.528.476		5.581.941	60,74%	1.190.824	6.772.765	73,70%
ENAIRE	15.617.352	2.648.178	2.501.744	2.352.972		7.502.894	48,04%	1.998.992	9.501.886	60,84%
ENAV	7.499.310	1.236.711	1.479.624	1.351.172		4.067.507	54,24%	904.068	4.971.575	66,29%
FREQUENTIS Consortium	6.410.132	808.991	1.080.775	1.221.359		3.111.125	48,53%	565.328	3.676.453	57,35%
HONEYWELL AEROSPACE	14.546.257	3.021.431	3.284.206	2.019.526		8.325.163	57,23%	1.210.554	9.535.717	65,55%
INDRA	19.878.000	4.066.800	5.668.406	2.924.046		12.659.253	63,68%	2.189.750	14.849.003	74,70%
LEONARDO	45.835.829	6.671.150	8.608.064	5.709.422		20.988.636	45,79%	5.469.863	26.458.499	57,72%
NATMIG Consortium	9.960.423	2.050.535	1.990.565	1.977.098		6.018.198	60,42%	1.303.276	7.321.475	73,51%
NATS	8.708.327	1.405.703	1.829.382	1.413.114		4.648.199	53,38%	1.616.056	6.264.255	71,93%
SEAC2020 Consortium	3.263.000		666.154	308.691	36.936	1.011.781	32,14%	343.467	1.355.248	41,53%
SKYGUIDE	1.373.305	263.677	374.675	278.669		917.020	66,77%	116.511	1.033.531	75,26%
THALES AVS	32.713.185	8.052.589	7.434.047	8.029.077		23.515.713	71,88%	4.930.458	28.446.171	86,96%
THALES LAS	71.986.475	6.695.308	8.763.602	6.345.208	220.657	22.024.775	30,90%	4.369.348	26.394.123	36,67%
Total Other Members	**307.372.404**	**54.234.818**	**60.753.342**	**45.974.388**	**264.013**	**161.226.562**	**52,54%**	**30.704.749**	**191.931.311**	**62,44%**
EUROCONTROL	**433.418.444**	**59.602.725**	**66.067.916**	**60.579.895**	**0**	**186.250.536**	**42,97%**	**51.429.767**	**237.680.303**	**54,84%**
Grand Total	**740.790.848**	**113.837.543**	**126.821.258**	**106.554.283**	**264.013**	**347.477.098**	**46,94%**	**82.134.516**	**429.611.614**	**57,99%**

The estimates reported by all members in January 2021 (for costs incurred in 2020) amount to EUR 82 134 516, which brings total net in-kind contributions to EUR 429 611 614 (58 % of the net in-kind contributions laid down in the membership agreement).

2.3.6. Budget out-turn

With the SESAR JU being a multiannual programme (with a limited lifetime and a fixed total budget ceilings), unused payment appropriations at the end of one budgetary year are not cancelled but inscribed as a budget result in the revenues of the next budget. The budget result for 2020 (i.e. total revenues of EUR 93 052 223 minus EUR 121 207 122 total payments minus EUR 3 990 exchange rate differences) amounted to a deficit of EUR 28 158 889 (a surplus of EUR 2 238 260 for SESAR 2020 and a deficit of EUR 30 397 149 for SESAR 1 following the reimbursement of SESAR 1 excess financial contributions). The 2020 cumulative surplus that remains within the JU amounts to EUR 22 081 501 (of which EUR 21 788 989 is for SESAR 2020 and EUR 292 513 is for SESAR 1, representing the final reimbursements to three members in January and February 2021).

SESAR 1 + SESAR 2020

all figures in EUR	2020	2019	2018
REVENUE RECEIVED FOR THE YEAR			
Contribution from the European Union SESAR1	(23.897.454)		
Contribution from the European Union SESAR2020	117.711.961	114.136.182	88.184.652
Contribution from EUROCONTROL	(3.641.583)	1.848.266	5.189.144
Contributions from other Members	(495.202)	2.729.585	2.546.435
Other sources of contribution and revenue SESAR1	81.564	915.510	1.886.316
Other sources of contribution and revenue SESAR2020	3.292.937	5.148.227	80.633
TOTAL REVENUE (1)	**93.052.223**	**124.777.771**	**97.887.180**
TOTAL PAYMENTS MADE FOR THE YEAR			
Staff Expenditure SESAR2020	(5.192.405)	(5.325.094)	(5.219.663)
Administrative Expenditure SESAR1	0	0	(169.470)
Administrative Expenditure SESAR2020	(2.945.854)	(2.448.741)	(4.050.475)
Operational Expenditure SESAR1	(4.128)	(885.282)	(1.670.690)
Operational Expenditure SESAR2020	(113.064.735)	(142.845.562)	(67.515.373)
TOTAL EXPENDITURE (2)	**(121.207.122)**	**(151.504.679)**	**(78.625.670)**
EXCHANGE RATE DIFFERENCES	**(3.990)**		
BUDGET SURPLUS of the year (3)=(1)-(2) SESAR1	*(30.397.149)*	*30.228*	*46.157*
BUDGET SURPLUS of the year (3)=(1)-(2) SESAR2020	*2.238.260*	*(26.757.136)*	*19.215.353*
Total Budget Surplus previous year (4) SESAR1	30.689.661	30.659.434	30.613.277
Total Budget Surplus previous year (4) SESAR2020	19.550.729	46.307.865	27.092.512
NEW TOTAL BUDGET SURPLUS (5)=(3)+(4) SESAR1	**292.513**	**30.689.661**	**30.659.434**
NEW TOTAL BUDGET SURPLUS (6)=(3)+(4) SESAR2020	**21.788.989**	**19.550.729**	**46.307.865**
TOTAL BUDGET OUTTURN (7)=(5)+(6)	**22.081.501**	**50.240.390**	**76.967.299**

SESAR 1

all figures in EUR	2020	2019	2018
REVENUE RECEIVED FOR THE YEAR			
Contribution from the European Union SESAR1	(23.897.454)		
Contribution from EUROCONTROL	(4. 778.826)		
Contributions from other Members	(1.798.305)		
Other sources of contribution and revenue	81.564	915.510	1.886.316
TOTAL REVENUE (1)	**(30.393.021)**	**915.510**	**1.886.316**
TOTAL PAYMENTS MADE FOR THE YEAR			
Staff Expenditure SESAR1			
Administrative Expenditure SESAR1			(169.470)
Operating Expenditure SESAR1	(4.128)	(885.282)	(1.670.690)
TOTAL EXPENDITURE (2)	**(4.127,50)**	**(885.282,26)**	**(1.840.159,63)**
BUDGET SURPLUS of the year (3)=(1)-(2) SESAR1	*(30.397.149)*	*30.228*	*46.157*
Total Budget Surplus previous year (4) SESAR1	30.689.661	30.659.434	30.613.277
NEW TOTAL BUDGET SURPLUS (5)=(3)+(4) SESAR1	**292.513**	**30.689.661**	**30.659.434**

SESAR 2020

all figures in EUR	2020	2019	2018
REVENUE RECEIVED FOR THE YEAR			
Contribution from the European Union SESAR2020	117.711.961	114.136.182	88.184.652
Contribution from EUROCONTROL	1.137.244	1.848.266	5.189.144
Contributions from other Members	1.303.103	2.729.585	2.546.435
Other sources of contribution and revenue SESAR2020	3.292.937	5.148.227	80.633
TOTAL REVENUE (1)	**123.445.245**	**123.862.261**	**96.000.864**
TOTAL PAYMENTS MADE FOR THE YEAR			
Staff Expenditure SESAR2020	(5.192.405)	(5.325.094)	(5.219.663)
Administrative Expenditure SESAR2020	(2.945.854)	(2.448.741)	(4.050.475)
Operational Expenditure SESAR2020	(113.064.735)	(142.845.562)	(67.515.373)
TOTAL EXPENDITURE (2)	**(121.202.994,69)**	**(150.619.396,75)**	**(76.785.510)**
EXCHANGE RATE DIFFERENCES	**(3.990)**		
BUDGET SURPLUS of the year (3)=(1)-(2) SESAR2020	*2.238.260*	*(26.757.136)*	*19.215.353*
Total Budget Surplus previous year (4) SESAR2020	19.550.729	46.307.865	27.092.512
NEW TOTAL BUDGET SURPLUS (6)=(3)+(4) SESAR2020	**21.788.989**	**19.550.729**	**46.307.865**

TABLE 18 BUDGET OUT-TURN AND CANCELLATION OF APPROPRIATIONS

Budget out-turn	N-3* (2018)	N-2* (2019)	N-1* (2020)
Reserve from the previous year's surplus (+)	57 705 789	76 967 299	50 240 390
Revenue actually received (+)	97 887 180	124 777 771	93 052 223
Payments made (–)	(78 625 670)	(151 504 679)	(121 207 122)
Carry-over of appropriations (–)			
Cancellation of appropriations carried over (+)			
Adjustment for carry-over of assigned revenue appropriations from previous year (+)			
Exchange rate differences (+/–)			(3 990)
Adjustment for negative balance from previous year (–)			
TOTAL	**76 967 299**	**50 240 390**	**22 081 501**

*N is the year covered by the programming document drafted in N-1 (as per Article 32).

2.3.7. Budget implementation allocation by area of operation

Figure 26 shows the commitments budget allocation by area of operation.

FIGURE 26 2020 BUDGET ALLOCATION BY AREA OF OPERATION (COMMITMENTS)

