Technical Specification of SESAR 2020 Exploratory Research Call H2020-SESAR-2019-2 (ER4)

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Abstract

This document constitutes the Technical Specifications for the SESAR 2020 Exploratory Research (ER) Call H2020-SESAR-2019-2 (ER4). It contains the comprehensive descriptions of all 31 Topics to be awarded under the Call. It specifies the challenges of exploratory ATM research, the designated scope of research activities addressing this call and the expected impact of these activities.

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1 Introduction

1.1 Purpose of the Document

This document constitutes the Technical Specifications for the SESAR 2020 Exploratory Research (ER) Call H2020-SESAR-2019-2 (ER4). It includes the description of all topic planned to be awarded under this call and complements the information that can be found in the Single Programming Document 2019-2021 [1].

1.2 Research Background

The research topics proposed in SESAR 2020 Exploratory Research are steered by the needs identified in the Aviation Strategy for Europe [2], the European ATM Master Plan [3], Flightpath 2050 - Europe's Vision for Aviation [4] and the ACARE's Strategic Research and Innovation Agenda (SRIA) [5]. This fourth call of Exploratory Research is driven additionally by the results from current and previous SESAR research, relevant H2020 projects and other research activities. Further, the SESAR Scientific Committee was consulted during preparation to provide an opinion on the relevance of the topics that were developed for this call.

1.3 Exploratory Research in the Framework of the SESAR2020 Programme

1.3.1 SESAR Programme Objectives and Scope

The SESAR programme aims to ensure the modernisation of the European air traffic management system by coordinating and concentrating all relevant research and development efforts in the European Union.

The SJU is responsible for the execution of the European ATM Master Plan and in particular for carrying out the following tasks:

- Organising and coordinating the activities of the development phase of the SESAR project in accordance with the European ATM Master Plan, by combining and managing under a single structure public and private sector funding;
- ensuring the necessary funding for the activities of the development phase of the SESAR project in accordance with the European ATM Master Plan;
- ensuring the involvement of civil and military stakeholders of the air traffic management sector in Europe and in particular; air navigation service providers, airspace users, professional staff associations, airports, the manufacturing industry and relevant scientific institutions and members of the scientific community;
- organising relevant research and development to be carried out under its authority;
- ensuring the supervision of activities related to the development of common products identified in the European ATM Master Plan, either through grants to SESAR JU Members or other appropriate mechanisms following proposals to achieve specific programme objectives (in accordance with Regulation 1271/2013).

1.3.2 The SESAR innovation pipeline

The second SESAR R&I programme (SESAR 2020 Programme) is structured in three main R & I phases that aim to deliver a pipeline of innovation, which matures operational and technology solutions through the European Operational Concept Validation Methodology (E-OCVM), a well-established control and monitoring process linked to the technology readiness level (TRL).

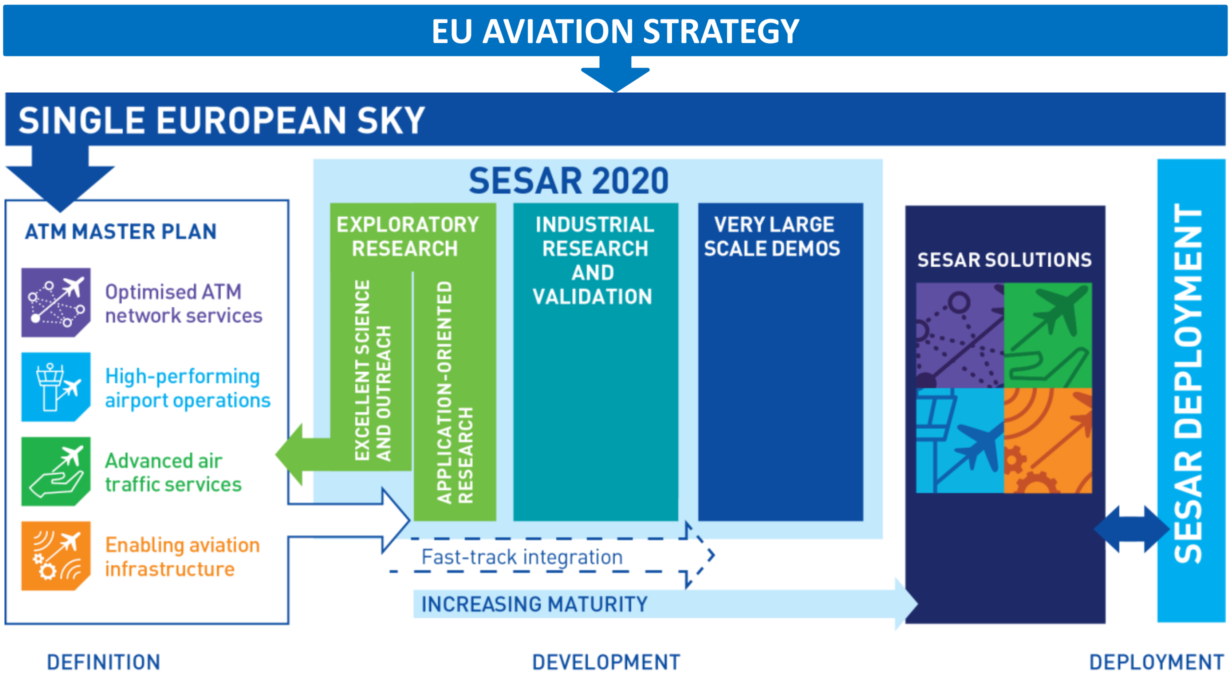

Figure 1: SESAR's innovation pipeline – from the EU Aviation Strategy to SESAR Solutions [1]

This pipeline starts with the EU Aviation Strategy and the SES objectives which feed into the European ATM Master Plan, the main planning tool defining the ATM modernisation ambition, roadmap and priorities. This document is maintained and updated on a regular basis with wide stakeholder consultation and also includes the results of SESAR research activities. Exploratory Research (ER) addresses both transversal topics for future ATM evolution and application-oriented research. According to the four Key Features defined in the Master Plan (Version 2015), it is then expanded with contributions from the SESAR JU Members that undertake Industrial Research and Validation (IR). As per the European ATM Master Plan, this will ultimately deliver results in the form of SESAR Solutions that will contribute to firmly establishing the performance benefits in preparation for deployment. The SESAR JU then further exploits the benefits of the partnership in demonstrating on a large scale the concepts and technologies in representative environments (VLD for Very Large-Scale Demonstration activities). In some cases, for instance where an iterative development model is appropriate or where technology is mature in sectors other than ATM, fast-track integration from Application-Oriented Research to Demonstration activities is also possible.

Not all research can be progressed at the same pace, nor is it beginning from the same level of understanding or will it deliver to the same expectation. Consequently, the key features, above, remain a persistent target, aligned with Single European Sky (SES) while the actual research is matured over time and in accordance with research and industry best-practice.

1.3.3 Research Maturity and Technology Readiness Levels (TRL) in the SESAR 2020 Programme

Technology readiness levels (TRLs) as established by the H2020 rules are used for the maturity assessment approach for SESAR projects. The three R & I phases of SESAR's innovation pipeline address different levels of Maturity. A definition of TRLs addressed by these three phases is provided in Appendix A.

Exploratory Research (ER): SESAR Exploratory Research drives the development and evaluation of innovative or unconventional ideas, concepts, methods and technologies; that can define and deliver the performance required for the next generation of European ATM system. It is the initial part of SESAR 2020 Research and Innovation and covers two types of activities: Fundamental Scientific Research ("ATM Excellent Science & Outreach") and "ATM Application-Oriented Research". The first type of activity covers research starting pre-TRL 1 aiming at least at TRL 1 at the end of the phase, the second type of activity addresses research starting at TRL 1 aiming at least at TRL 2 at the end of the phase.In both cases, projects are strongly encouraged to move to higher TRL levels than the indicated target levels. In particular, the Application-Oriented Research helps to mature new concepts for ATM beyond those identified in the ATM Master Plan as well as helps mature emerging technologies and methods to the level of maturity required to feed the applied research conducted in the Industrial Research and Validation phase of SESAR.

In order to facilitate the transfer of the research results or Exploratory Research projects either into further Exploratory Research projects or into future Industrial Research projects, as well as to comply with the Horizon 2020's open science and open access goals [6], SESAR Exploratory Research projects must ensure their results are made available to the European public to the extent possible.

Proposals marking any deliverables as confidential must provide a reasoned justification for the need of identification of such information as confidential in light of Article 26 of the MGA, and demonstrate that a meaningful set of deliverables and results will be publicly available in compliance with the obligations of Articles 27 and 29 of the GA, respectively, on protection and dissemination of results.

Industrial Research & Validation (IR): The second phase includes Applied Research, Pre-Industrial Development and Validation. As a whole this phase is referred to as 'Industrial Research and Validation' as it is delivered through the Partnership. These activities start at TRL 2 and result into TRL 6. Industrial Research and Validation is out of scope of this call.

Very Large Scale Demonstrations (VLD): Very Large Scale Demonstrations fill the gap between development and deployment phases and demonstrate key SESAR concepts and technologies to raise awareness regarding SESAR activities related to ATM performance issues and their results as well as assessing full-scale deployment readiness. These activities address TRL 7 and are out of scope of this call.

1.3.4 Previous Calls within the SESAR 2020 Programme

The three phases of Research & Development activities (ER, IR and VLD) in the SESAR 2020 programme were addressed by several calls in the past, either to the Members or through Opens calls, as shown in Figure 2.

As documented in the published Single Programming Document 2019-2021 for SESAR 2020 [1], the first call for Exploratory Research (ER1) and the first call for projects under the Industrial Research and Validation (IR) and Very Large Scale Demonstration (VLD) phases of SESAR2020 were launched at the end of 2015 (WAVE 1). In 2016, the second Exploratory Research call (ER2) focusing on RPAS was launched. The third Exploratory Research phase (ER3) and the first open VLD phase (VLD1) were launched together in the same call, also in 2016. In 2017, a Geo-fencing VLD call and a U-space VLD call were launched. The second call for projects (WAVE 2) under the Industrial Research and Validation (IR) and Very Large Scale Demonstration (VLD) phases was launched early 2019.

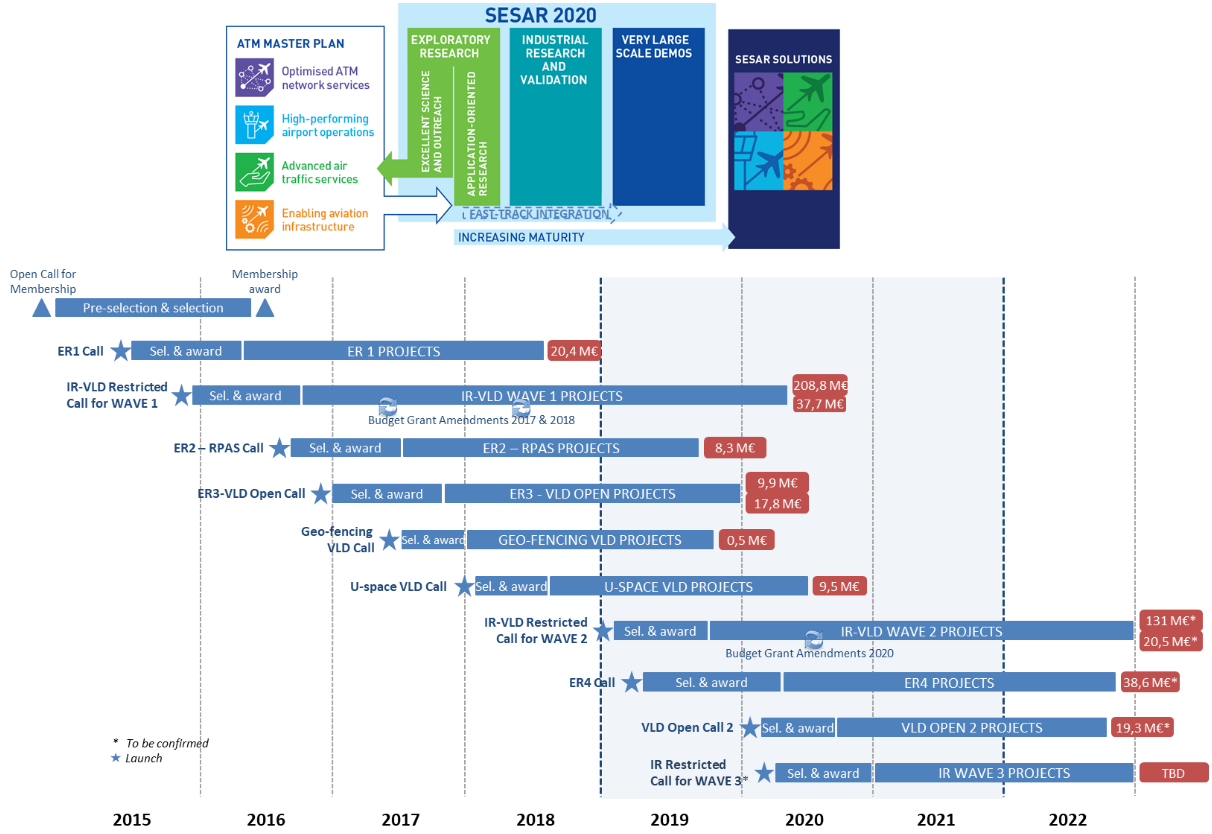

Figure 2: Call activities of the SESAR 2020 programme over the 2015-2022 period [1]

1.4 Work Breakdown Structure of this Call

This call is the fourth call for Exploratory Research within the SESAR 2020 programme (ER4). It consists of two Work Areas (WA) divided into sub Work Areas (SWA) with a clear scope of activities structured at the level of Topics. Work Area 1 addresses "ATM Excellent Science & Outreach" starting at pre-TRL 1. It consists of 6 Sub Work Areas and overall 11 Topics. Work Area 2 addresses "ATM Application-Oriented Research" activities starting at TRL 1. This Work Area consists of 7 Sub Work Areas and overall 20 Topics. The Work Breakdown Structure of this call is shown in Figure 3.