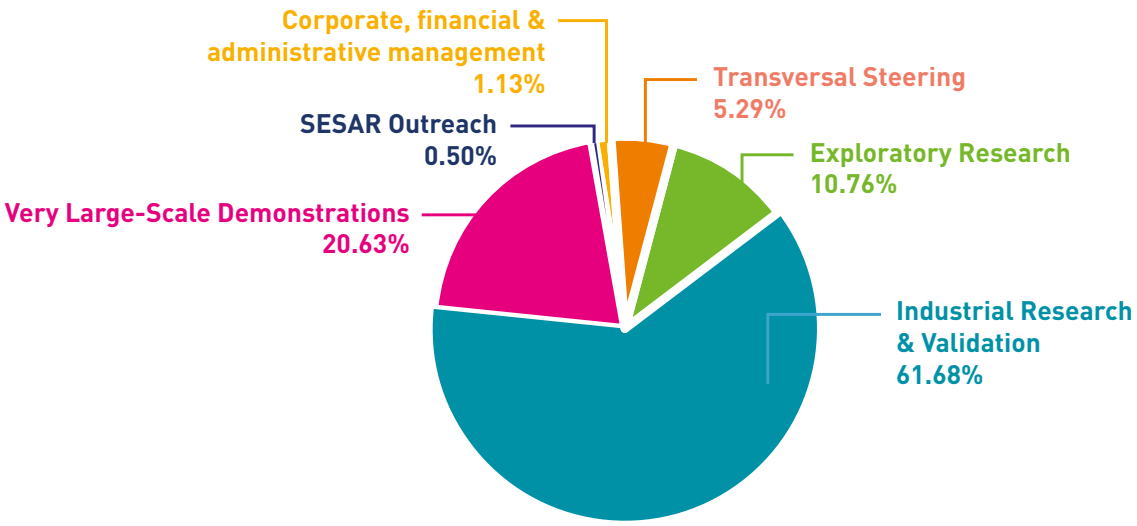
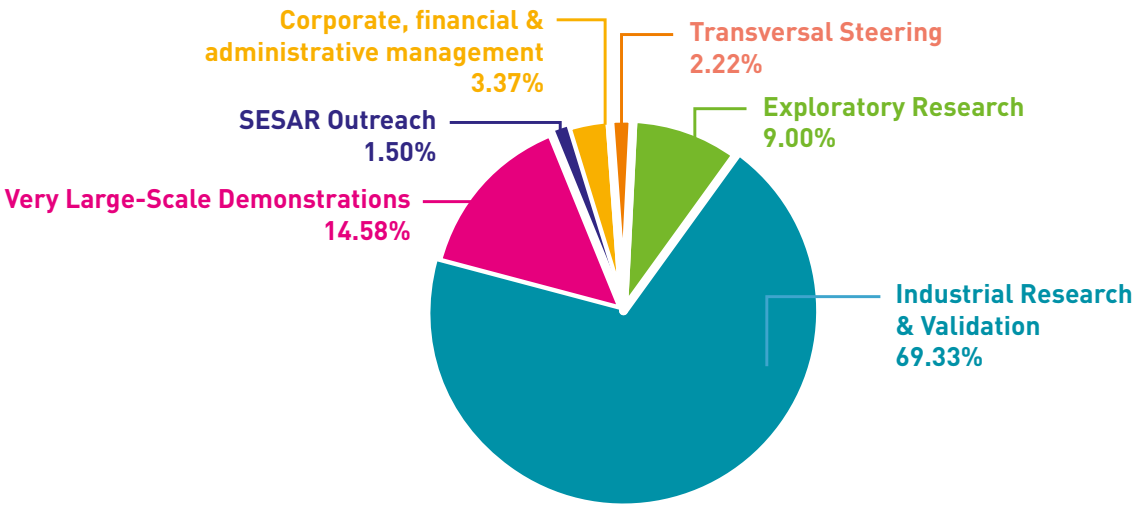


Figure 27 shows the payments budget allocation by area of operation (total).

FIGURE 27 2020 BUDGET ALLOCATION BY AREA OF OPERATION (PAYMENTS)



2.4. Delegation and subdelegation

In 2020, pursuant to Article 40 of the SESAR JU's financial rules, the authorising officer of the SESAR JU delegated his power of budget implementation to the SESAR JU authorising officer by delegation (AOD), the Deputy Executive Director. This delegation was signed on 17 December 2019 and is valid from 1 January 2020 until 31 December 2020.

According to Article 40 of the SESAR JU's financial rules, the delegatee may subdelegate the powers received with the explicit agreement of the Executive Director. The AOD subdelegated his power of budget implementation to the authorising officer by subdelegation (AOSD), the Chief Administration Affairs. This delegation was signed on 19 December 2019 and is valid from 1 January 2020 until 31 December 2020.

The empowered staff members can act only within the limits of the powers expressly conferred upon them. The AOD can act only in the absence or unavailability of the authorising officer or on ad-hoc temporary basis formalised through exchange of letters. The AOSD can act only in the absence of AOD, and can authorise transactions to a maximum amount of EUR 60 000.

In both cases, the delegatees are authorised to draw up individual budgetary commitments of appropriations; provisional budgetary commitments of appropriations; decisions on the award of financing agreements and public contracts; legal commitments; payment orders; and estimates of amounts receivable and recovery orders related to Titles 1, 2 and 3 of the SESAR JU budget.

The power delegated to the AOD also covers transactions related to the H2020 guarantee fund.

The AOD and AOSD have signed a charter which identifies the tasks entrusted, their rights and duties, and the responsibilities they assume in their capacity as AOD and AOSD.

In connection with the powers delegated to them, the AOD and the AOSD assist the authorising officer in reporting on the performance of their duties in the form of a biannual activity report. This report contains financial and management information including comments on the use made of these resources; information on the results of programmes operations or measures to achieve objectives set by the

SESAR JU; information on risks observed related to these programmes operations or measures; remarks on action taken following observations of the discharge, Court of Auditors or Internal Auditors and remarks on actions taken to remedy malfunctioning.

The SESAR JU Internal Audit Capability (IAC) performs twice a year an independent review of the transactions carried out by the AOD and AOSD and addresses a written report to the authorising officer with her conclusions.

2.5. Human resources management

The main achievements of the SESAR JU in 2020 in the field of HR management are reported in paragraph 1.7.3, 'Human resources management'. The Administrative Board also adopted decisions in relation to implementing rules (see Table 11), among which the following are related to HR management:

- ADB(D) 11-2020 on the non-application of the Commission Decision on the maximum duration for the recourse to non-permanent staff in the Commission services,
- ADB(D) 15-2020 amending Commission Decision on Leave,
- ADB(D) 16-2020 amending Commission Decision on Pension Rights.

In addition, the first phase of the implementation of SYSPER for Agencies was completed in November 2020, as reported in paragraph 1.7.3, 'Human resources management'.

The staff establishment plan can be found in Annex IV. Table 19 shows the results of benchmarking actual staff numbers at the end of 2020 against the staff establishment plan (including in addition three SNEs).

TABLE 19 BENCHMARKING ON HR

Job Type (sub) category	Year N-1 (%)	Year N (%)
Administrative support and Coordination	**29,1%**	**29,4%**
Administrative Support	15%	16%
Coordination	14%	13%
Operational	**61,2%**	**62,1%**
General operational	25%	23%
Programme management	24%	25%
Top-level operational coordination	10%	10%
Evaluation & Impact assessment	3%	3%
Neutral	**9,6%**	**8,5%**
Finance	10%	8%
Control	0%	0%

2.6. Strategy for efficiency gains

To cope with the complexity stemming from the management of its activities, the SESAR JU continued to strive for further efficiency gains.

This was particularly important in 2020 because contributions from members of the SESAR JU other than the EU were at risk as a consequence of the COVID-19 crisis and its impacts on the aviation sector. Furthermore, efficiency gains contribute to the mitigation of a major risk with reference CORP05, 'The SESAR JU may not be able to take up new challenges due to limited human resources' (see Annex VIII to the SESAR JU's 2020–2022 SPD).

In 2020, the SESAR JU benefited from efficiency measures already implemented in previous years and implemented new measures to achieve further efficiency gains.

- **Quality management.** The SESAR JU undertakes regular process improvement initiatives in the context of the SESAR JU QMS (see paragraph 1.7.7, 'Corporate quality management') supervised by the QICT Committee, in order to monitor effectiveness and efficiency of business processes and IT tools, and focus on value-added activities. In 2020, quality management in the SESAR JU focused not only on continuous improvement, which is at the core of the JU's quality management approach, but also on the implementation of the ICF.
- **Information and document management.** The QICT Committee also supervises the implementation and continuous improvement of the SESAR JU's IDMS, which aims to simplify and streamline the management of information and documentation within the organisation. The IDMS is based on software implemented in 2017 and has been continually improved since then. The SESAR JU has also considered the implementation of modules in ARES (the European Commission's record management system) to streamline communication with Commission services.

However, at the request of the Commission this has been postponed due to the COVID-19 crisis and limited HR availability on the Commission side.

- **Electronic workflows.** The managed configuration of electronic systems supporting quality and information processes and key workflows that can be operated either locally or remotely made it possible to implement teleworking measures with minimal impact on the SESAR JU's business continuity. The SESAR JU's ICT system, which includes collaboration platforms and electronic workflows, in combination with ABAC workflows, proved to be effective in supporting the most critical processes and those with strict deadlines. In 2020, ICT played a crucial role in the SESAR JU's mitigation plan and response to any potential reinstatement of COVID-19 protective measures. In addition to ensuring continuity of operations, the electronic workflows developed have resulted in a reduction in approval cycles and in operational risks such as the risk of losing documents.
- **Reduction in the number of staff missions.** In 2020, the number of missions undertaken by SESAR JU staff was reduced, with many activities, especially recurring monitoring activities, such as project reviews, replaced with video-conferences (see paragraph 1.7.10, 'Travel coordination'). Most meetings with grant beneficiaries relating to ER, IR and VLD projects, other than critical meetings such as kick-off meetings and critical reviews, took place by video-conference, with significant benefits such as a reduced environmental footprint, increased efficiency and better work–life balance for participants. As a result of COVID-19 restrictions, the SESAR JU also regularly used on-line collaboration platforms for meetings, and increased staff familiarity with these systems is likely to mean that the number of staff missions continues to be lower than in the past, even after travel restrictions are removed.
- **Launch in operation of the HR information system SYSPER for Agencies.** SYSPER for Agencies was implementd to streamline the management of HR-related transactions and reporting. Further information on this tool can be found in paragraph 1.7.3, 'Human resources management'. Highlight cost reduction and on running costs < max. See RTD productivity indicator.

2.7. Assessment of audit and ex post evaluation results during the reporting year

2.7.1. Internal Audit Service

Over the course of 2020, the Internal Audit Service (IAS) performed an audit entitled 'Audit on Horizon 2020 grant implementation in the SESAR JU'. The fieldwork took place remotely and the final report was issued on 8 December 2020.

The auditors concluded that, overall, the internal controls put in place by the SESAR JU for the implementation of grant agreements under H2020 are adequately designed and efficiently and effectively implemented. The auditors also expressed appreciation for the sound set of controls on project communication activities and on the specific amendment procedure on budgetary grounds.

The auditors issued four recommendations rated 'important' (Table 20). There were no 'critical' or 'very important' recommendations.

TABLE 20 RECOMMENDATIONS FROM THE AUDIT ON H2020 GRANT IMPLEMENTATION IN THE SESAR JU

Author	Topic and final date of the report	Recommendation	Criticality	Current status
IAS	Audit on H2020 grant implementation	Recommendation 1: implementation of a risk-based approach to ex ante controls	Important	Action plan under implementation
IAS	Audit on H2020 grant implementation	Recommendation 2: monitoring of project dissemination, exploitation and communication	Important	Action plan under implementation
IAS	Audit on H2020 grant implementation	Recommendation 3: project monitoring – definition and documentation of roles	Important	Action plan under implementation
IAS	Audit on H2020 grant implementation	Recommendation 4: reporting on H2020 indicators	Important	Action plan under implementation

In order to address these recommendations and underlying risks, the SESAR JU set up a detailed action plan which the IAS confirmed is suitable. The SESAR JU expects to implement all actions by year-end 2021.

2.7.2. Internal Audit Capability

In 2020, the IAC performed activities in accordance with the 2019 IAC annual audit plan , which was approved by the SESAR JU Administrative Board ([59]). These activities focused on assurance audits and consulting engagements.

In this context, ad-hoc advice on efficient and effective management and ethics was provided on a regular basis. The IAC twice performed a compliance review related to all payments executed by the AOD and the AOSD and contributed to the validation of ABAC user authorisations. The IAC also updated the SESAR JU anti-fraud strategy and held four sessions for staff on awareness-raising on ethics and anti-fraud measures (see subparagraph 1.7.7.4, 'Anti-fraud').

Furthermore, the IAC liaised with the IAS, the European Court of Auditors and other relevant audit actors, monitored the implementation of several SESAR JU action plans related to past audits and followed up on the discharge procedure regarding the 2017 and 2018 SESAR JU accounts. The IAC also coordinated the audit on H2020 implementation performed by the IAS and provided written replies to the European Court of Auditors in the context of the annual audit of the 2019 accounts.

In terms of internal control, the IAC was involved in the exercise to develop relevant key control indicators to assess the effectiveness of control activities and detect control weaknesses. A representative of the IAC was also a member of the SESAR JU COVID-19 crisis cell (see chapter 2.2, 'Major developments: facing the COVID-19 crisis').

The IAC reported regularly to the SESAR JU Administrative Board on risks, audits and implementation of recommendations. In addition, a detailed annual report on IAC and general audit activities in 2020 will be provided to the SESAR JU Administrative Board in Q2 2021.

2.7.3. European Court of Auditors

On 12 November 2020, the European Court of Auditors (ECA) published the final report on the annual audit of the SESAR JU accounts for the 2019 financial year. The report concluded the following.

- The SESAR JU accounts present fairly, in all material respects, the financial position of the SESAR JU, the results of its operations, its cash flows and the changes in net assets for 2019, in accordance with its financial regulation and with accounting rules adopted by the Commission's accounting officer.
- The revenue underlying the accounts for 2019 is legal and regular in all material respects.
- The payments underlying the accounts for 2019 are legal and regular in all material respects.

The ECA made observations related to the implementation of the FP7 and H2020 budget and internal controls. The report also included a follow-up of previous years' observations. In particular, the Court mentioned the excess members' cash contribution still held by the SESAR JU and the fact that the SESAR JU still needs to develop further relevant key control indicators to assess the effectiveness of its control activities and detect control weaknesses. Both items have now been addressed by the SESAR JU. The full report including the reply from the SESAR JU can be found on the ECA website ([60]).

([59]) ADB(D)01-2020, approval of the IAC 2020 annual audit plan.

([60]) https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=54396

2.7.4. Project audits

The main indicators of legality and regularity of Research and Innovation Framework Programmes are:

- the **representative detected error rate**, which is based on errors detected by *ex post* audits of a common representative sample of cost claims across the R & I family;
- the **cumulative residual error rate**, which is the extrapolated level of error after corrective measures have been implemented by the Commission services following the audits, accumulated on a multiannual basis.

Owing to its multiannual nature, the effectiveness of the control strategy of the R & I Directorates-General can only be fully measured and assessed in the final stages of the Framework Programme, once the ex post control strategy has been fully implemented and systematic errors have been detected and corrected.

For H2020, the objective is to obtain a cumulative residual error rate in the range 2–5 %, preferably as close as possible to 2 %, but not necessarily lower than 2 %.

Progress against these objectives is assessed annually based on the results of the implementation of the ex post audit strategy and taking into account the frequency and importance of the detected errors along with cost–benefit considerations regarding the effort and resources needed to detect and correct the errors.

As a result of the COVID-19 pandemic crisis and related travel limitations during 2020, the Common Audit Service (CAS) – in line with the instructions of the Commission – had to postpone on-the-spot missions until further notice. To minimise the impact of COVID-19 on the implementation of the audit campaign, the CAS converted traditional in-house audit assignments into desk audits, in line with international best practice and auditing standards. In the case of outsourced audits, the CAS instructed audit firms to maximise the number of audits carried out remotely with a view to complementing these

with on-the-spot audit missions once travel restrictions have been eased.

Despite travel restrictions, and other objective challenges due to the pandemic, in 2020 the CAS finalised audits on 790 participations, a remarkable 94 % of its target.

Results of the Horizon 2020 ex post audits

Control results for H2020 are related to audits launched by the CIC's CAS.

The error rates for H2020 (61) as of 31 December 2020 were:

- representative detected error rate: 2.95 % ([62]),
- cumulative residual error rate for the re family of R & I directorates-general: 2.16 % (2.24 % for the Directorate-General for Research and Innovation).

The above-presented error rates should be treated with caution because not all the results of the three common representative samples are yet available and, therefore, the error rate is not fully representative of the expenditure being controlled. Moreover, the nature of expenditure in the first years of the programme may not be totally representative of the expenditure across the whole period.

Since H2020 is a multiannual programme, the error rates, and especially the residual error rate, should be considered over the long term. Specifically, the cleansing effect of audits will tend to increase the difference between the representative detected error rate and the cumulative residual error rate, with the latter reducing over the course of the programme.

As was the case last year, there is evidence that the simplifications introduced in H2020, along with the ever-increasing experience of the major beneficiaries, has reduced the number and level of errors. However, beneficiaries still make errors, sometimes because they lack a thorough understanding of the rules, sometimes because they do not respect them.

In conclusion, the Directorate-General for Research and Innovation considers that the 2020 cumulative residual error rate for H2020 will fall within the target range established in the financial statement (63) and, therefore, no reservation for H2020 expenditure is necessary.

Results of the *ex post* SESAR-specific audits

In 2019, a snapshot of the population of the core SESAR activities (IR-VLD) was taken on 25 June. The amounts that had been paid by that cut-off date (a total of EUR 118 million) resulted in a sample of 17 participations in 13 beneficiaries and an audit coverage of 9 %. This sample was supplemented by an additional 10 participations as top-ups to the above population.

The CAS finalised audit reports, to 31 December 2020, covered 22 participations in 11 beneficiaries (out of a total of 27 participations in 15 beneficiaries) and resulted in a detected error rate of 3.46 %, with a systematic error rate of 3.12 % and a residual error rate of 2.49 %. The SESAR cumulative residual error rate was 1.00 %.

([61]) The H2020 audit campaign started in 2016, at which time three common representative samples with a total of 467 expected results were selected for audit. By the end of 2020, cost claims amounting to EUR 24.3 billion had been submitted by the beneficiaries to the services. The audit coverage for H2020 is presented in Annex VII. In addition to the common representative samples, common risk samples and additional samples were selected, amounting in total to 4 047 participations. The audits of 2 906 participations were finalised by 31 December 2020 (of which 790 in 2020). This sampling accommodates the special needs of certain stakeholders with regard to audit coverage and selection method. In addition, top-ups, which are participations of selected beneficiaries and which are added to the selected participations, are included in the total participations selected.

([62]) Based on the 334 representative results out of the 467 expected in the three common representative samples.

([63]) The legislative financial statement accompanying the Commission's proposal for the H2020 regulation states: 'The Commission considers therefore that, for research spending under Horizon 2020, a risk of error, on an annual basis, within a range between 2–5 % is a realistic objective taking into account the costs of controls, the simplification measures proposed to reduce the complexity of rules and the related inherent risk associated to the reimbursement of costs of the research projects. The ultimate aim for the residual level of error at the closure of the programmes after the financial impact of all audits, corrections and recovery measures will have been taken into account is to achieve a level as close as possible to 2 %'.

In 2020, a first snapshot of the population was taken on 31 May and a second snapshot was taken on 31 August. Audit of the cost claims received and paid by these cut-off dates resulted in a sample of 14 participations in 12 beneficiaries. This sampled population was topped up with one more participation. The results of these audits will be available in 2021.

2.8. a Follow-up of recommendations and action plans for audits and evaluations

In December 2020, four audit recommendations with a criticality level of 'important' were issued by the IAS in the context of the 'Audit on Horizon 2020 grant implementation in the SESAR JU' (see paragraph 2.7.1, 'Internal Audit Service'). The SESAR JU has set up an action plan to address these recommendations and expects to be able to implement these actions by year-end 2021.

Three recommendations that resulted from a previous audit, carried out by the IAS in 2018, on 'Coordination with the Common Support Centre (CSC) and implementation of CSC tools and services in the SESAR JU', were formally closed by the IAS in January 2020.

As a result, all IAS and ECA recommendations stemming from before 2020 have been implemented and are now officially closed.

2.8 b Follow-up of recommendations issued following investigation by the European Anti-Fraud Office

The SESAR JU was not subject to an investigation led by the European Anti-Fraud Office (OLAF) in 2020.

However, in November 2020, the SESAR JU was informed by the CAS that a red flag had been raised during an *ex post* audit of a SESAR JU project, indicating suspicion that fraud may have been committed by a SESAR JU beneficiary. At the time of writing of this report, the suspicion had not been confirmed, but OLAF and the relevant Commission services had been informed.

In accordance with the SESAR JU anti-fraud strategy ([64]), the SESAR JU uses the following indicators to report on OLAF cases.

- Number of files sent to OLAF for investigation. In 2020, one case of suspected fraud was reported to OLAF by the CAS.
- Time elapsed between receipt by staff or management of first information on alleged internal fraud and transmission to OLAF. This is not applicable as the information regarding the red flag was sent directly by the CAS to OLAF.
- Time elapsed between OLAF requests for information and date when information is provided to OLAF. This is not applicable as, at the time of writing of this report, OLAF had not opened a case.
- Time elapsed between receipt of an OLAF report and the decision on recovery or disciplinary sanctions by the SESAR JU. This is not applicable as, at the time of writing of this report, OLAF had not opened a case.

No follow-up actions to implement OLAF recommendations from previous years were required.

([64]) SESAR JU Administrative Board decision No ADB(D)04-2020, signed on 12 March 2020, on the updated 2020–2022 Anti-Fraud Strategy.

2.9. Follow-up of observations from the discharge authority

2.9.1. Discharge 2018 financial year

In May 2020 (65), the European Parliament granted discharge to the SESAR JU in respect of the implementation of the budget for the 2018 financial year and approved the closure of the accounts of the SESAR JU for the 2018 financial year.

In its resolution, the European Parliament made observations regarding budget and financial management; the multiannual budget implementation under FP7, TEN-T and H2020; performance; procurement and recruitment procedures; internal control; internal audits; and issues concerning the deployment phase of the SESAR project.

The resolution also included observations from the Transport and Tourism Committee. The Transport and Tourism Committee noted, in particular:

- 'The importance of the work of the SESAR JU in helping to accelerate innovation uptake and its role in the significant development of U-space and the production of a blueprint to enable the safe introduction and use of drones in the low-level airspace, which is the basis for a modern and rapidly growing sector' and
- 'The importance of the SESAR JU in preparing for the update of the European ATM Master Plan toward a Digital European Sky through a holistic and passenger-centric digital transformation of aviation' (66).

The observations of the Parliament have been formally acknowledged by the SESAR JU. The SESAR JU replied in writing to the Parliament, outlining the measures that the SESAR JU intends to adopt to address the observations made by the European Parliament.

The majority of the replies to the Parliament consisted of further clarifications or details regarding the context of observations. Notably, the SESAR JU provided details of the context of an observation made by the ECA in 2018. The SESAR JU also informed the Parliament on the content of the SESAR JU communication strategy and the wide range of channels the SESAR JU uses to communicate its activities and encourage market uptake. Furthermore, the SESAR JU updated the Parliament on the status of an audit performed in 2018 by the IAS regarding coordination between the SESAR JU and the Common Support Centre.