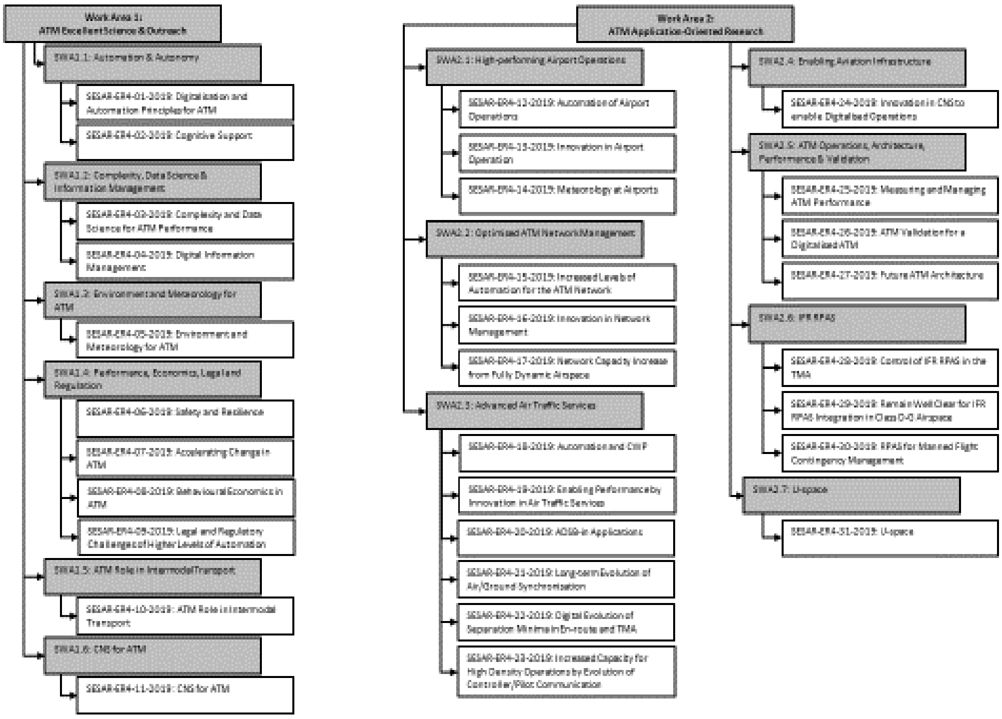

Figure 3: Work Breakdown structure of this call

2 Work Area 1: ATM Excellent Science & Outreach (Starting at pre-TRL 1)

ATM Excellent Science & Outreach aims at bridging ATM research with the wider research community and will provide the science necessary to support ATM change. The work will be performed not only within an existing ATM community but also through outreach to related research activities in other sectors and industries with the objective to look for potential applications into ATM.

The research performed under ATM Excellent Science & Outreach is typically curiosity-driven and explores new and innovative research areas for ATM. This type of scientific research not only brings new knowledge, but also encourages young scientists to develop innovative ideas, concepts and theories for the future ATM evolution. This will bring mutual benefits to SESAR research activities and to the Horizon 2020 transport Commission's work programme. Consequently, the purpose of this research area is to investigate through research and innovation actions 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 Flightpath 2050 vision, or identify new ATM business opportunities.

This Work Area covers 6 Sub Work Areas (SWA 1.1 to SWA 1.6). ATM Excellent Science and Outreach scope in this call includes research activities across the areas described in the following sections.

2.1 Sub Work Area 1.1: Automation & Autonomy

Automation could provide the key to significant performance improvements across many aspects of ATM. On the other hand, human cognitive abilities, especially in safety-critical situations, can have positive benefits and provide strong arguments against full autonomy in certain situations. The challenge is therefore to propose solutions with automation levels or autonomy that have the capability to provide substantial and verifiable performance benefits whilst fully addressing safety concerns.

Therefore, research activities under this theme should also address the application of new approaches to allow automation to cope also with non-nominal and unexpected situations and should explore new concepts for supporting the human operator under all conditions.

Under this sub work area, there is substantial scope for learning from aircraft automation, other industries and research sectors.

2.1.1 SESAR-ER4-01-2019: Digitalisation and Automation Principles for ATM

Specific challenge:

Increasing the Automation in ATM is considered as a key to significantly improve ATM performance. However, ATM is a continuous 24-7 set of services where the complexity of the ATM system, its fallback modes and necessary recovery steps has proved to be a major challenge for the introduction of further automation, and this has consequently slowed down the advancement of automation in ATM, especially in the most congested areas of Europe. The latest progress in the domain of Artificial intelligence and in particular Machine Learning may open new possibilities for further automation in ATM in high-density operations and some new applications have already been developed in SESAR (e.g. [7]). The application of Machine Learning for Automation in ATM also comes with new challenges, including sound assurance arguments that need to be solved to avoid a negative impact. In particular safety, business continuity and cyber security issues need to be proposed at an early stage of development of the automation concept.

One challenge of increasing automation is related to transparency of the automated system. Any automated assistance system needs to be able to provide the human operator with all information necessary to enable an understanding of the reasons for its behaviour and/or decisions. Otherwise the system may not be accepted or trusted by the operator, thus negating the theoretical benefits of the automation.

Another challenge is the Generalization of results from Machine Learning methods. Differences between the data used for training and the data feed to a trained algorithm can lead to unexpected results, including that not all situations can be anticipated during the training. Additionally, due to this behaviour, the system might not be able to adapt to changes of behaviour of other actors that could not be anticipated during the training of the system. In order to certify systems based on Machine-Learning, methods are needed to demonstrate that in delegating the control to these system sufficient assurance can be provided that it does not raise safety risks beyond what can be mitigated by other measures. Moreover, concerns have been raised that this behaviour may add uncertainty or unexpected behaviour to the ATM system.

Scope:

Proposals should select a specific ATM operational environment, present a vision of a higher level of automation in this operational environment (which may include the delegation of control to the automation) and address one or more of the specific challenges above that hinder the application of machine learning methods for the further automation of ATM (e.g. Transparency, Generalization). Proposals should aim at providing a better understanding of this challenge(s) and investigate innovative methods to address the(se) challenge(s) in ATM. Proposals may make assumptions about the availability of technology and/or operations enablers (e.g. data link), but need to state them clearly. This topic covers ground and airborne automation that impacts ATM.

Projects addressing the Transparency of automated systems incorporating machine learning methods required for cooperative human machine systems should identify which information needs to be provided to enable the human operator to cooperatively work together with the automation. Based on the identified information requirements, the project should select or develop and assess suitable machine learning methods for ATM automation that are able to provide these kind of information and assurances. The project may investigate the applicability of methods from the domain of Explainable Artificial Intelligence (XAI).

Projects addressing the Generalisation and the adaptation of the algorithms to changes in the operational environment, should investigate methods to estimate and increase the ability of an automated systems to handle a situations that were not foreseen during the development and training. These methods should enable automation to adapt to changes of the environment, like the change of behaviour of some actors (e.g. modification of operational procedures), the entrance of new actors or unforeseen traffic or weather situations. Projects may explore the possibility to apply algorithms able to learn during operation in order to adapt to optimise operations based on changes in the environment. Projects may also investigate the effects of uncertainty added to operations by these new methods.

Research activities may take aspects related to certification into account as required. However, this shall not be the primary focus of research in the proposal as this will be addressed in topic SESAR-ER4-09-2019.

Proposals can also suggest to address other challenges of applying AI machine learning for ATM Automation other than these mentioned above if justification is provided.

Expected Impact:

Projects are expected to provide principles that could enable higher levels of automation that are predicted to lead to an improvement of ATM performance, in particular cost efficiency, capacity and safety.

Type of Action:

Research and Innovation Action (RIA).

2.1.2 SESAR-ER4-02-2019: Cognitive Support

Specific challenge:

According to the SESAR vision outlined in the European ATM Maser Plan [3], advancing the automation in ATM is the key to significant performance improvements across many aspects of ATM and development and implementation of higher levels of automation will enable handling the predicted increase in air traffic demand and contribute significantly to achieving the SES High-Level Goals.

The ATM system is currently designed to rely upon relatively high levels of human intervention to manage the air traffic safely and efficiently. This role of the human is being challenged and it is expected to change towards more of a supervisory role yet also maintaining the human as a critical and an integral element of the ATM system. Experience from ATM and other domains shows that increased dependence on automation makes it important to consider automation failure scenarios, system resilience and the challenge of maintaining a skilled and competent workforce. There will be a need to assess the human performance issues for ATC in a similar way to those that are known to affect flight-crew performance in the glass cockpit. These include the need to prevent the risks associated to moving the human operator into a monitoring role: stress, lack of attention, loss of situational awareness and de-skilling.

A promising approach to preventing these issues is to progressively evolve the ATM system into a Joint Human Machine Cognitive System following an integrated design that optimises the collaboration of actors in view of optimising system performance. Development and implementation of higher levels of automation will require careful consideration of the strength of human and automation systems as well as the identification of new human roles in parallel with the development of ATM concepts and use of technology.

Scope:

Proposals for research in this area should target an ATM system with a medium to high level of automation in which the human operator is working cooperatively with advanced automation as a digital assistant. Both, ATM-related airborne and ground systems are in scope.

Research may address human performance aspects related to higher levels of automation (i.e. stress, lack of attention, de-skilling, complacency…) and resilience, e.g. by developing new approaches for defining suitable task allocation strategies enabling a cooperation of ATCOs and/or other ATM actors and automation. This may include the use of adaptable or adaptive automation concepts. Projects may in particular focus on potentially required hand-overs between automated systems and human operators as well as handovers between human-human and machine-machine in normal and degraded modes of operation. These new approaches may build upon the existing legacy and SESAR solutions in the pipeline, or they could take a clean-sheet approach to automation. These proposals should validate the proposed design of ATM systems automation, focusing of expected future roles and procedures. They may consider approaches focusing on the front-end of automation and using a human to operate the automation in the background (e.g. Wizard-of-Oz approach) or even use a predefined reaction of the automation.

Proposals may also address the implications of the expected future role of the human and the foreseen introduction of new support tools on training requirements and develop appropriate training concepts. Projects are encouraged to take into consideration the opportunities enabled by the current advancement of technology for the design and delivery of training.

Proposals may also focus on specific aspects of these new systems. For example, proposals may investigate the application of psychophysiological measurements like neurometrics or the detection of facial expressions for applications like stress management systems, fatigue declaration, new training techniques or adaptive automation. Proposals may also consider to investigate potential application of activity trackers available on the consumer market. Proposals planning to investigate the application of psychophysiological measurements need to propose a specific application within the ATM system.

Proposals addressing this topic should not only consider normal operating situations but also take into account system failures and degraded modes of operation. This requires identification of system failure states and definition of appropriate procedures.

Proposal addressing this topic should take into consideration the results of SESAR WP-E projects, in particular HALA! [8], and ER1 projects (AUTOPACE [9], MINIMA [10], STRESS [11]). Under this topic, there is also substantial scope for learning from other transportation modes and other industries and it is expected that proposals will build upon an established body of knowledge and apply this into the challenges of ATM.

Expected impact:

The concepts for Joint Cognitive Human Machine systems and/or innovative Training concepts developed in these research are expected to enlarge the body of knowledge that is needed to make it possible to safely introduce higher levels of automation in ATM, which should provide substantial benefits for capacity and cost-effectiveness, safety and security of ATM operations.

Type of action:

Research and Innovation Action (RIA).

2.2 Sub Work Area 1.2: Complexity, Data Science & Information Management

The research activities under this theme will address complexity science, data science and information management and their potential for applications in ATM. Complexity science will deal with the application of complexity theory in the ATM domain and will therefore contribute to a better understanding of how the ATM system works, in particular the interaction of its subsystems, capabilities and components.