(65) European Parliament decision No 2019/2100(DEC) of 13 May 2020 on discharge in respect of the implementation of the budget of the SESAR Joint Undertaking for the financial year 2018.

(66) European Parliament decision No 2019/2100(DEC) of 13 May 2020 on discharge in respect of the implementation of the budget of the SESAR Joint Undertaking for the financial year 2018, paragraph 37.

2.9.2. Discharge 2019 financial year

In 2020, the SESAR JU supported the European Parliament in the discharge to the SESAR JU in respect of the implementation of the budget for the 2019 financial year and approved the closure of the accounts of the SESAR JU for the 2019 financial year. This procedure will be completed at the beginning of 2021.

2.10. Environment management

As the SESAR JU is a tenant, and does not own its premises, and owing to the COVID-19 crisis, resulting in mandatory teleworking from March 2020 (see chapter 2.2, 'Major developments: facing the COVID-19 crisis'), with very limited presence of staff by derogation of the Executive Director, the SESAR JU had limited opportunity to adopt new environmentally friendly measures. As a result of the crisis, the consumption of paper for printers and cleaning services was significantly reduced, resulting in drastic reductions in waste. Furthermore, as reported in paragraph 1.7.10, 'Travel coordination', the reduction in the number of missions carried out in 2020 had a positive impact on the environmental footprint of the SESAR JU.

2.11. Assessment by management

Based on the control procedures performed by staff of the SESAR JU, a positive conclusion on the legality and regularity of transactions can be drawn.

This conclusion takes into consideration the need for SESAR JU to maintain a high level of efficiency of its internal control environment and to constantly assess and strengthen the existing controls in order to implement the ICF and to ensure the achievement of objectives in its annual work programme.

Overall budget implementation rate

As a result of budget monitoring throughout the year, the budget execution rate in 2020 was 61 % for revenue commitment appropriation execution and 95.4 % for expenditure commitment appropriation (see also subparagraphs 2.3.2.1, 'Revenue', and 2.3.2.2, 'Expenditure').

Legality and regularity

In order to ensure the sound financial management, legality and regularity of the underlying transactions, all transactions are submitted to the four eyes principle in the preparation phase as well as in the payment phase. The ex ante control function is exercised at operational level, to verify the work performed during the initiation of the transaction to ensure that the required results are achieved, and at financial level to verify the application of the rules.

The extensive ex ante controls helped prevent material errors and formal errors at all stages of the authorisation process (initiation, verification, authorisation and payment).

Procurement procedures

Six procurement procedures were launched and concluded in 2020. In addition, some procedures launched in previous years concluded in 2020, and some amendments were implemented. More details can be found in paragraph 1.7.5, 'Procurement activities'.

Registration of exceptions – report

The SESAR JU has established an exceptions and non-compliance events management process, authorised in 2018 in the SESAR

JU QMS through a decision of the Executive Director (67). This process includes the maintenance of 'exceptions and non-compliance events register' to manage and monitor possible deviations which are not initially foreseen by the procedures submitted to the authorising officer with a justification for endorsement. If such control overrides or deviations are approved before action is taken (ex ante), they are called 'exceptions'. If they are detected after an action has been taken (ex post), they are known as 'non-compliance events'. Non-compliance events can constitute a breach of existing regulatory and/or contractual provisions and can be the result of errors, flaws or even fraud. Non-compliance events reflect a deficiency in existing controls. They cannot be authorised (as in the ex ante cases), but should be reported by the appropriate management level.

In accordance with the abovementioned policy and process, in 2020, the SESAR JU recorded:

- one non-compliance event (payment of 2020 fees for services provided by the Directorate-General for Budget) and
- three exceptions: two linked to the COVID-19 crisis (electronic signature workflows put in place for legal documents/commitments and financial workflows) and one linked to the extension of the Scientific Committee.

The exceptions and non-compliance events register is available on request and is, for instance, consulted by the ECA during audits.

Audit results and recommendations

In 2020, no critical recommendations were issued or closed, and on 31 December 2020 no critical recommendations were open.

Actions in relation to recommendations issued by the IAS in 2020 (see paragraph 2.7.1, 'Internal Audit Service') are in progress. Moreover, all previous audit recommendations stemming from the IAS, the ECA and the European Commission either have been formally closed or have been submitted for closure. See chapter 2.8 a, 'Follow-up of recommendations and action plans for audits and evaluations', for further detail.

Business continuity

Despite the COVID-19 crisis, the SESAR JU was able to ensure continuity of its operations and achieved all its objectives with no major disruption of service. See chapter 2.2, 'Major developments', for further detail.

(67) Executive Director decision 647 of 23 March 2018.

Part IIb.
External evaluations

The SESAR JU was subject to two evaluations in 2017. One concerned the closure of the SESAR 1 programme (final evaluation of SESAR 1: 2007–2016), while the second focused on ongoing research activities under the SESAR 2020 programme (interim evaluation of SESAR 2020: 2014–2020).

The SESAR JU management considers that the action plan related to both evaluations has been implemented except for one recommendation which has been put on hold as it is subject to the next Multiannual Financial Framework perspectives.

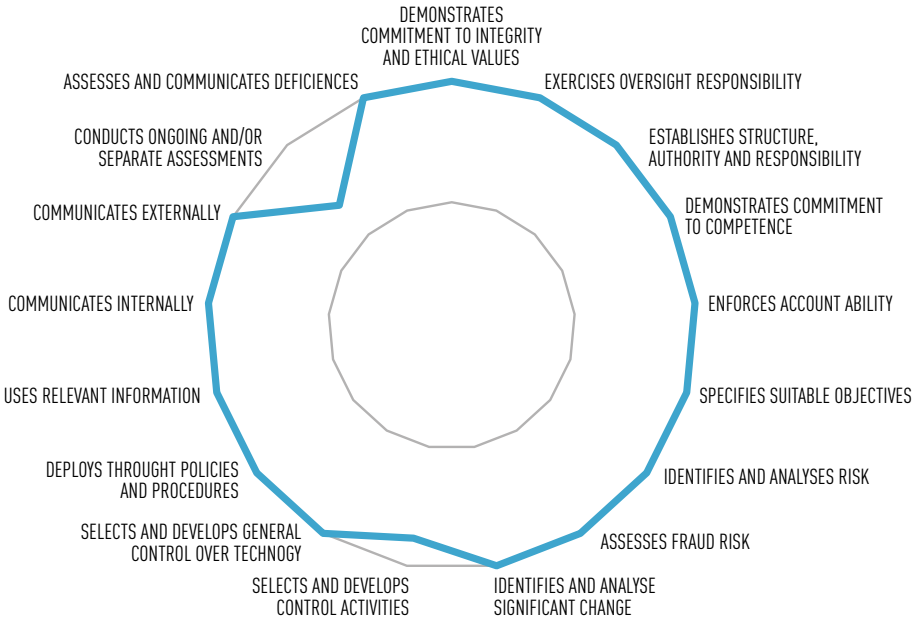
In 2020, the SESAR JU was not subject to an external evaluation.

Part III. Assessment of the effectiveness of the internal control systems

3.1. Effectiveness of internal control systems

The corporate management team reviews, assesses and monitors its internal control in accordance with the ICF introduced by the European Commission in 2017. This is done on a yearly basis, by assessing each of the 50 characteristics of the 17 principles across the five components of the ICF (68), with each given a rating of 1–3 (3 = full compliance; 2 = partial compliance requiring improvement; 1 = non-compliance requiring action plan). The assessment of the principles for 2020 is shown in Figure 28.

FIGURE 28 ASSESSMENT BY THE SESAR JU MANAGEMENT TEAM AGAINST THE ICF AT THE END OF 2020



As shown in Figure 28, the SESAR JU implements 15 out of the 17 principles in full and partly implements two others.

In the case of principle 10, 'Selects and develops control activities', the SESAR JU implements all control activities that are required by the key regulations and Commission guidance (the financial regulation and framework financial regulation, the SESAR JU regulation, the staff regulation, etc.); these control activities are embedded in the business processes that form part of the QMS, along with the control strategy adopted in 2020 in the context of the 2021–2023 SPD. The control strategy has been applied since the beginning of 2021.

In the case of principle 16, 'Conducts ongoing and/or separate assessments', the SESAR JU has established a list of indicators covering the 17 principles of the ICF, as explained in subparagraph 1.7.7.1, 'Internal control and quality management'. These indicators have been applied since the beginning of 2021.

A complete report on the assessment of the implementation of the ICF is available in Annex VII.

For the annual self-assessment and monitoring of the effectiveness of the control activities required by the ICF, the SESAR JU developed relevant indicators for all internal control principles and related characteristics, that will be used as from 2021.

(68) The Internal Control Framework was published by the European Commission in 2017: Commission Communication C(2017) 2373 final from Commissioner Oettinger on the revision of the internal control framework.

3.2. Conclusions of assessment of internal control systems

As reported in the previous chapter, the SESAR JU management considers its internal control systems to be effective, although some improvements under way.

3.3. Statement of the manager in charge of risk management and internal control

I, the undersigned,

Manager in charge of risk management and internal control within the SESAR Joint Undertaking,

In my capacity as Manager in charge of risk management and internal control, declare that in accordance with the SESAR JU's ICF, I have reported my advice and recommendations on the overall state of internal control in the Joint Undertaking to the Executive Director.

I hereby certify that the information provided in the present Consolidated Annual Activity Report and in its annexes is, to the best of my knowledge, accurate, reliable and complete.

Brussels, 30 June, 2021

Signature

(Signed)

Peter Hotham
Deputy Executive Director
Manager in charge of risk management and internal control
SESAR Joint Undertaking

Part IV.
Management assurance

4.1. Review of the elements supporting assurance

This chapter provides information on the set of 'building blocks' that enables the Executive Director to obtain a full picture of the state of play of the SESAR JU, underpinning the reasonable assurance given by the authorising officer in his declaration of assurance of the Annual Activity Report and allowing him to give adequate assurance to the Management Board.

Building block 1 – assessment by management

This assessment can be found in chapter 2.11, 'Assessment by management'.

Building block 2 – register of exceptions

This assessment can be found in chapter 2.11, 'Assessment by management'.

Building block 3 – audit results during the reporting period

Audit results and recommendations are presented in chapters 2.8 a, 'Follow-up of recommendations and action plans for audits and evaluations', and 2.8 b, 'Follow-up of recommendations issued following investigation by the European Anti-Fraud Office'.

Paragraph 2.7.4, 'Project audits', presents the results of H2020 ex post (project) audits. While the audit process for FP7 projects was carried out under responsibility of the SESAR JU, the audit of H2020 cost claims is fully centralised in the CAS of the CIC (69).

Building block 4 – internal control systems

The assessment of the SESAR JU's internal control systems can be found in chapter 4.1, 'Effectiveness of internal control systems'.

On the basis of the above elements, the management provides a reasonable assurance that all necessary control procedures are in place to guarantee the legality and regularity of the SESAR JU's activities, in line with the principles of economy, efficiency and effectiveness.

4.2. Reservations

There are no reservations with regard to the SESAR JU's activities in 2020.

(69) CAS for the H2020 Framework Programme for R & I expenditure at the European Commission hosted by the Directorate-General for Research and Innovation.

Part V. Declaration of assurance

I, the undersigned, Executive Director of the SESAR Joint Undertaking,

In my capacity as Authorising Officer,

Declare that the information contained in this report gives a true and fair view.

State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees concerning the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment, ex-post controls, the work of the Internal Audit Service, the work of the Internal Audit Capability and the lessons learnt from the reports of the Court of Auditors for years prior to the year of this declaration.

Confirm that I am not aware of anything not reported here which could harm the interests of the agency.

Brussels, 30 June, 2021

Signature

(Signed)

Florian Guillermet
Executive Director
SESAR Joint Undertaking

Annexes

Annex I. Core business statistics

Annex I.1: Horizon 2020 scoreboards

The following tables follow the instructions on annual activity reports for JUs operating under H2020.

TABLE 21 SCOREBOARD OF H2020 COMMON KPIS

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (70)	Value in 2019	Value in 2020 (71)
1	SME – share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years) (number of SMEs that have introduced innovations)	Number and percentage of participating SMEs that have introduced innovations to the company or to the market	N	91 (32.9 %)	54 (24 %) (72)
2	SME – growth and job creation in participating SMEs (turnover of company, number of employees)	Turnover of company Number of employees	N	Not available	EUR 189 613 781.74 1 643 (73)
3	Number of publications in peer-reviewed, high-impact journals	The percentage of papers published in the top 10 % of journals, ranked by impact factor, by subject category	N	20	8
4	Patent applications and patents awarded in the area of the joint technology initiative (number of patents awarded)	Number of patent applications by theme Number of awarded patents by theme	N	Number of patent applications: 0 Number of awarded patents: 0	Number of patent applications: 0 Number of awarded patents: 0
5	Number of prototypes testing activities and clinical trials	Number of prototypes, testing (feasibility/demonstration) activities, clinical trials	N	Prototypes: 294 Feasibility activities: 431 Clinical trials: not applicable	Prototypes: 292 Feasibility activities: 442 Clinical trials: not applicable (74)
6	Number of joint public–private publications in projects	Number and share of joint public–private publications out of all relevant publications.	N	27	66 (32 %) (75)
7	New products, processes, and methods launched into the market	Number of projects with new innovative products, processes, and methods	N	Innovative products: 16 Innovative processes: 19 Innovative methods: 22	Innovative products: 17 Innovative processes: 17 Innovative methods: 20 (76)

(70) Data not provided by the SESAR JU are provided by beneficiaries through project reporting.
(71) Data refer to the projects within SESAR 2020.
(72) Data refer to projects with an end date between 2020 and 2023.
(73) Data refer to projects with an end date in 2020.
(74) Cumulative amount referring to 2016–2020.
(75) Cumulative amounts referring to 2016–2020.
(76) Cumulative amounts referring to 2016–2020.

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (70)	Value in 2019	Value in 2020 (71)
8	Time to inform all applicants of outcome of evaluation	Number and percentage of information letters sent to applicants within target (153 days) Average time to inform (calendar days) Maximum time to inform (calendar days)	Y	16 (100 %) Average: 91 days Maximum: 91 days	144 (100 %) Average: 131 days Maximum: 136 days (77)
9	Redress after evaluation/evaluation review	Number of redress requests	Y	0 %	0 %
10	Time to grant from call deadline to grant signature	Number and percentage of grants signed within target (eight months) Average time to grant in calendar days Maximum time to grant in calendar days	Y	12 (75 %) Average: 234 Maximum: 382	43 (30 %) Average: 219 Maximum: 317 (78)
11	Time to sign from successful applicant letter	Number and percentage of grants signed within target (92 days) Average time to sign in calendar days Maximum time to sign in calendar days	Y	0 out of 16 Average: 140 Maximum: 258	29 out of 53 Average: 92 Maximum: 181 (79)
12	Time to pay (percentage on time) for pre-financing, interim payment and final payment	Average number of days for to pre-financing (target 30 days), interim payment (target 90 days) and final payment (target 90 days) Average number of days for administrative payments Number of experts appointed	Y	100 % on time for pre-financing Average number of days for pre-financing: 5	100 % on time for pre-financing Average number of days for pre-financing: 15.5 Experts contracted: 66 (80)
13	Vacancy rate (%)	Vacancy rate during the reporting period (%)	Y	2.5 %	4.8 %
14	Budget implementation/execution: 1. Contract agents, percentage of total budget 2. Permanent agents, percentage of total budget	Percentage of contract and permanent agents	Y	1. 91.69 % 2. 82.66 %	1. 90.40 % 2. 69.22 %
15	Administrative budget: number and percentage of total of late payments	Number of delayed payments	Y	0 %	6.75 % (489 payments, of which 33 late)

(77) Data referred to call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020.

(78) Data refer to call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(79) Data refer to call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(80) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

TABLE 22 INDICATORS FOR MONITORING CROSS-CUTTING ISSUES

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (81)	Value in 2019	Value in 2020
16	Number of nationalities in H2020, applicants and beneficiaries	Nationality of H2020 applicants and beneficiaries (number of)	N	19	32
17	Total amount of EU financial contribution by Member State	Nationality of H2020 beneficiaries and corresponding EU financial contribution	N	Austria: EUR 2 326 766 Belgium: EUR 451 721 Croatia: EUR 328 510 Czech Republic: EUR 903 441 Denmark: EUR 458 366 France: EUR 36 517 413 Germany: EUR 5 674 567 Hungary: EUR 740 293 Ireland: EUR 429 679 Italy: EUR 11 967 153 Lithuania: EUR 879 196 Netherlands: EUR 464 601 Poland: EUR 1 987 879 Spain: EUR 14 410 918 Sweden: EUR 3 097 005 United Kingdom: EUR 3 553 069	Austria: EUR 2 942 214 Belgium: EUR 2 149 282 Croatia: EUR 312 875 Cyprus: EUR 100 187 Czech Republic: EUR 955 054 Denmark: EUR 375 500 Finland: EUR 430 500 France: EUR 11 752 103 Germany: EUR 11 170 822 Greece: EUR 602 500 Hungary: EUR 326 000 Ireland: EUR 350 991 Italy: EUR 879 856 Netherlands: EUR 4 400 926 Poland: EUR 537 616 Portugal: EUR 485 000 Spain: EUR 11 960 546 Sweden: EUR 2 953 642 (82)
18	Number of nationalities in H2020, applicants and beneficiaries (associated countries)	Nationality of H2020 applicants and beneficiaries (number of)	N	2 (Norway, Switzerland)	5 (Iceland, Norway, Serbia, Switzerland, Turkey) (83)
19	Total amount of EU financial contribution by associated country	Nationality of H2020 beneficiaries and corresponding EU financial contribution	N	Norway: EUR 1 545 019 Switzerland: EUR 2 016 023	Iceland: EUR 336 250 Norway: EUR 800 000 Serbia: EUR 627 127 Switzerland: EUR 3 383 125 Turkey: EUR 1 154 250 (84)
20	Share of EU financial contribution going to SMEs	Number of H2020 beneficiaries flagged as SMEs Percentage of EU contribution going to beneficiaries flagged as SMEs	N	31 SMEs 5.3 %	52 SMEs 15.8 % (85)
21	Percentage of women in H2020 projects	Gender of participants in H2020 projects	N	19 %	30 % (86)

(81) Data not provided by the SESAR JU are provided by beneficiaries through project reporting.

(82) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(83) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(84) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(85) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(86) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (81)	Value in 2019	Value in 2020
22	Percentage of women project coordinators in H2020	Gender of MSc fellows, European Research Council principal investigators and scientific coordinators in other H2020 activities	N	20 %	24 % (87)
23	Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of memberships in advisory groups, panels, etc.	Y	Not available	Administrative Board: 2 out of 28 (7 %) Evaluation panel: 4 out of 9 (44 %) Scientific committee: 3 out of 10 (30 %) External observers: 1 out of 3 (33 %)
24	Share of third-country participants in Horizon H2020	Nationality of H2020 beneficiaries	N	0	TP: 22 (9 %) 9 nationalities
25	Percentage of EU financial contribution attributed to third-country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	N	0	0
26	Share of projects and EU financial contribution allocated to IAs	Number of IA proposals and projects properly flagged in the WP; follow-up at grant level	Y	Number of IA projects: 2 Percentage of IA projects out of all projects: 14 % IAs out of overall EU contribution: 4 %	Number of IA projects: 5 (88) Percentage of IA projects out of all projects: 12 % IA out of overall EU contribution: 31 %
27	Within the IAs, share of EU financial contribution focused on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	Y	100 % (all IA projects are VLD activities)	100 % (all IA projects are VLD activities)
28	Scale of impact of projects (high TRL)	Number of projects between TRL-4 and TRL-6 and between TRL-5 and TRL-7	Y	17 projects up to TRL-2 or equivalent operational concept maturity level ('ER') 17 projects from TRL 2 to 6 or equivalent operational concept maturity level 22 projects at TRL-6 or TRL-7 or equivalent operational concept maturity level 3 projects address transversal activities, i.e. non-directly TRL or operational concept-related activities	42 projects up to TRL-2 or equivalent operational concept maturity level ('ER') 9 projects at TRL-2 to TRL-6 or equivalent operational concept maturity level 19 projects at TRL-6 or TRL- 7 or equivalent operational concept maturity level 3 projects address transversal activities, i.e. non-directly TRL or operational concept-related activities
29	Percentage of H2020 beneficiaries from the private, for-profit, sector	Number and percentage of total H2020 beneficiaries classified by type of activity and legal status	Y	258 out of 346 (76.6 %) for PRC IR: 250 out of 333 (75 %) VLD: 8 out of 13 (61.5 %)	177 out of 348 (50.9 %) for PRC IR: 30 out of 38 (79 %) VLD: 52 out of 66 (79 %)
30	Share of EU financial contribution going to private, for-profit, entities (enabling and industrial technology and Part III of H2020)	H2020 beneficiaries classified by type of activity; corresponding EU contribution	Y	EUR 72 288 758 for PRC out of total EUR 87 751 621 (82.4 %)	EUR 35 210 989 for PCR out of EUR 71 374 590 (49 %)

(87) Data refer to call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(88) Amounts refer to call H2020-SESAR-2019-1, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (81)	Value in 2019	Value in 2020
31	EU financial contribution for PPP (Article 187)	EU contribution to PPP (Article 187)	Y	EUR 359 627 633	EUR 496 953 067 (89)
32	PPPs leverage: total amount of funds leveraged through Article 187 initiatives, including additional activities, divided by the EU contribution	Total funding made by private actors involved in PPPs - in-kind contributions already committed by private members to project selected for funding - additional activities (i.e. research expenditures / investment of industry in the sector, compared with previous year)	Y	See indicator 40	See indicator 40
33	Dissemination and outreach activities other than publications in peer-reviewed journals	The type of dissemination activity can be chosen from a drop-down list. Number of events, funding amount and number of persons reached thanks to the dissemination activities	N		
34	Proposal evaluators by country	Nationality of proposal evaluators	Y	Greek: 1 Polish: 1 UK: 1 Bulgarian: 1 Austrian: 1 Portuguese: 1 Italian: 1 + SESAR JU staff involved in the evaluation: Spanish: 2 UK: 1 Dutch: 1	Austria 2 Belgium 1 Cyprus 1 Finland 2 France 5 Germany 6 Greece 4 Hungary 1 Ireland 1 Italy 7 Netherlands 3 Poland 3 Portugal 4 Romania 5 Slovenia 1 Spain 6 Sweden 3 Switzerland 1 Turkey 7 United Kingdom 3
35	Proposal evaluators by organisation's type of activity	Type of activity of evaluators' organisations	Y	Higher education: 3 Research organisation: 1 Public organisation: 1 Other: 2	Higher education: 9 Research organisation: 28 Public organisation: 10 Other: 19

(89) Cumulative amount refers to the signature of grant agreements resulting from the calls H2020-SESAR-2015-1, H2020-SESAR-2015-2, H2020-SESAR-2016-1, H2020-SESAR-2016-2, H2020-SESAR-2019-1 H2020-SESAR-2019-2, H2020-SESAR-2020-1 and H2020-SESAR-2020-2.