Data science is an emerging field of research in ATM concerned with managing and exploiting large data sets through mining, big-data techniques, novel algorithms or artificial intelligence and their application to air traffic management. This will enable further exploitation of information management, knowledge creation and improved insight into optimizing planning and execution of ATM.

Effective application of information management into ATM must also address the need for Safety and Security, in particular cyber-security. Research activities in this theme are expected to address this need in some way but proposals can also be made on the application of state of the art trust frameworks into ATM, such as blockchain.

2.2.1 SESAR-ER4-03-2019: Complexity and Data Science for ATM Performance

Specific challenge:

Due to the rapidly developing techniques of data science it is possible to analyse large data sets and to detect new correlations and relationships. In fact, data science techniques are already having a huge impact in many application areas. The application of innovative methods of data science in the ATM domain could provide new insights to measure and improve the performance of the ATM system.

Scope:

Proposals should select data-driven methods that allow to identify so far unknown patterns, correlations or even cause-effect relationships in ATM data or allow for improved predictions on different levels (e.g. trajectories, sectors, and network). Proposals may suggest to use model-based approaches as a complement to data-driven methods, including a 'data-twin' representing reality.

Research activities should consider potential sources of uncertainty (e.g. partial observations, inaccurate information, incomplete knowledge inherent random nature, etc.) and their impact on the potential conclusions. Research activities may aim to provide improvements to the whole data workflow including data acquisition, cleaning, processing, and analysis.

Research activities addressing this topic should aim at providing new insights into the performance of the ATM system and investigate how the findings can be used to support strategic or real-time decision making in order to improve ATM performance. They should develop specific case studies and aim to identify actionable indicators or develop innovative visualisation techniques for complex data to support decision making.

As a part of their activity, projects may also define and make available standardised data-sets for training statistical models and a 'gold standard' (e.g. best theoretical classification of input data).

For example, proposals could offer to study how data science can be used to provide new insights into optimising airspace management (e.g. sector design and configuration, demand and capacity balancing, separation management), for example by studying delay sinks and amplifiers.

In case research activities investigate safety critical applications, potential safety issues (determinism, certifiability, etc.) raised by the selected method must be addressed.

Expected impact:

Successful research in this topic should provide new insights into ATM performance and identify specific use-cases to show how these insights can be used to support strategic or real-time decision making in ATM.

Type of action:

Research and Innovation Action (RIA).

2.2.2 SESAR-ER4-04-2019: Digital Information Management

Specific challenge:

Due to the increasing Digitalisation of ATM, more and more data is being recorded and even more data will be recorded in the future. This data could be used to improve operations e.g. by creating a common situation awareness among stakeholders and support their collaborative decision making towards measuring and communicating about ATM performance attributes, safety, security etc. and contribute more efficient organisation of the entire mobility system [12]. Additionally, data can be used for research and development purposes, like comparing new concepts with current operations. However, there is historically some technical barriers and reluctance to make data available to other stakeholders for various reasons, e.g. concerns regarding the costs of making data available, insights into business decisions that may be revealed or lack of knowledge how data can be shared while protecting privacy.

The challenge is to overcome the barriers for the benefit of stakeholders and the ATM system as a whole.

Scope:

Proposals should develop innovative concepts supporting and simplifying storing, cataloguing and sharing of data between stakeholders and address this from different perspectives: operational, technological, economical and legal. Different types of data could be considered, e.g. operational data, performance data or safety data.

Research activities should identify the benefits that could be achieved by sharing data between stakeholders. They should investigate which technological solution should be used and which architecture would be appropriate for a potential platform to allow for a cost-efficient and secure provision of data. Proposals should explore potential business models of making data available taking into account the related costs of preparing and proving data and the ownership of date. Proposals may also investigate the need for regulations for generating, distributing and exploiting ATM data (i.e. enforcing more open data). Additionally, they may investigate concepts for allowing the use of private data while respecting the confidentiality of the data sources, i.e. the usage of secure computation methods and other cryptographic approaches that allow data to be processed without disclosing the information (e. g. zero- knowledge outsourced computation).

Research activities could also investigate how data could be made available for research and third-parties and would allow prototyping of innovative data-driven applications

Proposals should investigate one or several use-cases. For example, proposals may investigate sharing of operational data like planned and historical runway configurations, LIDAR readings on final approach, STARs in use, sector configurations, AMAN and DMAN planned time or radar data. Proposals may also investigate how performance relevant data could be shared across stakeholders and with the general public to communicate and increase the awareness of ATM performance.

Proposals may also focus on accident and incident data, study the availability in different European states and other counties and investigate how the availability of this data could be increased in order to improve safety. This research may include sharing of safety data through EASA and/or the NSAs, or propose complementary channels.

Expected impact:

Depending on the selected use case, research activities could contribute to improving ATM performance in different Key Performance Areas like safety, cost-efficiency, capacity or others. The specific benefits expected by selected use cases should be identified in the proposal and further investigated in the project.

Type of action:

Research and Innovation Action (RIA).

2.3 Sub Work Area 1.3: Environment and Meteorology for ATM

The research activities will aim at better understanding the impact of aviation on the environment and the ways in which ATM can reduce these effects. Research activities should take into account CO2 but also other aspects like for example NOx, contrails, air quality (NOx, particle matter) and noise. Research activities may address research aimed at developing 4D trajectories that are optimised to take account of environmental considerations.

Further, research activates will study the vulnerability of the ATM system to local and global weather phenomena and how enhanced meteorological capabilities and their integration into ATM planning processes can be utilised for improving ATM efficiency and safety. This requires understanding of the potential of different types of weather-related information that could be used in ATM operations taking into account the inherent uncertainty of meteorological information.

Research activities will also investigate the impact of global and/or long-term phenomena such as changes in the frequency and severity of extreme weather resulting from climate change, or ash-cloud formation on ATM operations and ways to increase ATM robustness.

2.3.1 SESAR-ER4-05-2019: Environment and Meteorology for ATM

Specific challenge:

Air traffic management has an important role to play in reducing the environmental impact of aviation, in addition to the improvements to be derived from new aircraft and engine technologies. Research is needed to better understand the ways in which ATM can help reduce the impact of aviation on the environment, considering not only fuel burn but other aspects such as CO and NOx and contrails.

Also, over the last few years important improvements in observational (e.g., satellites, LIDARs) and numerical weather prediction (NWP) models in the atmospheric sciences have taken place leading to improved meteorological products, however they are not in systematic use by ATM actors. Increasingly weather is becoming a significant causal factor for delay, in the Network Operations Report for 2017 (issued by the Network Manager) it is stated *"A great number of en-route weather events combined with capacity and staffing issues in some ACCs accounted for much of the delay in*

2017. En-route weather delay increased by 30% compared to 2016 and was the double of 2015 weather delay. Airport ATFM delay decreased by 3.6% in 2017. Airport capacity and weather contributed to 83.9% of the total airport delays". Global and/or long-term phenomena such as climate change, the frequency and severity of extreme weather may even further increase this effect in the future.

Scope:

Proposals may investigate innovative operational changes to ATM aiming at reducing the environmental impact from aviation. These activates should considered different aspects of environmental impact, e.g. climate impact through CO2 and other emissions, local air quality and noise and the effect this will have in the context of global and/or long-term phenomena such as climate change, global warming, and changes in the frequency and severity of extreme weather or ash-cloud formation on ATM operations.

Also proposals may research to secure the proper integration of existing and possible new meteorological products into ATM for example to reduce the vulnerability of the ATM system to local weather phenomena and to improve the prediction of 4D Trajectories and network forward planning to enable a minimisation of consequential weather-related delays.

Research activities may focus on the development of a concept for using very high-resolution, very short-range forecasts using numerical weather prediction models and observational data assimilation, and assess the need of new MET data/products. The incorporation of ensemble weather information into decision-support tools, adapted for different ATM stakeholders may also to be investigated.

With respect to the local (airport) operations, the accurate prediction of weather conditions (e.g. visibility, glide-path wind) influencing airport arrival and departure operations along with a consolidated climate risk assessment methodology may be investigated.

This topic is linked to ACARE Challenge 3 [4].

Expected impact:

The environmental research should enhance the understanding of how the environmental impacts of ATM operations can be reduced during different phases of flight.

The Meteorological research should contribute to enhance ATM efficiency by integrating meteorological information and by leading to a better understanding of the resilience of the ATM system to local weather and global and/or long-term phenomena to better manage consequential delays in the Network.

Type of action:

Research and Innovation Action (RIA).

2.4 Sub Work Area 1.4: Performance, Economics, Legal and Regulation

In recent years, the importance of understanding the evolution of the ATM service market structure, the need to minimize airborne costs, use of cost-effective new business and pricing models has become evident. The research performed under this area will contribute to the wider innovation and competitiveness of the European ATM industry, therefore contributing to Challenge 2 of Flightpath 2050.

The links between economics, the legal and the regulatory frameworks and the research performed in each subject are close; this means that the implications of change in one area have to be integrated across the whole, otherwise change in ATM can be unnecessarily blocked.

2.4.1 SESAR-ER4-06-2019: Safety and Resilience

Specific challenge:

Safety is inherent to ATM, so safety of operations has always been the highest priority and consequently ATM has reached a very high level of safety. However, research is necessary to maintain or increase this level in the future while capacity and cost-efficiency are also being increased. Additionally, upcoming challenges like increased digitalisation and the foreseen increase of automation can change the way organizations deliver services and thus could impact upon safety and resilience. A better understanding of this influence/impact is necessary to support the design of a safe and resilient future ATM system.

Scope:

As safety is the result of the complex interaction between processes, technology and people working together, the introduction of automation can have more implications on safety than just technical reliability. Proposals can research how increasing the level of automation in ATM could affect the delivered safety levels and develop guidelines for organizations and their respective interactions as well as research and development activities on future automation. These research activities should take into account the state of art on the research on High Performance and High Reliability Organisations and related disciplines.

Proposals may also aim at identifying future research needs related to safety by analysing performance or safety recordings, in which case proposals must demonstrate that they have access to this data. In particular, research activities may aim to identify safety challenges through a large scale analysis of accident and incident data. These activities should evaluate how well identified safety challenges are expected to be addressed by existing SESAR solutions [13] or candidate solutions [14] and, if necessary, may propose at the end of the project new potential SESAR solutions to address the identified and not yet covered safety challenges.

Proposals may also address the increasing need to consider resilience during system design and take into account the three complementary resilience capacities: absorptive capacity, restorative capacity and adaptive capacity [15]. Projects working in this area should analyse the resilience of today's ATM system and assess how envisioned changes might impact its resilience in the future. In today's system, humans are a key element for system resilience through team-work, coordination and learning. The expected increase of automation is likely to impact the role that humans are able to play in supporting resilience, thereby requiring an evolution. As there is a huge potential to learn from other sectors (e.g. public safety, banking), projects are encouraged to investigate how resilience, in particular disruption management, is addressed in these domains and to identify approaches and asses their potential for transferring them to ATM to address current or future needs. Projects may consider multiple possibilities and compare and benchmark them against each other and todays ATM systems and procedures. Modelling and simulation might be used for assessing the resilience of selected approaches.

Expected impact:

Projects are expected to contribute to increase the body of knowledge of Safety and Resilience of the ATM system by identifying areas of improvement, providing design guidelines and identifying future research needs and in doing so supporting decision making regarding the research and the future design of the ATM system.

Type of action:

Research and Innovation Action (RIA).

2.4.2 SESAR-ER4-07-2019: Accelerating Change in ATM

Specific challenge:

Due to growing demand, new regulations, the emergence of new market entrants and innovation in business models there is an increasing market pressure and a need for increasing operational resilience and agility with continued pressure on Europe-wide cost efficiency for aviation and air traffic management. New technology advancements could provide the necessary improvements but the process from innovation to deployment in ATM is currently slow. Research is need to better understand the economic barriers and to identify mechanisms (including, but not limited to, regulations) to accelerate the Research and Innovation (R&I) lifecycle.

Scope:

The range of research that could be covered in this topic is broad and topics mentioned here are only indicative. Research proposals may target and challenge existing SES economic, regulatory and legal frameworks within the timeframes set-out in the Flightpath 2050 vision document.

Research activities should study potential measures to speed up/shorten the R&I lifecycle. This includes changes driven by regulation or derived from natural or forced economic incentives. As introducing new ATM operational improvements often requires the deployment of enabling ground and airborne technology, the adoption of novel technologies in ATM is also determined by the pace of ground system and avionic updates cycle. In particular, proposals may investigate how to accelerate the avionics update cycle. Research activities should study the state of the art practices in ground system and avionics update cycle, explore potential benefits of moving to shorter cycles and identify and evaluate mechanisms to speed-up the spread and adoption of novel technologies or accelerate and lighten any certification and/or approval processes. Proposals may, for example, investigate the feasibility and the potential impact of introducing best equipped or best performing – best served rules through case studies and extract lessons learned.

Proposals may also explore ideas and measures to shorten the R&I lifecycle by focusing on the gap between R&D and deployment. For example, projects may analyse case studies of previous successful or unsuccessful deployment experiences in order to extract lessons learned and develop innovative ways for aligning technology investment and business needs that could help reducing the time between these two phases. Projects may also analyse the challenges associated to the deployment of a specific SESAR solution, be it an already mature solution or one that is still in the research phase.

Proposals may investigate the feasibility of setting up a framework for assessing the impact that regulations will have in practice (e.g. via pilot projects or regulation restricted to a limited area). Although models and simulations are available to assess the effect of policy decisions and regulations in advance, the validity of these approaches remain limited and policy decision still have to be made under high levels of uncertainty regarding their effects. A regulatory testbed should allow to test policy decisions while limiting their potential negative impact. Projects investigating this possibility may analyse the state-of-the-art and best practices in other domains and assess their applicability to the ATM domain

Expected impact:

Proposals are expected to contribute to a better understanding of change and barriers of change in ATM and to provide recommendations on how to facilitate change in ATM. This should contribute to accelerating development and deployment of new technologies better fitting stakeholder needs and consequently accelerating the achievement of the ATM Master Plan performance ambition enabled by SESAR solutions.

Type of action:

Research and Innovation Action (RIA).

2.4.3 SESAR-ER4-08-2019: Behavioural Economics in ATM

Specific challenge:

The application of economic models supports well targeted policy making. However, current economic models applied in ATM are often normative, thus making a number of assumptions about agent rationality that have been demonstrated not to work in practice in several cases. This is because real decision are often not fully rational. An assessment of novel ATM concepts using behavioural economics in ATM at an early design stage could help to predict the actual behaviour of ATM stakeholders and inform decisions about the specific design of the concepts and policy decision making related to their introduction.

Scope:

Proposals and their research activities may investigate the application of behavioural economics to improve economic models in ATM by integrating an improved prediction of actual stakeholder behaviour. These activities should provide insights into how to incentivise desirable behavioural change and enable better decisions though incentives, policies, etc. Proposals should suggest a specific application and justify their selection by explaining the expected benefits of applying behavioural economics for this application.

For example, proposals may investigate suggested business changes that are expected to bring significant benefits to the ATM network and analyse how their introduction may impact the behaviour of stakeholders. The research activities are expected to provide new insights on the expected benefits and recommendations for investigated business changes. In particular proposals may, for example:

- Investigate the introduction of new types of legal contracts and changes to regulations required by the concept of the trajectory broker which foresees an evolution of the Network Manager offering trajectory products to Airspace Users and ordering capacity from Air Navigation Service Providers [16]. These projects should cover the relationship between Network Manager and Air Navigation Service Providers and between Network Manager and Airspace Users;

- Aim at improving demand forecast models at network or local level by predicting passenger behaviour more accurately, for example by analysing how the modal choice is impacted by airport access time or environmental considerations;

- Study existing capacity provision strategies of ANSPs and their impact on airline route choices in order to develop improved demand prediction models or capacity provision strategies. Furthermore, projects could aim at providing a better understanding of perceived fairness and equity of potential upcoming regulations making it possible to plan how to better implement new policies;

- Perform a comparative study of existing controller rostering policies, including shift entry and exit times and sector rostering during a particular shift of different ANSPs, analyse their correlation to the capacity offered by the ANSP and provide recommendations for changes. Research activities must consider human performance aspects of controller rostering, as well as the psychological, cognitive, emotional, cultural and social aspects.

These examples are indicative and proposal may suggest to apply behavioural economics to other decision processes if this can be duly justified.

Expected impact:

The research will make it possible to provide a better prediction of stakeholder behaviour and contribute to inform policy making so that behaviour that improves the overall system performance be realised.

Type of action:

Research and Innovation Action (RIA).

2.4.4 SESAR-ER4-09-2019: Legal and Regulatory Challenges of Higher Levels of Automation

Specific challenge:

The introduction of advanced automation in ATM is not only a technical challenge, before this technology can be deployed questions of responsibility and liability have to be answered. Additionally, procedures and methods are required for the approval and/or certification of advanced automation. Additional challenges are presented by more advanced automation that applies novel methods like machine learning to learn and adapt its behaviour (in real time) during operation as the exact behaviour of the automation cannot be predicted in advance.

Scope:

Proposals and their research activities may address issues related to the means of approval/certification of novel ATM-related airborne and ground systems that enable higher levels of automation. Proposals may in particular focus on systems based on machine learning techniques. Proposals should follow a holistic approach and consider legal and regulatory aspects including privacy as well as the technical aspects (architecture, system performance, reliability, etc.) of the approval/certification jointly to ensure that the different disciplines are aligned. On the one hand, the research activities could investigate and evaluate approaches that can potentially be applied for the approval and/or certification of automation and that allow to demonstrate the safety of automation during normal, impaired operation and recovery phases of continuous and safe service provision. On the other hand, these research activities could aim at providing guidelines for developing advanced automation in order to simplify approval/certification. Of particular interest is to show how safety can be ensured even if not all situations and variations of parameters can be anticipated during the design phase. Research activities may apply Uncertainty Quantification to address this issue and also cover the specific challenges of certification of automation that can adapt is behaviour to changes of the environment over time.

Research activities shall take into account other initiatives developing safety of life systems that may have different approaches to certification and review their applicability to ATM.

Please note that EASA is developing an Artificial Intelligence (AI) Roadmap planned to be released by mid-2019 (see [17]) which aims at identifying the opportunities, challenges and impact of this emerging technology and to propose a corresponding action plan. Proposals should plan effort to analyse how their research is positioned with respect to the EASA roadmap.

Expected impact:

The expected outcome is twofold: Projects are expected to provide guidelines for the designing of advanced automation in line with approval and/or certification requirements and to provide new methods for the approval and/or certification of advanced automation. Both should contribute to enabling high levels of automation in ATM while a keeping safety on a high level.

Type of action:

Research and Innovation Action (RIA).

2.5 Sub Work Area 1.5: ATM Role in Intermodal Transport

The research activities under this theme will address the connection and dependence between ATM/aviation and other transport modes, from the perspective of ATM. Consequently, it is envisaged that complementary research will be performed linking to activities launched by the EC and potentially other transport areas (i.e. rail, road, water) to ensure interoperability and delivery of complementary services to realise cross-modal performance as described by the EU transport policy documents.

2.5.1 SESAR-ER4-10-2019: ATM Role in Intermodal Transport

Specific challenge:

Air Traffic Management (ATM) and Air Transport are part of an intermodal transportation system. In an intermodal transportation system, a passenger’s journeys consists of a succession of different transport modes, which depends on transport availability, but also on individual preferences regarding travel time, comfort, environmental impact and other criteria. Considering ATM as an integrated part of an intermodal transportation system will make it possible to optimize the performance of the overall transportation system and the complete door-to-door journey, instead of optimizing the individual modalities.

Seeing air transportation at the heart of an integrated, seamless, energy efficient, diffused intermodal system, Flightpath 2050 [4] set the goal to allow travellers to reach their target destination within Europe within a maximum door-to-door time of four hours. Passengers should experience a seamless journey with full connectivity. In order to be able to reach these ambitious goals, a close collaboration between different transportation modes is required. A better understanding is needed on how ATM can better contribute to improve passenger’s intermodal journeys and how to increase the performance of the overall transportation system.

Scope:

Research activities should explore the connection and dependence between ATM/Air Transportation and other transport modes. Proposals should address the main barriers and identify how Air Transport, in particular urban and extended urban mobility, can evolve by efficiently connecting information and services with other transport modes to achieve the 4hr door to door ACARE goal and a seamless journey.

Proposals may investigate how sharing ATM information with other transportation modes or taking into account information from other transportation modes in ATM decision making could improve the individual journeys and the overall transportation systems.

Research activities may also investigate the legal feasibility and potential impact of introducing regulations aiming at optimizing the overall transportation system and allowing passengers to make informed choices, e.g. by proving more information on the environmental impact (carbon footprint, other emissions and noise) or by introducing a route charging scheme taking into account environmental criteria and the availability of other transportation modes for this route for defining the route charges.

Further, research activities may also study the feasibility of considering multimodal aspects (like the availability of modal choices) during all three phases of Air Traffic Flow and Capacity Management (ATFCM) activities and analyse the potential impact on the performance of the overall transportation and passengers door-to-door journeys.

Proposals may explore the possibility of involving passengers in playing an active role in co-designing door-to-door services and generating data to incrementally define and improve new interconnected services following the approach of "participatory design".

Proposal need to demonstrate their complementarity to activities launched by the European Commission and potentially other transport areas (i.e. rail, road, water) to ensure interoperability and delivery of harmonised services to realise cross-modal performance.

Activities are linked to ACARE action areas 1.1 (low carbon transport systems), 1.2 (design and implement an integrated, intermodal transport system) and 1.3 (door to door targets) [4].

This topic is also linked with topic SESAR-ER4-25-2019 (ATM Performance) which aims at defining ATM performance indicators better capturing the ATM contribution to the performance of the transportation system.

<u>Expected impact:</u>

Proposals are expected to contribute to better integrate and connect ATM and air transportation with other modalities, to improve passenger experience during door-to-door journeys and in doing so, contribute to reaching the FlightPath2050 goals, in particular the 4h door-to-door target and the seamless journey.

<u>Type of action:</u>

Research and Innovation Action (RIA).

2.6 Sub Work Area 1.6: CNS for ATM

As Communication, Navigation and Surveillance (CNS) are subjects not exclusive to ATM, activities proposed under this theme must show clear relevance for ATM.

Therefore the study and use, or adaptation, of new CNS technologies or techniques developed outside ATM must be able to meet both the operational needs as well as an appropriate analysis of the safety, performance and security implications for the ATM system.

2.6.1 SESAR-ER4-11-2019: CNS for ATM

Specific challenge:

Communication, Navigation and Surveillance (CNS) is one of the fundamental enablers of ATM as it supports locating and identifying air vehicles, and exchanging information with them.

The CNS services are currently delivered based on a network of technologies based on techniques which, for some of them, have been developed several decades ago and may not be as efficient as technologies being currently researched or in use in other domains.

Quality of services provided by the CNS network may suffer degradations (e.g. due to technical failures, external effects (e.g. solar storms), software issues, intentional or non-intentional disruptions (e.g. cyber-attacks)). As an example, availability is currently managed through redundancies which can have a significant cost.

The challenges to be addressed is to identify new technologies and/or configurations capable to provide the CNS services while also maintaining or improving the integrity, availability, performance and quality of these services whilst avoiding unnecessary cost and the perception of over-engineering the solutions.

Scope

More modern techniques and technologies which are under research in contexts other than aviation shall be investigated to consider their relevance for ATM communication, surveillance or navigation domains or to combination of these domains as they may have the capabilities to unlock unforeseen possibilities.

Intelligent network management solutions shall also be investigated to ensure that the required quality of service by applying powerful network management techniques leading to cost-effective solutions.

During the research, it shall be considered that the population of air vehicles in the considered timeframe will drastically change integrating new types of flying objects (unmanned, orbital vehicles, flying cars) which all need to be considered as “clients” of the CNS services.

Research area 1: Application of new techniques and new technologies to provide CNS services
Communication, Navigation and Surveillance are not exclusively an ATM subject; they are also being researched and used in other domains.

The objective of this research area is to consider the relevance of new and innovative techniques and technologies, being researched outside the ATM, which could support localisation of air vehicles, acquiring their position and allowing exchange of information while maintaining, as overarching principles, the upmost level of integrity and safety. A technique could support one or several CNS domains.

The research should address any potentially innovative technologies without limiting the research to technologies which are specifically being researched for the CNS/ATM; as a matter of example technologies such as laser could be explored or any other innovative techniques. In particular, the usage of techniques operating outside the spectrum currently used by aviation is encouraged.

Research shall address the integration, interoperability and openness of proposed solutions for the long term, exploiting synergies, reducing costs and optimising spectrum usage.

Research area 2: Intelligent CNS network

The objective of this research area is to address new ways of managing the CNS network through intelligent network management principles. In particular advanced techniques such as Artificial Intelligence, Artificial Neural network, etc. that could enable the network to reorganise or reconfigure in case the demand for service would significantly change in specific circumstances (e.g. a sudden increase in traffic in a specific region) or in case one or several components of the network are suffering deficiencies (e.g. technical failures, non-intentional adverse conditions (e.g. solar storm) or cyber-attacks).

Expected impact:

Successful research in this topic will have the potential to generate high positive benefits for ATM in terms of resource efficiencies, improvements in security, increased safety and cost efficiency.

Type of action:

Research and Innovation Action (RIA).

3 Work Area 2: ATM Application-Oriented Research (starting at TRL 1)

ATM Application-Oriented Research encourages innovative and visionary ideas that will contribute to SESAR 2020 Research and Innovation (R&I) cycle. ATM application-oriented research will help mature new concepts for ATM that extend or go beyond those identified in the ATM Master Plan as well as help mature emerging technologies and methods to the level of maturity required to feed the applied research conducted in the Industrial Research and Validation phase of SESAR; thus connecting the ATM Exploratory Research to the ATM Applied Research in the context of the European ATM Master Plan.