Reference	Name of H2020 KPI	Definition	Data provided by SESAR JU (81)	Value in 2019	Value in 2020
36	Participation of RTOs and universities in PPPs	Number of participations of RTOs in funded projects and percentage of the total Number of participations of universities in funded projects and percentage of the total Percentage of budget allocated to RTOs and to universities		68 (REC) out of 485 (all entity types) – 14 % 8 (HES) out of 485 (all entity types) – 1.7 % Budget allocated to RTOs and to universities: 6.4 %	70 (REC) out of 348 (all entity types) – 20 % 77 (HES) out of 348 (all entity types) – 22 % Budget allocated to RTOs and to universities: 30.3 (90)
37	The objective is to ensure that research projects funded are compliant with provisions on ethics efficiency	Proposals not granted because of non-compliance with ethical rules as a percentage of proposals invited to grant (target 0%); time to ethics clearance (target 45 days)	Y	0 %	0 %
38	Error rate (for H2020 grants)	Representative error rate (%) Residual error (%)	Y	2.61 % 1.76 %	3.46 % 2.49 %
39	Implementation of ex post audit results for H2020 projects	Number of cases implemented in total EUR million of cases implemented / total cases	Y	68 % (EUR 166 767/ EUR 247 045)	33 % (EUR 314 407/ EUR 943 472) (91)

(90) Cumulative amounts and percentages refer to beneficiaries of and third-party participants in call H2020-SESAR-2019-1, call H2020-SESAR-2019-2, call H2020-SESAR-2020-1 and call H2020-SESAR-2020-2.

(91) Cumulative amounts refer to 2017, 2018, 2019 and 2020.

Annex I.2: Scoreboard of key performance indicators specific to SESAR JU

TABLE 23 KPIs SPECIFIC TO THE SESAR JU – 2019 AND 2020

Reference	Name of H2020 KPI	Definition	Value in 2019	Value in 2020	Target by 2024
40	PPP – Leverage: in-kind contributions committed by private members to SESAR 2020 projects selected for funding	Ratio of private to public funding in all project types (see paragraph 2.3 for explanation)	Forecast leverage at the end of the programme: Method 1 (interim evaluation): 1.40 Method 2 (refined interim evaluation): 1.44 Method 3 (H2020): 2.44 Partnership leverage: 2.05		Programme target: Method 1 interim evaluation): 1.40 Method 2 (EU body leverage): 1.44 Method 3 (H020): 2.44 Partnership leverage: 1.95
41	Completion of SESAR 2020 programme	Actual versus planned percentage of each project that had been completed as of the end of the reporting period	7 calls for proposals completed + 1 ongoing out of the 10 planned at the end of 2019 62 grants completed + 1 terminated 37 grants in execution 31 grants in preparation	10 calls for proposals completed of the 10 planned at the end of 2020 85 grants completed + 2 terminated 67 grants in execution 2 grants in preparation	100 %
42	Delivery of SESAR 2020 Solutions	Number of solutions ready for pre- industrialisation compared with plan	Not applicable (planned for Release 9)		70 % [92]

In addition, the European ATM Master Plan sets out performance ambitions (PAs) that the SES initiative should achieve by 2035, provided SESAR Solutions can be deployed in an optimal and timely manner. Table 24 provides an overview of the SES performance scheme, showing KPAs and the related KPIs and PAs.

[92] Approximate target. The estimated number of solutions will be refined in 2020 on the basis of the results of the call IR-VLD Wave 2.

TABLE 24 SES PERFORMANCE SCHEME SET OUT IN THE EUROPEAN ATM MASTER PLAN

Reference	ATM Master Plan SES Performance Ambition KPA	KPI	ATM Master Plan overall SESAR 2020 Performance Ambition (vs. baseline 2012)
43	Cost efficiency	PA1	30–40 % reduction in ANS costs per flight
44	Operational efficiency	PA2	3–6 % reduction in flight times
		PA3	5–10 % reduction in fuel burn
		PA4	Arrival predictability: 70 % of flights arriving at gate within a two-minute predicted time window
45	Capacity	PA5	10–30 % reduction in departure delays
		PA6	5–10 % additional flights at congested airports
		PA7	System able to handle 80–100 % more traffic
46	Environment	PA8	5–10 % reduction in CO_2 emissions
47	Safety	PA9	Safety improved by a factor of 3–4
48	Security	PA10	No increase in ATM-related security incidents resulting in traffic disruption

The SESAR programme is expected to contribute significantly to the SES performance scheme. That contribution is defined in the SESAR performance framework, which is composed of KPAs (SESAR KPAs and KPIs, linked to SES KPAs and KPIs) and the overall SESAR 2020 ambition, and which was updated in 2017 to recognise the achievements of the SESAR 1 programme and to set the objectives for the SESAR 2020 programme.

In 2019, in continuation of the activities conducted in previous years, in collaboration with its members and with the support of project PJ.19, the SESAR JU assessed the performance benefits in each KPA expected to result from the candidate solutions. A consolidation exercise conducted in 2019 gave the following results (the achievements in Table 25 are based on only those solutions that have reached the V3/TRL-6 maturity level, and exclude the results of candidate solutions that have not yet reached that maturity level).

TABLE 25 PERFORMANCE AMBITIONS, VALIDATION TARGET STARTING POINT AND SESAR 2020 INITIAL PERFORMANCE ASSESSMENT RESULTS (EXPECTATIONS)

KPA	Overall SESAR 2020 ambition	Units	Cumulative SESAR 1 + SESAR 2020 V3 achievement
Safety	–51 %	Reduction in accidents	–36.5 %
Airport capacity (CAP3)	10 %	Increase in peak hourly throughput	18.5 %
TMA capacity (CAP1)	47 %	Increase in peak hourly throughput	27.7 %
En route capacity (CAP2)	49 %	Increase in peak hourly throughput	48.8 %
Punctuality (PUN1)	7 %	Increase in proportion of flights departing within three minutes (either way) of scheduled off-block time	2.7 %
Predictability (PRD1)	96 %	Reduction in variance of block-to-block flight time	40.5%
Environment / fuel efficiency (FEFF1)	500	Fuel saving (kilograms per flight)	143. 1
ATCO productivity (CEF2)	97.7 %	Increase in ATCO productivity	70.8 %
Technology cost (CEF3)	43.4 %	Reduction in technology cost per flight	30.8 %

Annex I.3: Procurement activity in 2020

In order to manage and ensure the timely implementation of procurement activities to support the SESAR JU objectives, the SESAR JU uses a contract action planning tool to record all the procurement/ contract activities. This file is updated on a weekly basis in concert with OIAs and the corporate management team. This planning tool is a repository of all procurement activities planned in the SPD as well as activities unforeseen at the time of the SPD adoption upon validation of the corporate management team, and details the timeline for implementation of these activities on the basis of SESAR JU needs and applicable rules.

The procurement activities launched and finalised by the SESAR JU in 2020 are shown in Table 26.

TABLE 26 MAIN PROCUREMENT ACTIVITIES LAUNCHED AND COMPLETED IN 2020

SAoO	Type of procedure	Description	Total budget (EUR) (estimated)	Type of contract	Signed
6	Inter-institutional procurement	Management consultancy services	Not applicable	MoU	7/1/2020
5	Not applicable	Digital communication, event support and other public relations activities (lot 3)	147 525	Specific contract	4/2/2020
6	Inter-institutional procurement	ICT Software – order for 50 Adobe Acrobat Pro DC licences	6 088	Specific contract	13/2/2020
6	Inter-institutional procurement	Use of ABAC ASSET Suite	Not applicable	Amendment to SLA	14/2/2020
5	Not applicable	Provision of airspace users experts for SESAR 2020 programme (lot 1)	410 000	Specific contract	12/2/2020
5	Not applicable	Provision of airspace users experts for SESAR 2020 programme (lot 2)	140 000	Specific contract	10/2/2020
5	Not applicable	Provision of airspace users experts for SESAR 2020 programme (lot 3)	85 000	Specific contract	10/2/2020
5	Not applicable	Provision of airspace users experts for SESAR 2020 programme (lot 4)	85 000	Specific contract	10/2/2020
5	Not applicable	Professional staff association – specific contract 2 (lot 1)	59 850	Specific contract	5/3/2020
5	Not applicable	Professional staff association – specific contract 2 (lot 2)	59 850	Specific contract	1/3/2020
5	Not applicable	Professional staff association – specific contract 2 (lot 3)	59 850	Specific contract	2/3/2020
5	Not applicable	Professional staff association – specific contract 2 (lot 4)	59 850	Specific contract	12/3/2020
5	Not applicable	Professional staff association – specific contract 2 (lot 5)	59 850	Specific contract	26/2/2020
6	Inter-institutional procurement	Replacement of the standing SLA with the Directorate-General for Budget	102 157	LA	12/3/2020
1	Not applicable	Airports expertise for the execution of SESAR 2020 (specific contract 5 to cover activities up to November 2020)	200 000	Specific contract	3/3/2020
5	Not applicable	Amendment no 2 to framework contract SESAR JU/ LC/332-CTR	Not applicable	Amendment	12/3/2020
5	Not applicable	Digital communication, event support and other public relations activities/material (lot 2, digital communication)	–3 850	Amendment to specific contract	16/4/2020
6	Inter-institutional procurement	Frontex call for purchase of personal protective equipment	40 000 (total amount to be divided among various framework contracts for personal protective equipment over four years)	MoU	24/4/2020

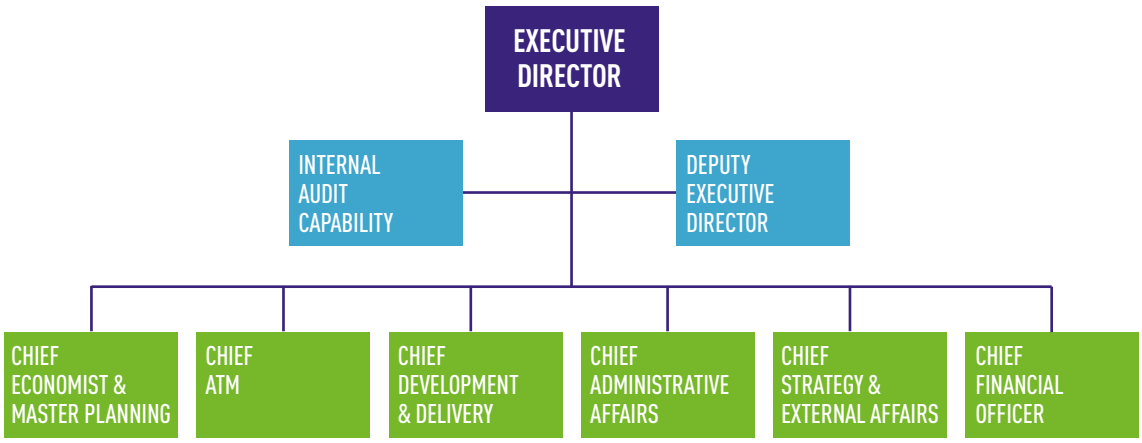
SAoO	Type of procedure	Description	Total budget (EUR) (estimated)	Type of contract	Signed
6	Inter-institutional procurement	Supply of protective face masks	40 000 (total amount to be divided among various FWCs for PPEs over 4 years	MoU	13/5/2020
6	Inter-institutional procurement	Languages training services		Memorandum of understanding	
6	Inter-institutional procurement	Trans-European services for telematics between administrations (Testa) new generation (NG) specific contract 31	9 626	Specific contract	10/7/2020
6	Inter-institutional procurement	Key skills training		Memorandum of understanding	
3	Not applicable	Provision of SDSS to the SESAR JU for SESAR 2020 programme management	5 000 000	Amendment to direct service contract	2/12/2020
6	Inter-institutional procurement	Assurance lot 4 – Fire (incendie)	3 233.09	Memorandum of understanding	13/8/2020
6	Inter-institutional procurement	Assurance Lot 5- Terrorism(terrorisme)	370.14	Memorandum of Understanding	13/08/2020
6	Inter-institutional procurement	Purchase order EC FWC DI/07722. Acrobat Pro licences	15 160	Purchase order	19/2/2020
5	Not applicable	Digital communication, event support and other public relations activities/material (lot 1, strategic communication)	56 540	Specific contract	25/9/2020
5	Not applicable	Digital communication, event support and other public relations activities/material (lot 2, digital communication)	52 745	Specific contract	15/9/2020
5	Not applicable	Digital communication, event support and other public relations activities/material (Lot 3, communication events)	47 273	Specific contract	29/9/2020
5	Inter-institutional procurement	Joint Undertakings' 'Innovation in Action' event	1 687.50	Memorandum of understanding	30/4/2020
6	Negotiated procedure for low value	Purchase of a key management system implementation of the recommendations of the security audit	14 849	Purchase order	8/7/2020
3	Negotiated procedure for low value	Provision of the SESAR 2020 programme intermediate status report	12 000	Direct service contract	9/10/2020
5	Negotiated procedure for low value	AeroDays 2020	5 000	Sponsorship agreement	25/9/2020
6	Negotiated procedure for low value	COVID-19 coaching sessions	3 600	Purchase order	6/10/2020
6	Inter-institutional procurement	Provision of management training and coaching		MoU	20/9/2020
5	Not applicable	Digital communication, event support and other public relations activities/material (lot 3, communication events)	–90 549	Amendment to specific contract	8/10/2020
6	Inter-institutional procurement	Audit SESAR JU annual accounts	39 843	Specific contract	23/10/2020
6	Inter-institutional procurement	Renewal of specific contract based on framework contract (Comparex) EC (SIDE) DI/7720 EC FWC – PO 1011489	17 364	Specific contract	9/11/2020
2	Contest	Young Scientist Award 2020	5 000	Not applicable	18/11/2020
6	Inter-institutional procurement	Advertising of senior management vacancies in the international media	45 000	MoU	18/11/2020
6	Inter-institutional procurement	TESTA (trans-European services for telematics between administrations) NG (new generation)	21 316	Specific contract	2/12/2020
5	Not applicable	Professional staff association – specific contract 3 (lot 2)	59 850	Specific contract	29/12/2020
5	Not applicable	Professional staff association – specific contract 3 (lot 3)	59 850	Specific contract	21/12/2020
5	Not applicable	Professional staff association – specific contract 3 (lot 5)	59 850	Specific contract	21/12/2020
5	Negotiated procedure pursuant to Point 11.1(b) of Annex 1 of the financial regulation	Provision of airports' expertise for the execution of the SESAR programme 2020/S 242-595169	500 000	Framework service contract	22/12/2020

Annex II. Statistics on financial management

Statistics on financial management are provided chapter 2.3.

Annex III. Organisation chart

FIGURE 29 ORGANISATION CHART OF THE SESAR JU AS AT 31 DECEMBER 2020



Annex IV. Establishment plan and additional information on human resources management

TABLE 27 ESTABLISHMENT PLAN

Key function	Type of contract	Function group, grade of recruitment	Indication whether the function is dedicated to administrative support or operations
Executive Director	TA fixed term + renewable	AD 14 – external	Operations
Chief Finance Officer (planned as of January 2020)	TA fixed term + renewable	AD 12 – external	Administrative support
Internal Audit Capability	TA fixed term + renewable	AD 5 – external	50 % administrative support 50 % operations
Assistant to the Executive Director	TA indefinite (*)	AST 1 – external	Administrative support
Deputy Executive Director Corporate Affairs [93]	TA indefinite (*)	AD 12 – external	50 % administrative support 50 % operations
Head of Corporate Support	TA indefinite (*)	AD 7 – external	Administrative support
Administrative Assistant	TA indefinite (*)	AST 3 – external	Administrative support
Administrative Assistant	TA fixed term + renewable	AST 3 – external	Administrative support
Head of Corporate Quality, Planning & Reporting	TA fixed term + renewable	AD 8 – external	50 % administrative support 50 % operations
Programming & Planning Officer	TA fixed term + renewable	AST 4 – external	Operations
Chief Strategy & External Affairs	TA indefinite (*)	AD 12 – external	Operations
Head of International Affairs	TA fixed term + renewable	AD 10 – external	Operations

[93] The role of Deputy Executive Director of the SESAR JU is a functional role, created to ensure full continuity of the agency's operations, and does not refer to provisions related to deputy heads of agencies in the Conditions of Employment of Other Servants.

Key function	Type of contract	Function group, grade of recruitment	Indication whether the function is dedicated to administrative support or operations
Head of Stakeholders and Institutional Relations	TA fixed term + renewable	AD 10 – external	Operations
Senior Communications & Media Relations Officer	TA fixed term + renewable	AD 5 – external	Operations
Communications & Events Officer	TA fixed term + renewable	AD 5 – external	Operations
Head of Release Management & Validation	TA fixed term + renewable	AD 7 – external	Operations
Call Coordinator	TA fixed term + renewable	AD 9 – external	Operations
Grant Manager	TA fixed term + renewable	AD 6 – external	Operations
Grant Manager	TA fixed term + renewable	AD 6 – external	Operations
Grant Manager	TA fixed term + renewable	AD 6 – external	Operations
ATM Architecture Framework Expert	TA fixed term + renewable	AD 5 – external	Operations
Chief ATM	TA fixed term + renewable	AD 10 – external	Operations
ATM Expert – Architecture & Systems Engineering	TA fixed term + renewable	AD 8 – external	Operations
ATM Expert – Airport & Airspace User Operations	TA fixed term + renewable	AD 6 – external	Operations
ATM Expert – TMA, En-route & Network Operations	TA fixed term + renewable	AD 6 – external	Operations
Chief Economist & Master Planning	TA indefinite (*)	AD 10 – external	Operations
Manager Digital Transformation & Innovation	TA fixed term + renewable	AD 8 – external	Operations
Chief Administration Affairs	TA fixed term + renewable	AD 12 – external	Administrative
Project Auditor	TA fixed term + renewable	AD 5 – external	Administrative
Head of Finance & Budget	TA fixed term + renewable	AD 8 – external	Administrative support
Financial Officer	TA fixed term + renewable	AD 6 – external	Administrative support
Financial Officer	TA fixed term + renewable	AD 5 – external	Administrative support
Financial assistant	TA fixed term + renewable	AST 3 – external	Administrative support
Head of Legal Affairs and Procurement	TA indefinite (*)	AD 8 – external	Administrative support
Legal & Procurement Officer, Data Protection Officer	TA fixed term + renewable	AD 5 – external	Administrative support
Legal & Procurement Officer	TA fixed term + renewable	AD 5 – external	Administrative support
Legal & Procurement Officer	TA fixed term + renewable	AD 5 – external	Administrative support
HR Legal Officer	TA fixed term + renewable (**)	AD 7 – external	Administrative support
HR Officer	TA indefinite (*)	AST 7 – external	Administrative support

Annex V. Human and financial resources by activity

Human and financial resources allocation by activity is provided in chapter 2.5, 'Human resources management'.

Annex VI. Contribution, grant and service-level agreements. Financial framework partnership agreements

Annex VII. Environment management

Report on the main actions/targets implemented by the agency to reduce the impact of its administrative operations on the environment as planned in the Annex VI of the SPD.

Annex VIII. Provisional/Final annual accounts

The provisional annual accounts for 2020 are provided in a separate document, which was officially handed over to the Budgetary Authorities, the European Court of Auditors (ECA) and the external auditors.