In many cases, the research results from previous ATM Excellent Science & Outreach projects could be candidates for further research under Application-Oriented Research in order to increase the maturity and stakeholder buy-in to new ideas aligned to the European ATM Master Plan key features.

After a maturity assessment of the ATM Applications-oriented research projects their results will be transferred, if applicable, into SESAR 2020 industrial research.

3.1 Sub Work Area 2.1: High-performing Airport Operations

The research activities under this theme will include research of methods to increase the level of automation of airport processes, research of innovative concept for airport operations like the use of service drone and an enhanced coordination with other transportation modalities and research on improved use of meteorological information at the airport.

3.1.1 SESAR-ER4-12-2019: Automation of Airport Operations

Specific challenge:

Airports remain one of the most significant bottlenecks in ATM. At capacity constrained airports, traffic demand can exceed the airport capacity (either at the runway, taxiway or apron) and, with the expected rapid growth in air traffic in the coming years, there will be an increasing number of capacity-constrained airports for significant periods of each day. This situation will become even more critical under adverse weather conditions. As a consequence, there is a need to find solutions to improve the efficiency of airport operations and their resilience in visually and/or challenging meteorological conditions. One of the potential areas of improvement aims at increasing the level of automation for supporting ATCOs and flight crews during the execution of their tasks. This would allow ATCOs to manage higher levels of airport throughput while at least keeping (if not improving) safety levels and to also allow flight crews to execute their tasks more efficiently. The research activities under this theme support of the Airports Council International (ACI) vision for the digital transformation of the airport business [18].

Scope:

The scope of this topic covers the following aspects:

Application area 1: Advanced HMI interactions for tower controllers
This application area covers the development of new human machine interface (HMI) interaction modes and technologies in order to minimise the load and mental strain on the Tower controllers (especially under high traffic density situations, low visibility conditions, etc.).

The proposed applications shall go beyond or be complementary to those that are being addressed in Industrial Research (IR) solutions PJ.16-04 (Wave 1): multi-touch input (MTI) devices, use of in-air gestures, automatic speech recognition (ASR), attention guidance (AG), user profile management systems (UPMS) and use of virtual and augmented reality in different means and tracking labels [13]. The output of PJ.16-04 is expected to be made public at the end of 2019; proposals for work in this area should plan effort to review this output and plan to incorporate it in their research if it is relevant. Note that it is expected that IR work continues as part of IR Wave 2 activities (Wave 2 candidate solution PJ.05-W2-97). Proposals should demonstrate how their work goes beyond the scope of the work planned for IR Wave 2 as described in the IR Wave 2 technical specifications [14].

Proposals must identify a specific improvement to operations and propose a plan to undertake its initial validation. The proposals must identify the technical enablers that are required for the proposed improvement. The work to be undertaken may include the development of the technical enabler, but cannot be limited to it, i.e. the research must include work towards the validation of how the enabler will be used. The operational validation needs to involve ATCOs.

The SJU has identified the following innovative HMI elements of interest:

- The potential use of already developed technologies (e.g. for remote towers) in towered airports as well as the required adaptations to the specificities of these environments e.g. how to present to ATCOs tracking labels superimposed to their out-the-window view while avoiding information clutter;
- The application of technologies in order to better integrate different information sources to reduce switching between head-up and head-down in the tower environment;
- The potential application of emotion recognition, facial expressions, etc., in support of the optimization of human performance;
- The integration of artificial intelligence (AI) and machine learning algorithms for the intelligent data provision to the controllers on the HMI (providing instead of "raw data", information with context to ensure it is clear why data is being shown and what should be done based on the information presented, while avoiding information overflow). If addressing AI/machine learning, the research shall address the interaction, interplay, division, etc. of tasks and responsibility between ATCOs and algorithms as well as the deviations of ATCOs decisions from those suggested by the automated means e.g. AI.

The above list is not intended as prescriptive. Proposals for work in areas other than those listed above are welcome provided they include adequate background and justification.

Note that the proposed improvements may be applicable to current operations and/or to future operational concepts still under development by industrial research activities in SESAR.

The proposals must indicate the potential applicability of the proposed improvements in terms of categories of airports i.e. a given feature may be required for a major airport but not for a smaller one.

The proposals shall take into consideration relevant exploratory research projects such as MOTO [19], RETINA [20], etc.

Application area 2: Automation support to help flight crews on the airport surface

This application area addresses potential applications to improve the flight-crew performance during surface operations at the airport. In particular, this includes the development of on-board automation in support of a better integration with air traffic management for surface operations at the airports, such as:

- Applications to inform the flight crew before the non-compliance takes place on the surface e.g. if approaching an intersection at high speed, etc. The warning/alert could be based upon different means e.g. input to aircraft controls, etc. Note that the aim of this application oriented concept is not conformance monitoring (covered in the following point);
- Applications alert flight crews when they have deviated from ATC instructions (e.g. cleared route), from ATC procedures and/or from the airport configuration (AUO-0614 in the ATM Master Plan [21]). This includes the autonomous generation of the appropriate conformance monitoring alerts by the on-board system on the basis of discrepancies detected between aircraft position and Airport Map Data Base and between aircraft position and clearances/instructions provided by ATC. Note that the ATM Master Plan operational improvement AUO-0614 is currently under research in IR by PJ3b, whose results are expected to be made publicly available at the end of 2019. Proposals for work in this area should explain how the proposed work would go beyond the IR scope, and plan effort to review the output of PJ3b and incorporate it in their work [14].
- Enhanced arrival runway occupancy time thanks to efficient runway turn-off (AUO-0705 in the ATM Master Plan [21]). The research shall address the combination of existing optimized braking to vacate solutions at a pre-selected runway exit with new applications for assisting the flight crew for achieving an efficient turn-off until aircraft has left runway protected area on the runway exit. This results in a reduced and more predictable arrival ROT. The expected reduced ROT and improved ROT predictability is relevant in good visibility conditions but it is even more so in low visibility conditions (especially in AUTO-LAND mode in CAT IIIb & c), where the observed arrival ROT is generally larger than in good visibility conditions. Proposals for work in this area must describe how they will go beyond previous SESAR 1 research in this area, referring in particular to the output of SESAR 1 project 06.08.02 [22][23][24].The concept may be limited to the reduction, include an element of increased predictability of arrival ROT by ATC in the planning phase (e.g. equipped aircraft to indicate equipage or even prediction in seconds in flight plan), or even include an element of coordination with ATC in the execution phase (e.g. by aircraft downlinking predicted ROT to ATC around TOD or during the approach).
- Enhanced departure runway occupancy time thanks to efficient line-up and take-off (AUO-0706 in the ATM Master Plan [21]). The research shall address potential on-board applications to assist the flight crew of a departing aircraft for a more efficient (fast, accurate, reliable and safe) line-up and take-off. This optimised ROT, will result in a reduced and more predictable ROT at departure. The concept may be limited to the reduction of ROT, include an element of increased predictability of arrival ROT by ATC in the planning phase (e.g. equipped aircraft to indicate equipage or even prediction in seconds in flight plan), or even include an element of coordination with ATC in the execution phase (e.g. by aircraft downlinking predicted ROT to the tower ATC).
- The integration of artificial intelligence (AI) and machine learning algorithms for the intelligent data provision to the flight crew (providing instead of “raw data”, information with context to ensure it is clear why data is being shown and what should be done based on the information presented, while avoiding information overflow) in support of reduced flight crew workload and increased safety during surface operations. If addressing AI/machine learning, the research shall address the interaction, interplay, division, etc. of tasks and responsibility between flight crew and algorithms as well as the deviations of flight crew decisions from those suggested by the automated means e.g. AI.

The above list is not intended as prescriptive. Proposals for work outside of these areas are welcome provided they include adequate justification and background.

The proposals shall assess the role of automation and its implications upon the role of the flight crew.

Application area 3: Automated apron and ground control
This research area aims at developing the operational concept for a highly automated apron management and manoeuvring area control at the airport. It shall address ground movement advisory service (apron) and/or control service (manoeuvring area). It is expected that clearance to enter/cross a runway, take off or land will still be delivered by a controller in all cases.

The research will work towards introducing a high-level of automation (corresponding to a Sheridan level of automation of 7 [25] or more) for some or all of the following tasks:

- Start-up approval;
- Automatic push-back management;
- Ground operations e.g. taxing, guidance from the gate to the runway, etc.; and/or
- Detection of aircraft or vehicle movement, as well as of all other relevant objects, e.g. birds and debris on the runway, in order to ensure that the automation system has a situational awareness equivalent to o superior to what the human controller has in current operations, under all weather conditions, including low visibility;

The project may assume that the communication segment is solved by datalink or use voice communication (ATCO instructions sent using a combination of text-to-speech technology, pre-recorded messages, etc., and voice recognition to process incoming pilot communications). The research shall clearly identify their assumption in terms of datalink technologies and wireless communications.

The research must address fallback solutions in case of failure in the fully automated system. If the fallback requires human intervention, the relevant automation challenges must be considered (human-machine symbiosis).

The environment could be limited at small airports with less complex surface operations, and/or focused on airport with Remote Tower operations, but it could also be focused on increasing levels of automation at large airports (e.g. automatic start-up approval).

Proposals must explain how their research is positioned with respect to previous SESAR exploratory research projects in this domain MOTA [28] , TACO [26] and AUTOPACE [9], etc., but may choose a completely different approach provided they include adequate justification and background.

Expected impact:

The proposed solutions under this sub-work area aim at:

- Increasing airport capacity;
- Improving cost efficiency (ATCO productivity);
- Ensuring safety and security levels.

Type of action:

Research and Innovation action.

3.1.2 SESAR-ER4-13-2019: Innovation in Airport Operation

Specific challenge:

The airport is at the heart of the air traffic management system and any improvement in the airport operations will likely have positive results throughout the network. The specific challenge under this topic is exploring innovative ideas that help improving the following aspects:

- Airports have been generally considered as pure air traffic management transportation nodes but there is a need to fully place them within their context as intermodal nodes in a larger multimodal transportation network. The transformation of the airport into an interchange node within a wider network imposes environmental, safety, security and financial challenges which differ from those of a single-mode node;
- With the expected rapid growth in air traffic in the coming years, there will be an increasing number of capacity-constrained airports for significant periods of each day [27]. There is a need to explore innovative solutions in order to deliver additional airport capacity. However, this must be done paying particular attention at maintaining the airports' environmental sustainability.
- The increasing number of drones is causing safety and security concerns within the aviation industry, in particular at the airports. A number of incidents involving drones at big airports in Europe have been already reported, and this number will likely increase in the coming future if nothing changes.

The research fully supports the vision for the digital transformation of airports put forward by ACI [18], contributing in particular to the evolution of processes and services to deliver a better experience to all passengers and customers, by adopting and implementing new technologies and integrating them with existing ones.

Scope:

The following non-exhaustive list of application areas of interest has been identified by the SJU:

Application area 1: Incorporation of Autonomous and Non-Autonomous Engine-off Taxiing into surface operations

The research shall propose potential solutions to incorporate autonomous and non-autonomous engine-off taxiing into surface operations and thus reduce fuel consumption and emissions and increase safety.

Taxi-out and Taxi-in phases can be done through:

- Non-autonomous engine off taxiing (AUO-0806 in the ATM Master Plan [21]) used from the gate to the holding point before line up (i.e. for push back and taxi out) and from the runway exit to the gate (i.e. for taxi in to in block). This may be realised with the aircraft using other external means to taxi (e.g. towing trucks, taxibot) [28].
- Autonomous engine off taxiing (AUO-0805 in the ATM Master Plan [21]) used from the gate to the holding point before line up (i.e. for push back and taxi out) and from the runway exit to the gate (i.e. for taxi in to in block). This may be realised thanks to e.g. electric motors added to the main landing gear and drawing power from either the Auxiliary Power Unit (e.g. [30])or from an alternative cleaner power source (replacing the APU or being complementary to it) with central control from the cockpit.

The research shall provide an operational concept description and required operational procedures for performing autonomous and non-autonomous engine-off taxiing operations. Please note that the research must be focuses on the ATM aspects; non-ATM aspects of green taxi are covered by Clean Sky research [29] [31]. Important aspects that need research are the following:

- For non-autonomous engine-off taxi, development of an operational concept, which must include the management of the tow fleet, including the parking space at the airport and the procedures to manage their operations, including communications between the tow vehicle's management centre, ATC and the flight crews, and communication with the tow vehicle's drivers in the case of manned tow vehicles.
- For autonomous engine-off taxi, development of operational procedures for engine start-up during the taxi-out phase and shut-down during the taxi-in phase, development of minimum performance requirements for engine-off taxi, e.g. speed and acceleration required for smooth airport operations, quantification of the impact on airport operations of autonomous engine-off taxi, e.g. slower taxi operations, procedures for ATC to update the take-off clearance time during taxi-out for flight crews to be able to optimise engine start-up time, etc.

The research should not focus on providing initial quantitative benefits of the performance improvements related to environmental sustainability e.g. reduction of fuel consumption, decrease in CO2 and NOx emissions, reduced noise, improved safety, reduction of noise impact around the airport and safety (most FOD and blast damages are typically in the area close to the gate and engine off taxi could eliminate both risk), because these already exist (e.g. [32],[33], [34]). Instead, the research must provide a refinement of the previous estimates of benefits based on their work, for example:

- Comparison of the airport and ATC costs of autonomous vs. non-autonomous engine-off taxi, e.g. by modelling costs in a particular airport.
- Estimation of the impact of different potential safety and performance requirements on the benefits (e.g. requiring faster taxi performance would require more powerful on-board engines for non-autonomous engine-off taxi, engine start-up procedures requiring changes to airport lay-outs and slower taxi-out phase…
- Impact on the benefits of the quality of the prediction of the ATC prediction of the take-off clearance time for engine start-up in autonomous engine-off taxi.

Note that the development of the technical means to perform engine-off taxiing operations e.g. towing trucks, taxibot, electric motors, etc. is out of the scope of the research topic. However, the research may work in the development of ATC system support for enabling engine-off taxi operations in the ATC side. However, the main focus of the research should not be the development of automation support, but the definition of the operational concepts for AUO-0805 and/or AUO-0806, in order to pave the way for their introduction in Industrial Research in the future if the research so justifies it.

Application area 2: Land-behind without runway vacated

The research shall address the development and validation of a European "land behind without runway vacated" concept.

Today, in the case of long runways, landing aircraft are allowed to use the runway simultaneously under certain circumstances, or the clearance to land may be delivered before the previous aircraft has crossed the threshold (similar to the FAA land behind clearance).

Note that this is not strictly a reduced wake separation concept, but a way to make it possible to take full advantage of reduced wake separation concepts for arrivals (the closer the arrivals are, the more constraining it is to require that the previous aircraft has landed before the next can be cleared to land).

The research shall take into consideration the work performed on reduced wake separation concepts for arrivals in Industrial Research (IR) solutions PJ.02-01 (Wave 1) [13] and PJ.02-W2-14 (Wave 2) [14].

Application area 3: Airport contribution to multimodality
The aim is to increase the efficiency of the overall transport chain by improving the interoperability of different modes of transport, addressing in particular the contribution of airports to multimodality to increase the environmental sustainability, to make more efficient use of the existing infrastructures and improve the passenger's experience.

The research shall address the definition and development of an integrated intermodal process for passengers / baggage / freight w.r.t time efficiency, predictability, seamlessness, resilience, security, convenience, accessibility) in a door-to-door environment building on customer expectations. This may include:

- The feasibility and potential benefits of connecting the schedules/time tables of public transport modes with access to the airport e.g. train, bus, metro, taxi with flight schedules. This should include the whole airport catchment area. Proposals could research the potential benefits of establishing standard coordination processes between airports scheduling and other public transportation modes e.g. bus, train, etc.
- The improvement of knowledge regarding pax location and demand, incl. airport access and dwell times, thus ensuring a better and dynamic knowledge of passenger airport densities and delays;
- The definition of the required technology and standards, information exchange requirements and data management technology to support integrated multimodal (passenger / baggage / freight) concept and process management;
- The identification of infrastructure requirements for supporting multimodal processes for passengers / baggage / freight;
- The identification of required regulations and policies regarding multimodal aspects of passenger / baggage / freight process (e.g. customs, security);
- The development of innovative technologies and services for safe, efficient, frequent, comfortable airport access (last mile only or supporting catchment areas e.g. short distance individual air vehicles);
- The development of intelligent systems – and better multimodal planning, management and integration (e.g. aps), incl. under disruption (e.g. re-booking onto HSR);
- The improvement of improved aircraft wait/no-wait rules so AUs make better use of last-minute capacities and pax re-accommodation;
- The identification of airborne pax connectivity requirements (links to ground services and pax tools);
- The assessment of the Impact of multimodal pax rights and personal data security.

The research shall take into consideration the digital citizen perspective:

- Assess the benefits for the traveller of an integrated planning/monitoring of multi-modal traffic flows at the airport (or the region) where the airport is considered as a node connecting traffic flows to/from other means of transport (e.g. rail, bus, etc.);
- Provide advance warning of incidents impacting the traveller and propose alternative options to mitigate the disruption for the traveller plan.

Note that many of the aspects listed above are intentionally at the boundary of the scope of ATM. The proposals must justify how the proposed research will contribute to improve ATM or contribute to improve multimodal mobility by using ATM related information.

Proposals should explain how their research is positioned with respect to related previous and ongoing projects (e.g. BigDATA4ATM [35], DATASET2050 [36], Mobility4EU [37] and CAMERA [38]) and initiatives from other sectors contribution to multimodality (e.g. Shift2Rail Innovation Programme 4 [39]).

Application area 4: Protecting the airport from drones.
The research shall propose and assess potential solutions for ensuring the protection of the aircraft and airport (runway and ground) operations from intruder drones, which may be either intruding by mistake or through malicious intent. The performance objectives are related to improvements in safety and security

The research activities may address the following features:

- The detection of any potential / actual intrusion by cooperative and non-cooperative drones in the airport environment and its vicinity e.g. approach area or any threat to the aircraft;
- The tracking of the intruders' flight path;
- Issuing the corresponding advisory, caution and warning alerts e.g. in case there is an intruder for the ATCO, in case active measures are needed to ensure safety, and for the airport authority, to allow them to initiate remedial action, as required (Note that the provision of warnings and alerts directly to the pilot of a manned aircraft is not in scope). Research should consider the different levels of alerts. For example, warning alerts could be triggered when the drone enters a critical zone while advisory and caution may be triggered when the drone enters a buffer area beyond the critical one (in case of a known, unintentional intrusion the drone operator could also receive an alert so he/she can take the relevant corrective action, either directly or through an appropriate U-space service provider);
- Procedural issues to enable all stakeholders to work together to resolve the situation in a timely and coordinated fashion. Such stakeholders must include, as a minimum: the airport operator; ATC; U-space service provider(s); and the emergency and security services.

The research shall explore potential architectural and design alternatives that could include the following options (the list is not exhaustive):

- The definition of how critical and any buffer areas are designed and warnings/alerts managed, within the wider context of aeronautical information management and airport operations management;

- Sensors able to detect non-cooperative intruding drones and issue the relevant alert. Note that the development of such sensors is outside the scope of this Call, but research should consider the performance, system and interface requirements of such systems;
- Use of geo-awareness to support the prediction and detection of unauthorised intrusions and to support the resolution of such intrusions and the identification of transgressing drone operators.
- The scope of this application area does not include the development of the technologies (there are already technologies in the market that can be used for this purpose). The research must focus on the definition and initial validation of the operational integration of the system. The proposal must include the initial validation of the proposed operational concept in the airport environment. The proposed concept must include the integration with ATM, and the proposed validation activities must address the integration with TWR ATC. The research must include both a safety and a security assessment of the proposed solution to the level appropriate for the target maturity level, and also make a preliminary regulatory assessment.

Research may investigate the possibility of the employment of systems to disable, or bring down the drone, but the development of such systems themselves is explicitly outside of the scope of the project. Where such systems are considered, the safety of the airport environment, other aircraft and people and property on the ground must be assured. Consequently, the following factors must be taken into account:

- The use of airport jammers or spoofers for the GNSS signal or other signals used for aviation purposes, or other devices such as lasers that have already been classified as dangerous by ICAO close to airports (since reflections can never be fully controlled), can only be considered if a detailed evaluation is also conducted showing how their employment can be deemed safe;
- The potential use of such devices by law enforcement will need to follow specific procedures, and will require advance warning to appropriate aviation actors (ATM, pilots, etc…). This stipulation covers any device transmitting on aviation safety-of-life frequencies in the vicinity of an airport, or in an area where such use could interfere with aviation operations or systems.

The above list of applications areas is not intended to be exhaustive. Proposals addressing alternative application areas are welcome, provided adequate justification and background is included in the proposal.

<u>Expected impact:</u>

The proposed solutions under this sub-work area aim at:

- Ensuring safety and security levels;
- Improving the interoperability of ATM with other modes of transport and finally the passenger's experience;
- Improving the airport environmental sustainability and capacity;
- Increasing airport cost efficiency.

<u>Type of action:</u>

Research and Innovation action.

3.1.3 SESAR-ER4-14-2019: Meteorology at Airports

Specific challenge:

Weather has a significant impact on airport operations: snow, sleet, and freezing rain, which along with strong winds, low clouds, and reduced visibility may create dangerous conditions at or around an airport. These weather conditions can result in major disruptions in air traffic management, leading to delays and cancellations of hundreds or thousands of flights, thus affecting the plans of millions of travellers. Continuous development of weather forecasting solutions and technologies is paramount if airports are to cope with the rising passenger demand.

Scope:

The scope of this topic covers the following aspects:

Application area 1: From Runway Visual Range (RVR) to Slant Visual Range (SVR).
The Runway Visual Range (RVR) is the distance over which a pilot of an aircraft on the centreline of the runway can see the runway surface markings delineating the runway or identifying its centre line. RVR (normally expressed in feet or meters) and has been in use for decades. By providing RVR information, pilots can appraise aerodrome visibility conditions and in particular determine whether these conditions are above or below the company, aircraft or aerodrome operating minima. RVR does not take into consideration important variables e.g. reduced visibility from other factors such as rain on the windshield of the aircraft.

The objective is to conduct research on what is necessary to complement the RVR with the Slant Visual Range (SVR), also known as Slant Runway Visibility. SVR is defined as the slant distance to the farthest high intensity runway edge light or approach runway light which a pilot will see at an altitude of 100 ft. (decision height) on the approach path or, if larger, the slant distance which would have a constant transmittance of 5.5 percent. The research shall investigate the potential operational benefits of providing a measured SVR to pilots in support of their own visual assessment of the visibility conditions, with the objective of improving safety and reducing the number of missed approaches caused by unexpected low visibility and/or the number of unnecessary diversions in borderline meteorological conditions. The research may assess the advantages and disadvantages of different technical means to provide SVR e.g. use of the information from LIDAR installed along the glide path, monostatic acoustic radars, etc., provided that the development of technical means to measure SVR is justified by the operational need.

The proposal may include data collection campaigns, in which the SVR measurements obtained by one or more technical solutions are compared against what a pilot actually sees during the operations, etc. In this case, the analysis of the data must include an estimation of the number of prevented missed approaches and unnecessary diversions, as well as an assessment of the impact on safety.

Application area 2: Windshear and turbulence data prediction on approach:
The research objective is to define and perform initial validation of a concept to share from ground to cockpit predictions of windshear and turbulence on approach (with a focus on final approach) based on pilot reports, ground measurements, or a combination of both. The research must provide an initial analysis of the potential safety benefits of the concept, as well as of its cost.

Note that SESAR solution #21 “Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP)” [40] includes already technical specifications for the ground WX monitoring system for airports, and SESAR solution #35 “Meteorological information exchange” [41] covers technical specifications for observation systems for significant low level turbulence and windshear. Proposals for work in this area must explain how their work would fit within and complement these two solutions.

Expected impact:

The proposed solutions under this topic aim at improving airport capacity and resilience and ensuring safety and security levels.

Type of action:

Research and Innovation action.

3.2 Sub Work Area 2.2: Optimised ATM Network Management

The optimised ATM network management theme will include research activities in the areas of Digitalisation of the ATM Network (including network management operations and improved involvement of the Airline Operation Centre), innovations in network management (like innovative technics and models for uncertainty management and innovative route charging schemes) and fully dynamic airspace.

3.2.1 SESAR-ER4-15-2019: Increased Levels of Automation for the ATM Network

Specific challenge:

The network is not sufficiently robust or resilient to react to significant perturbations e.g. meteo, industrial actions, etc.; this imposes unplanned/additional costs on airlines, which have a huge impact on airlines' annual revenue. Airspace users' full participation through their flight operations centres (FOC/WOC) into ATM collaborative processes is essential to minimise impacts of deteriorated operations for all stakeholders, including airspace users themselves. An improved recovery process offering more flexibility to accommodate AUs' changing business priorities and equity in the ATM system is therefore needed.

Scope:

As an applications oriented research topic, proposals must describe a specific improvement to operations and explain how it is proposed to undertake an initial validation. The improvement to operations can be either a new operational improvement or a new technical enabler (e.g. an improvement to traffic prediction and execution of the plan that would improve the performance of current network operations without changing the current network management procedures).

Proposals must demonstrate how their work would go beyond what is currently under research in IR in Wave 1 (PJ07, PJ08 and PJ09) [13] and in Wave 2 [14].