Annex IX. Other annexes

List of acronyms and definitions

Acronym or abbreviation	Long name / definition
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
20-CAT	20 wake category
ABAC	Accrual based accounting
ABSR	assistant-based speech recognition
ACC	area control centre
A-CDM	airport collaborative decision-making
ACI	Airports Council International
ADS	automatic dependent surveillance
ADS-B	automatic-dependent surveillance - broadcast
ADS-C	automatic dependent surveillance - contracts
ADSP	ATM data service provider
AEON	Advanced Engine Off Navigation
AeroMACS	aeronautical mobile airport communication system
AFISO	aerodrome flight information service officer
AI	artificial intelligence
A-IGS	adaptive increased glide slope
AIM	aeronautical information management
AIXM	aeronautical information exchange model
ARAIM	advanced received autonomous integrity monitoring
Airpass	Advanced Integrated RPAS Avionics Safety Suite
AMAN	arrival manager
ANS	air navigation service
ANSP	air navigation service provider
AOA	angle of arrival
AOD	authorising officer by delegation
AOP	airport operations plan
AOSD	authorising officer by sub-delegation
A-PNT	alternative position, navigation and timing
APOC	airport operations plan
Asprid	Airport System Protection from Intruding Drones
A-SMGCS	advanced-surface movement guidance and control systems
ASR	automatic speech recognition
ATC	air traffic control
ATCEUC	Air Traffic Controllers European Union Coordination
ATCO	air traffic control officer
ATFCM	air traffic flow and capacity management
ATFM	air traffic flow management

Acronym or abbreviation	Long name / definition
ATM	air traffic management
ATN	aeronautical telecommunication network
ATS	air traffic services
ATSU	air traffic system unit
AU	airspace user (civil)
BVLOS	beyond visual line of sight
CAAR	Consolidated ANNUAL ACTIVITY report
CAAS	Civil Aviation Authority of Singapore
CAEP	Committee on Aviation Environmental Protection
CAS	Common Audit Service of the Directorate-General for Research and Innovation of the European Commission
CCO	continuous climb operations
CDM	collaborative decision-making
CDO	continuous descent operations
CEF	Connecting Europe Facility
CIC	Common Implementation Centre
CMSC	Civil–Military Stakeholder Committee
CNS	communications, navigation and surveillance
ConOps	concept of operations
CORUS	Concept of operation for European unmanned traffic management systems
COTS	commercial off-the-shelf
COVID-19	coronavirus disease 19
CPDLC	controller–pilot datalink communications
CTA	controlled time of arrival
CWP	Controller working position
DAA	detect and avoid
DAC	dynamic airspace configurations
DCB	demand–capacity balancing
DFMC	dual-frequency multiconstellation
DMA	dynamic mobile area
DME	distance measuring equipment
DMSC	Delivery Management Subcommittee
DPO	data protection officer
E-AMAN	extended arrivals manager
EASA	European Union Aviation Safety Agency
EASCG	European Air Traffic Management Standards Coordination Group
EATMA	European air traffic management community
ECA	European Court of Auditors
ECAC	European Civil Aviation Conference
ECHO	European Concept of Higher airspace Operations
EDA	European Defence Agency
EDES	Early Detection and Exclusion System Database
EDPS	European Data Protection Supervisor
E-TMA	extended TMA (terminal manoeuvring area)

Acronym or abbreviation	Long name / definition
EFTA	European Free Trade Association
EFVS	enhanced flight vision system
EFVS-L	enhanced flight vision system to land
EGNOS	European Geostationary Overlay Service
EOC	essential operational change
EOCVM	European Operational Concept Validation Methodology
EPP	extended projected profile
ER	exploratory research
ETF	European Transport Workers' Federation
E-TMA	extended terminal manoeuvring area
Eurocae	European Organisation for Civil Aviation Equipment
eVTOL	electric vertical take-off and landing
EWS	early warning system
FAA	Federal Aviation Administration (USA)
FANS	future air navigation system
FCI	future communication infrastructure
FDCI	flight delay criticality indicator
FIMS	flight information management system
Flightpath 2050	report of the High Level Group on Aviation and Aeronautics Research established by the European Commission in December 2010, setting out a new vision for the aviation sector by 2050
FMP	flow management position
FMS	flight management system
FO	flight object
FOC	flight operations centre
FPL	flight plan
FP7	Seventh Framework Programme
FTE	full-time equivalent (staff)
GA	general aviation
GANP	global air navigation plan (from the International Civil Aviation Organization)
GAT	general air traffic
GBAS	ground-based augmentation system
GLS	GBAS landing system
GNSS	global navigation satellite systems
GPS	global positioning system
GSA	European GNSS Agency
GWMS	ground weather monitoring system
H2020	Horizon 2020 framework programme
HF	high frequency
HLLP	high-level partnership proposal
HMI	human–machine interface
HR	human resources
IA	innovative action
IAC	Internal Audit Capability

Acronym or abbreviation	Long name / definition
IALN	Inter Agencies' Legal Network
IAS	Internal Audit Service (of the European Commission)
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICF	internal control framework
iCNS	integrated communications, navigation and surveillance
ICT	information and communication technology
IDMS	information and document management service
IFATCA	International Federation of Air Traffic Controllers' Associations
IFATSEA	International Federation of Air Traffic Safety Electronics Associations
IFR	instrument flight rules
IGS	increase glide slope
ILS	instrument landing system
Imhotep	Integrated Multimodal Airport Operations for Efficient Passenger Flow Management
IOP	Ground-to-ground interoperability
IP	internet protocol
IPS	internet protocol suites
IR	industrial research and validation
JU	Joint Undertaking
KPA	key performance area
KPI	key performance indicator
KTN	Knowledge Transfer Network
L-DACS	L-band digital aeronautical communications system
LMIG	Legal Mechanism Issue Group
LVP	low-visibility procedures
MAWP	Multiannual Work Programme
M/C	multiconstellation
M/F	multifrequency
MET	meteorological/meteorology
ML	machine learning
mmW	millimetre wave
MoC	memorandum of cooperation
MoU	memorandum of understanding
MPC	Master Planning Committee
MUAC	Maastricht Upper Area Control Centre
NM	Network Manager
NWM	numerical weather model
NOP	network operations plan
NSA	national supervisory authority
OCC	operations control centre
OLAF	European Anti-Fraud Office
ORD	optimised runway delivery
OSD	optimised separation delivery
OSED	operational services and environment description

Acronym or abbreviation	Long name / definition
PBN	performance-based navigation
PMU	Programme Management Unit
PSO	professional staff organisation
PWS	pairwise separation
Q & A	questions and answers
QMS	quality management system
QICT	Quality, Information and Communication Technology
RC	rotorcraft
RF	radiofrequency
R & I	research and innovation
RNP	required navigation performance
ROCAT	runway occupancy time categorisation
ROT	runway occupancy time
RP	reference period
RPAS	remotely piloted aircraft systems
RSP	required surveillance performance
RTCA	Radio Technical Commission for Aeronautics
RWC	remain well clear
SBAS	satellite-based augmentation system
SDM	SESAR deployment manager
SDN	software-defined networking
SDSS	SESAR Development Support Services
SEAC	SESAR European Airports Consortium
SES	single European sky
SESAR	Single European Sky ATM Research
SESAR 2020	SESAR 2020 innovation R & I programme, also referred to as the 'SESAR 2020 Programme' or 'SESAR 2020 R & I Programme'. It is the coordinated set of activities described in this document and which are being undertaken by SESAR JU members and managed by the SESAR JU
SESAR JU	Single European Sky ATM Research Joint Undertaking, established as a joint undertaking within the meaning of Article 187 of the Treaty on the Functioning of the European Union, established under the SESAR JU basic act
SESAR JU basic act	Council Regulation (EC) No 219/2007 of 27 February 2007 (OJ L 64, 2.3.2007, p. 1) on the establishment of a joint undertaking to develop the new generation European air traffic management system (SESAR), as amended by Council Regulation (EC) No 1361/2008 of 16 December 2008 (OJ L 352, 31.12.2008, p. 12) and by Council Regulation (EU) No 721/2014 of 16 June 2014 (OJ L 192, 1.7.2014, p. 1)
SLA	service-level agreement
SMEs	small and medium-sized enterprises
SNE	seconded national expert
SPD	single programming document
SPR/Interop	safety and performance and interoperability requirements document

Acronym or abbreviation	Long name / definition
SRAP	second runway aiming point
SRIA	Strategic Research and Innovation Agenda
STAM	short-term ATFCM measures
START	a Stable and resilienT ATM by integrAting Robust airline operations into the neTwork
SURF-A	surface traffic alerts and indication on runways for pilots with optional display, caution and warning alerts
SURF-ITA	surface traffic alerts and indication on runways for pilots with optional display, caution and warning alerts
SWIM	system-wide information management
SWOT	strengths, weaknesses, opportunities and threats
TA	temporary agent
TBO	trajectory-based operation
TC	thematic challenge
TCAS	traffic collision avoidance system
TEN-T	Trans-European Transport Network
TI	technical infrastructure
TOA	time of arrival
TMA	terminal manoeuvring area
TRL	technology readiness level
TSP	transport service provider
TTA	target time of arrival
UAM	urban air mobility
UAS	unmanned aerial system
UAV	unmanned aerial vehicle
UAC	upper area control area
UDPP	user-driven prioritisation process
U-space	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 operations
UTM	unmanned traffic management
VDL	very high frequency data link
VHF	very high frequency
VLD	very large-scale demonstration
VLL	very low level
VR	virtual reality
VTOL	vertical take-off and landing
WDS	weather-dependent separation
WOC	wing operations centre
WP	work package
XAI	explainable artificial intelligence
XMAN	Extended AMAN

Composition of the Administrative Board as at 31 December 2020

SESAR JU founding members	Member	Alternate
European Union	Mr Henrik Hololei (Chair), European Commission	Mr Filip Cornelis
EUROCONTROL	Mr Eamonn Brennan (Deputy Chair), EUROCONTROL	Mr Philippe Merlo
SESAR JU members	**Member**	**Alternate**
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AT-One consortium	Prof. Dr.-Ing. Dirk Kügler	Dr Helmut Többen
B4-consortium	Mr Maciej Rodak	Mr Lubos Hlinovsky
COOPANS	Mr Robert Schneebauer	
Dassault Aviation	Mr Alain Boucher	Ms Catherine Champagne
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ENAV	Mr Alessandro Ghilari	Mr Cristiano Cantoni
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Frequentis	Mr Hermann Mattanovich	Mr Michael Holzbauer
Honeywell	Mr George Papageorgiou	Mr Sander Roosendaal
INDRA	Mr Rafael Gallego Carbonell	Mr Ramon Tarrech
NATMIG	Mr Trond Runar Hagen	Mr Trond Bakken
NATS	Mr Dave Curtis	
SEAC	Mr Frank Pötsch	Mr Fredrik Nygaard
Skyguide	Mr Thomas Buchanan	Mr Pascal Latron
Thales LAS France SAS	Mr Luc Lallouette	Mr Todd Donovan
Thales AVS France SAS	Mr Olivier de la Burgade	Mr Pascal Combe
Stakeholder representatives	**Member**	**Alternate**
Military	MG (ret.) Eric Labourdette	Mr Per Coulet Mr Emilio Fajardo
Civil users of airspace	Mr Giancarlo Buono	Mr Robert Baltus
	Ms Sylviane Lust (permanent observer)	
Air navigation service providers	Ms Tanja Grobotek	Mr Eduardo Garcia Gonzalez
Equipment manufacturers	Mr Vincent de Vroey	Mr Benjamyn Scott
Airports	Mr Olivier Jankovec	Mr Aidan Flanagan
Staff in the ATM sector	Mr Michele Altieri	Mr Theodore Kyritsis
Scientific community	Prof. Peter Hecker	Prof. Jacco Hoekstra
Permanent observers	**Member**	**Alternate**
European Commission – Directorate General for research and Innovation	Mr Sebastiano Fumero	Not applicable

Permanent representatives	Member	Alternate
SESAR JU Executive Director	Mr Florian Guillermet	Not applicable
SESAR JU Deputy Executive Director	Mr Peter Hotham	Not applicable
SESAR JU Chief Administration Affairs	Mr José Calvo Fresno	Not applicable
SESAR JU Internal Audit	Ms Véronique Haarsma	Not applicable
Secretary of the Board	Ms Ilaria Vazzoler	Not applicable

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