The scope of this sub-work area covers the following aspects:

Application area 1: Digital Network Management Operations
The research activities shall explore improvements to the Network Management (NM) function based on digital technologies such as:

- The potential use of new data sources (big data), machine learning algorithms (including neural networks), AI based decision support tools, behavioural economics, improved market modelling, complexity science, etc. to support network operations e.g. models and methods for improving demand, flow and complexity forecasting and resolution;

- The use of Big data analysis, machine learning and digital-twin techniques for better planning the actors (controllers, FMPs, AUs) reactions to potential operational improvements based on the emerging trends (e.g. incentives, etc.);
- The development of methodologies to analyse, quantify and manage the effects of weather and other uncertainties on the network for all phases of flights and in particular on:
  - Trajectory planning (including MET forecasts evolving over time), aircraft performance, etc.;
  - Storm avoidance (including reduction of thunderstorm prediction uncertainty);
  - Sector demand and capacity balancing using the best available plan of action.
- The better consideration of airport events in network traffic prediction that minimises network disruption;
- Better consideration of the diversity in data quality from different ATC centres/airports and identify where improvements would bring the biggest gain for operations;
- Innovative DCB resolution algorithms, e.g. using radically different algorithms to what is used today, e.g. building on previous exploratory research project OPTIFRAME [42] or using alternative approaches, or working on fine-tuning today's methods, e.g. by considering additional inputs.
- The use of machine learning for:
  - The identification and prediction of: major traffic flows, complexity assessment, calibration of airspace/sector capacity, flight delays, estimated arrival and overflight times, etc. with the objective of reducing NM capacity buffers;
  - To improve the handling of AU priorities/preferences;
  - To improved disruption management;
- The use of machine learning and/or advanced visual analytics for DCB decision support tools and automation e.g. hotspot resolution;
- The adaptation of applications that use models/techniques that are already applied for uncertainty management in other domains.
- The development of probabilistic approaches based on historical data mining techniques.

Application area 2: Improved Integration of Airline Operations into the Network
The research shall address potential improvements of airline operations based on the use of advanced digital technologies, e.g. big data, machine learning algorithms, AI, IoT, behavioural economics, improved market modelling, complexity science, etc. such as:

- The potential use of new data sources (big data), machine learning algorithms, AI based decision support tools, etc. to support airline decision making in disruption scenarios in order to improve the resilience of the system;
- The development of new tools for improving the integration of airline operations into the network, in order to mitigate the impact of disruptions on the overall ATM network and/or improving operations in nominal conditions (e.g. earlier update of TTOT, better adherence to TSAT, more accurate turn-around time planning, more accurate 4D trajectory calculation for the eFPL by using AI to improve predictions, etc.).
- The identification of innovative applications to improve the collaboration between AOCs and Network management function and ATC, e.g. to support the involvement of AOC's that track flights in trajectory revision, in particular for long-haul flights, or to facilitate the inclusion of airline

preferences and priorities in the DCB processes or sequencing processes beyond what is already covered in IR Wave 1 [13] and the scope of IR Wave 2 (candidates solutions 38, 39 and 40) [14].

The research may build on previous SESAR ER projects using complexity science to better understand delay propagation (e.g. NEWO [43], TREE [44]) or use entirely new approaches.

Application area 3: CASA Evolution
The Computer-Assisted-Slot-Allocation (CASA) algorithm is used by the Network Manager to allocate departure slots. The Airline Operator (AO) files a flight plan and requests a slot. NM takes into account all the regulation requests from FMPs and allocates some aircraft a delay for entering the regulated area based on the principle of 'First Planned - First Served'. On this basis, the system calculates the Calculated Take-Off Time (CTOT), which is transmitted to the concerned AOCs and to the control tower at the aerodrome of departure. On top of this basic process, there are a number of compensation mechanisms that take into consideration modifications to the flight plan, late received flight plans, etc., as well as for the cases when a flight crosses more than one regulated area.

Proposals shall include activities that propose areas for the evolution of the current CASA and constraints reconciliation algorithm and slot allocation processes in order to improve efficiency and reduce the adverse impact of multiple regulations affecting the same flight or flows, e.g. by finding less constraining ways to handle flights that cross several regulated areas than the current most penalising regulation criterion., or facilitating a more collaborative approach between ANSPs by better allocating CASA delay minutes between ANSPs in the case of regulations that are not formally linked.

Proposals must demonstrate in-depth knowledge of the CASA baseline and explain how they plan to assess the potential benefits of the proposed evolutions against it; the use of a non-regulated scenario as reference for comparison is not acceptable.

The research may include the use of big data and machine learning to identify best practices regarding regulation strategies for particular traffic load patterns based on historical data. The analysis of historical data on regulation strategies should be complemented by the results from network simulations to develop optimized strategies for the most frequent traffic load situations in the European ATFCM network.

The research may build on previous SESAR ER research (e.g. OPTIFRAME [42]) or propose entirely new approaches. Please note that PJ09 results are expected to become publicly available at the end of 2019. Projects planning to work in this area must reserve effort for analysing PJ09's output and incorporate it in their research. Please note also that proposals must show how they go beyond the IR Wave 2 scope of candidate solution 47 [14].

Application area 4: More automated ATFCM
The research shall identify mechanisms to allow the introduction of higher levels of automation in the coordination of DCB actions at the pre-tactical and tactical levels.

<u>Expected impact:</u>

The proposed solutions under this topic aim at improving:

- Safety, thanks to better anticipating and managing demand-capacity imbalances;
- Robustness and resilience of the network to perturbations;
- Efficiency thanks to a better monitoring of the DCB measures and network performance and the implementation of corrective actions;

- Cost-efficiency: an improved network management will allow better planning of ATM resources, as well as making better use of existing capacities, which would lead to reduced ATC and airport costs;
- Flexibility: common awareness to all stakeholders of the network situation and access to opportunities in case of late changes in capacity or demand.

Type of action:

Research and Innovation action.

3.2.2 SESAR-ER4-16-2019: Innovation in Network Management

Specific challenge:

This topic covers innovative network management application concepts that aim at responding to emerging business needs that can only be addressed by the increased collaboration between stakeholders that is made possible by implementation of new technologies.

Scope:

Proposals for this topic must propose an innovative improvement to operations and a plan to undertake its initial validation. The analysis of data without proposing an improvement to operations is out of scope for this topic.

The following potential application areas of interest have been identified by the SJU:

Application area 1: Improvement of ATFM processes by including the consideration of convective weather information
The post-operations analysis of re-routing choices made by flight crews or airline operations (when flight-planning) when the weather situation is non-nominal (e.g. convective weather) may provide valuable information for improving how similar convective weather events are managed in the future. The objective is to anticipate the changes in demand in non-nominal weather situations, and to define scenarios and CDM processes for the management of similar situations. Proposals proposing to work in this area must demonstrate that the research activities will have access to sufficient historical information of re-routing choices to perform the initial validation of the concept.

Application area 2: Increasing the use of middle airspace
The “middle airspace” (approximately between 15.000 ft. and 25.000 ft.) is for the most part not used for cruising, except by aircraft with gas-turbine-powered propellers (turboprops), which represent a relatively low proportion of the fleet. The research should identify the extent to which the use of the middle airspace would provide benefits in terms of reducing ATFM delay minutes at ECAC level, and make an assessment of the business case for providing ATFM slots for flights in the middle airspace considering the potential increased fuel and environmental impact against the savings in terms of delay minutes. The research may propose changes to the route charging scheme in support of the business case, as well as other incentivization methods to encourage the use of turboprop vs. jet engines for the busiest routes. The impact that incentivizing the use of aircraft with smaller capacity on routes with high demand in airport operations must be considered (more flights needed to move the same number of passengers).

Application area 3: Innovation in route-charging schemes
Previous exploratory research in SESAR (projects COCTA [16] and SATURN [45]) has shown the potential of new trajectory pricing schemes to support a more flexible distribution of the demand.

Proposals addressing this area may build on these previous research, or propose additional innovative schemes, e.g. lower charges in periods of low demand, discounts for early flight planning with route commitment (in order to promote the SESAR SBT concept and enable better ANSP resource planning), overcharge for changes after filing flight plan, etc. Research may also look into charging schemes that consider environmental penalties or rebates, e.g. higher charges for flights filing flight-plans with longer routes than necessary.

Application area 4: Consideration of airport departure slots in ATFM
This application area looks into the development and initial validation of a concept for the consideration of airport departure and/or arrival slots as an input parameter to the network TT and slot allocation processes, beyond the indirect consideration of airport arrival slots what is enabled through the AOP participation in TT allocation processes. Proposals must demonstrate awareness of previous research in this area and the reasons why previous concepts did not progress to implementation. As well as changes to the ATFM processes to improve the consideration of airport slots, the research may propose the refinement of the airport slot allocation concept and/or associated monitoring processes in order to increase their relevance to ATFM (e.g. consideration of TMA capacity in slot allocation processes, addition of tolerance values associated to airport slot compliance, detection of unrealistic planning of departure and arrival times resulting in non-compliance of airport slots, etc.).

Application area 5: Development of a trajectory broker concept
Proposals should describe a trajectory broker concept and propose a plan for the initial validation of the potential benefits. The objective is to add a brokering layer to make better use of available capacity in all phases of ATFM operation (strategic, pre-tactical, tactical) and in all areas (airport, TMA, en-route). Proposals should not only look at the technical aspects but also take into account necessary regulatory/organisational changes. The concept should either build on previous Exploratory Research in project COCTA [16] or propose alternative approaches. Proposals for research that does not build on COCTA should explain how they diverge from COCTA and provide adequate justification and background.

The above list of application areas is not intended as prescriptive; bids proposing to work in other areas are welcome, provided adequate background and justification are provided in the proposal.

<u>Expected impact:</u>

Improved network management will result in an overall performance improvement in ATM.

<u>Type of action:</u>

Research and Innovation action.

3.2.3 SESAR-ER4-17-2019: Network Capacity Increase from Fully Dynamic Airspace

<u>Specific challenge:</u>

In today's operations, the available airspace configuration options are limited and not necessarily able to manage the traffic demand efficiently. If the ACCs cannot cope with the demand, then additional sectors are opened. In addition, due to the uncertainty in traffic demand, ACCs normally keep a capacity buffer to be able to safely manage traffic above the expected demand. Airspace configurations are selected with a focus on the local benefit rather than considering the network as a whole. The current airspace organisation is not yet fully optimised to network flows and makes limited use of cross-FIR cooperation.

The challenge is to develop a fully dynamic and cross-border airspace management concept that will take into consideration all capacity/demand aspects and constraints in one seamless process, with a higher level of modularity and flexibility up to the execution phase all supported by automated tools. The outcome of this will be a process that is able to take all the available inputs into consideration (predicted workload/complexity, airspace reservations, ATCO availability, etc.) and calculate the optimum configuration.

The research in this area contributes to the vision put forward in the Airspace Architecture Study (AAS) [51].

Scope:

This area of work is complementary to the work of PJ07 and PJ08 in SESAR IR Wave 1 and to the work covered by Wave 2 candidate solution 44 [14], Dynamic Airspace Configuration, and is of special interest for the realisation of the vision put forward in the Airspace Architecture Study (AAS) [51]. Proposals must demonstrate awareness of the work covered in IR, and show how their work would go beyond. Projects must reserve effort to analyse and incorporate into their work the output of PJ07 and PJ08, which is expected at the end of 2019.

The following potential areas of application beyond IR have been identified by the SJU:

Application area 1: Dynamic Mobile Areas (DMA) Type 3
The concept of an ARES that moves along with the military aircraft whose mission requires an airspace reservation (DMA Type 3, AOM-0209) is part of the European ATM Master Plan. The original DMA Type 3 high-level concept was based on a pre-departure agreement of the DMA Type 3 4D dimensions during the planning phase. The concept is currently under initial development in IR Wave 1 by PJ.08-02, but due to the low maturity of the concept it has been decided that more ER is needed before IR can continue, and therefore DMAs type 3 will not be addressed in IR Wave 2.

The SESAR concept has evolved as a result of R&D and the possibilities opened up by advanced digital technologies. Advanced automation will allow a more dynamic and flexible management of air traffic, thereby making penalising pre-departure agreements less necessary. The challenge is to define how the original DMA Type 3 objective can be fulfilled in this more dynamic context. The expectation is that some military missions can be managed by defining a volume of protected airspace around the moving military aircraft operating under Operational Air Traffic rules (OAT), instead of requiring an ARES. The size of the protected volume would be specific for each aircraft type and mission (e.g. fighter, tanker, re-fuelling, formation...). The research should investigate the potential of this concept to reduce the need for ARES in the busy European airspace, by providing an in depth assessment of the types of military missions that may be handled in this way and quantify if there are potential benefits in further pursuing the DMA Type 3 concept.

Proposals for work in this area must demonstrate access to military stakeholders and describe how they plan to gather information to answer the research question. The output of the research should be a recommendation to either discard the DMA Type 3 concept or recommend its inclusion in the ATM Master Plan with a new refined definition. Proposals should include effort to review the output of PJ.08-02 (expected to be publicly available at the end of 2019) and incorporate it in their work.

Application area 2: Fully Dynamic Airspace beyond Industrial Research
Dynamic Airspace Configurations is currently in the scope of Wave 1 IR PJ08, and it is expected to continue in Wave 2 (Wave 2 candidate SESAR solution 44). Proposals may address DAC aspects beyond the scope of Wave 2 IR, for example:

- Explore the integration in the DAC process of areas that are potentially unsafe due to weather phenomena that can evolve in four dimensions (moving hazard zones). The research shall explore the possibility to extend these hazard areas due to other phenomena such as volcanic ash, etc.
- Define the required mechanisms to build adequate airspace configurations all along tactical operations (the IR scope is currently focused mainly on the planning phase).
- Moving hazard areas.

Proposals in this application area should plan effort to review and integrate the output of PJ.08-02 (expected to be publicly available at the end of 2019) and incorporate it in their work.

Expected impact:

The proposed solutions under this sub-work area aim at improving:

- Capacity: a fully dynamic airspace allows a better use of available ATC capacity and a better balancing of ATC workload leading to reduced demand/capacity imbalance;
- Cost-efficiency: fully dynamic airspace allows improved ATM resource planning and better use of existing capacities leading to reduced ATC costs
- Environment sustainability: increased efficiency enabling optimised flight trajectories and profiles with the end result being reduced fuel burn, noise and CO2 emissions;
- Flexibility: fully dynamic airspace allows increasing the flexibility of airspace configurations to adapt to any change of demand pattern or unexpected change of user's trajectory intents.

Type of action:

Research and Innovation action.

3.3 Sub Work Area 2.3: Advanced Air Traffic Services

The research activities under advanced air traffic services will include research into the Automation of Air Traffic Services including advanced Human-Machine-Interactions for controllers and concepts for full automation in low density. They will further address innovation in Air Traffic Services like interfaces with orbital and very high level operations or concepts for formation flying, the long-term evolution of air/ground synchronisation, evolution of separation minima in En-route and TMA and the digital evolution of controller/pilot communication.

3.3.1 SESAR-ER4-18-2019: Automation and CWP

Specific challenge

Increasing the level of automation in air traffic control is a key enabler for the realization of the Master Plan vision. This topic explores automation applications for air traffic control beyond what is currently covered by the Industrial Research programme.

The exploratory research challenge is to bring new automation applications for air traffic control towards the maturity level required for their inclusion in the industrial research programme. Bids should describe their proposed application and outline a plan for the project to undertake its initial validation, with the objective of at the end of the research activities being able to make a recommendation to either propose its inclusion in the European ATM Master Plan or discard it.

Scope

Proposals submitted for this topic should clearly describe an automation application concept for the en-route or TMA air traffic control position and describe what the expected benefits are and how they will undertake its initial validation. Please note that applications for the automation of air traffic management tasks other than the air traffic control position (e.g. Flow Management Position, improvement of traffic prediction algorithms for flow management purposes) are out of the scope of this topic. Applications for the air traffic control positions used to improve controller training are in scope.

The following non-exhaustive list of potential candidate application areas has been identified as being of interest by the SESAR Joint Undertaking:

Application area 1: Advanced automation support for en-route and TMA
Advanced automation support currently under development in the Wave 1 SESAR industrial research [13] programme include use of multi-touch inputs, use of speech recognition to reduce the amount of typing for entries into the ground system required from controllers, attention control elements to measuring the level of attention (e.g. by measuring eye movement) and use of User Profile Management Systems (UPMS) for controller identification that use iris, speech recognition, finger print authentication or face recognition. Results of this research are expected to become publicly available at the end of 2019, and more research is planned for the Wave 2 IR programme (candidate SESAR solution 96) [14]. Proposals for work in this topic must demonstrate how they go beyond the scope of the work planned for Wave 2 IR. Examples of potential areas for exploratory research are: exploration of the use of machine learning to model and be able to anticipate controller behaviour and pre-fill entries into the ground system or CPDLC messages, advanced context-sensitive information presentation concepts, use of 3D representations, etc.

Application area 2: On-screen presentation of MET data to ATCOs
Combining ground-based meteorological radar information with data downlinked from aircraft's on-board weather radar can provide high-quality weather information with granularity in both the vertical and the horizontal domain. This information would be very useful for controllers, because it would make it possible to anticipate how aircraft are likely to be requesting deviation from their horizontal or vertical route to avoid areas of weather activity. However, the on-screen presentation to controllers of detailed weather information is challenging, due to the need to avoid screen clutter and information overload on screen. The research may explore information presentation concepts, which may be context dependent, e.g. present only information relevant to the traffic that the controller is handling, or even present only an indication of which aircraft are likely to deviate and offer alternative courses to controllers, e.g. for vectoring arrivals and departures around weather activity in the TMA. Research in this area must be focused on the definition of the operational application; it should define the high-level requirements of the meteorological prediction process needed to support it. Bids on this topic proposing to work focused on improvement of the meteorological prediction processes rather than on its operational application are out of scope.

Application area 3: Applications of physiological measurements
Previous SESAR exploratory research work (projects STRESS [11], NINA [46], 6th SENSE [47], MINIMA [10]) has shown that there is a potential for applying physiological measurements to air traffic control, e.g. measuring of brain waves to assess the level of attention, use of speech recognition combined with physiological measurements to monitor stress, correlation of eye-movement patterns with the

occurrence of events that are potentially safety relevant. Please note that this is an applications-oriented topic, and consequently bids must propose a specific application. Bids may build on previous SESAR exploratory research or propose entirely new applications. All bids, whether proposing applications new to SESAR or building on previous SESAR research, must provide adequate background information in their proposal.

Application area 4: Automated ATC in low-density en-route airspace
Previous research [48] shows the potential of using supervised learning to model some of the functions of an air traffic controller and can be used for training and task analysis purposes. IR solution PJ.16-04 [13] is also developing ATCO task modelling in support of advanced HMI applications for ATC, and their results are expected to become publicly available at the end of 2019. This application area should explore if it is possible to build on this idea and develop and perform preliminary validations (TRL0 to TRL1) of a concept to automate ATC for high-level en-route sectors.

This concept may foresee that controllers have to intervene in certain situations, e.g. when two aircraft are anticipated to get closer than a pre-defined distance or below a certain flight level, but controllers can’t be expected to be able to be able to safety intervene if requests to intervene are for last-minute critical situations that can’t be handled by the automatic system. The role of the human would need to be carefully assessed in order to ensure that it is fully consistent with human capabilities. In particular, it is expected that in this application the controller should not be required to monitor the automated system, because this may create a safety issue; instead, the monitoring task must also be automated. Adaptable and adaptive automation concepts may be useful in support of optimised human performance and safety. Additionally, high automation may lead to the potential risk associated to monotony and boredom, and the concept should foresee measures to address this risk.

The research must address fallback solutions in case of failure in the fully automated system.

The concept would need to take into consideration the take-over procedure by the ATCO (automatic ATC-to-human ATC transfer process). ATC system–pilot communications may need to be adapted for this application, e.g. it might be necessary to notify pilots that the flight is being handled under automatic ATC, and a special call mechanism to require human controller intervention might be needed. The role that voice communications should play must be established (i.e. should the automatic ATC always send clearances via datalink, or would it be appropriate that some clearances be sent using synthetic voice?).

It is anticipated that voice communications check-in would still be necessary for all flights to ensure that they are immediately contactable via R/T at all times. The concept should determine whether the check-in on R/T would need to be handled by a human controller or it could also be handled by the automatic system. The concept may consider current datalink performance and messages or define more advanced datalink requirements.

It is expected that the R&D and eventual implementation of such an application may not have significant benefits in itself, but would provide invaluable operational experience in support of future more ambitious developments in ATC automation. Proposals should plan effort to analyse whether It may be possible to realise benefits in the short to medium term from this research though related concepts, e.g. though applications in ATCO training.

Application area 5: Clear air turbulence data consideration
According to IATA, turbulence is the leading cause of injuries to airline passengers and crews globally [49]. Flight crews routinely report clear air turbulence to controllers, who, workload permitting, relay turbulence reports with aircraft that will be overflying the same area. However, controller workload

may not always allow for controllers to properly relay this information. In order to overcome this limitation, the IATA turbulence Aware Platform [50] allows this information to be automatically shared between pilots and AOCs. However, this initiative does not include the sharing of information with ATC, while turbulence information is also relevant for controllers, e.g. because it can support proactive management of level change requests or raise awareness of potential speed changes. An application could be developed to either connect ATC to an ongoing sharing initiative or to develop a complementary system for sharing turbulence reports between aircraft and ATC. The research must consider how controllers would be presented the information and how they would use it. New system support concepts may be proposed to assist controllers in effectively taking into consideration clear air turbulence information. The output of this project should be the definition of a concept for inclusion in the ATM Master Plan, with one or more operational improvements and enablers.

Application area 6: Standardization of ATCO procedures and more generic en-route controller validations

The amount of training required for en-route controllers to get endorsed in a sector is a limiting factor for controller mobility; in addition, the number of hours that are required to stay current in a sector limits the number of sectors that they can be endorsed for, which makes the controllers' work more tedious (always working on the same sectors, same callsigns, etc.), and also makes efficient rostering harder for the ANSP. Applications to provide on-the-job support to controllers on local knowledge may alleviate this situation and support the controllers in accepting delegation of airspace as outlined in the Airspace Architecture Study (Airspace Architecture Study (AAS) [51]) (virtual centre / delegation of airspace / capacity on demand) [51]. Some basic applications are already locally implemented today, e.g. applications that check transfer conditions against LOAs or provide on-demand AIP information on the screen. However, the local knowledge required to control a sector includes a lot more than remembering AIP information. In particular, the exploratory research challenge is to provide difficult to define information items, e.g. information that would make a controller recognize a situation as unusual even though it is not against the established procedures, like unusual incoming or outgoing transfer condition, unusual vertical profile, etc. This type of information is an important part of what controllers learn during sector-specific on-the-job training and it may evolve with time. Bids may propose applications to capture this type of soft sector-specific rules and display it to controllers when it is relevant, e.g. using machine learning for detection of unusual situations that a controller who is inexperienced in a sector should be warned about, analysis of recordings of training sessions where veteran controllers are taught how to work in a new sector (i.e. they are learning the sector rather basic air traffic control skills), etc. Special care to avoid information overload must be taken.

Please note that applications outside these areas may also be proposed provided adequate justification and background is provided in the proposal.

Expected impact:

Increasing the level of automation in en-route and TMA ATC is a key aspect for the realisation of the digital aviation vision put forward in the European ATM Master Plan. Its expected performance benefits are increased controller productivity and increased safety.

Type of action:

Research and Innovation action.

3.3.2 SESAR-ER4-19-2019: Enabling Performance by Innovation in Air Traffic Services

This topic looks at the development of innovative concepts air traffic services with the objective of enabling the extension of air traffic services beyond what is possible today.

Specific challenge

The evolution of demand for new kind of operations made possible by new technologies requires air traffic services to evolve accordingly. This topic develops applications to cater to emerging challenges and opportunities, like the advent of very-high level operations, the need to respond to the demand for civilian formation flying, or the reduced dependence on the magnetic compass for navigation.

Scope

The objective is for the exploratory research projects to support the development of the concept of operations, rather than the enablers required to support it. The link to the European ATM Master Plan must be addressed.

The following two innovative areas of interest have been identified by the SESAR Joint Undertaking:

Application area 1: 'Higher airspace' operations
Demand for use of very high-level airspace has increased in the last years, and this trend is expected to gain momentum in the coming years. ICAO has provisionally adopted the term 'higher airspace'[1] to refer to that volume of airspace between airspace where ATM provides services (typical upper level of FL600) and the boundary between airspace and space (approximately 100 km[2]). AU operating in this airspace are sometimes referred to as 'New Entrants', and have many different operating characteristics, such as unmanned HALE vehicles providing internet coverage or surveillance over large areas and Unmanned Free Balloons (UFB), as well as manned sub-orbital flights for leisure or scientific purposes (e.g. experiments, films or tourism at zero gravity) and supersonic or hyper-sonic passenger aircraft. This volume of airspace will, therefore, be used by all classes of air vehicle, from static, barely manoeuvrable unmanned balloons, through high-speed passenger aircraft to rapidly-climbing rockets.

Although State and commercial space launchers will transit this volume of airspace, space operations, or 'space traffic control', are not in the scope of this topic. However, research should reflect that higher airspace is capable of allowing such operations to proceed without undue hindrance to them, and without adversely affecting the safety of higher-airspace vehicles.

The management of higher airspace is only just being considered by ICAO, and even its vertical boundaries are, as yet, undefined. The exploitation of space is a politically very sensitive issue and so research into this topic, at the boundary with space, should consider, inter alia, political sensitivities, operational concepts and CNS issues, while performing a thorough, global analysis of operational and business needs.

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[1] AN-Conf/13-WP/311 dated 18th October 2018, although it is unlikely that this term will be retained long term.

[2] This altitude should not be considered definitive, and this boundary is a sensitive topic. It is used here in an indicative fashion to show that higher airspace has a limit and does not include orbital or other space operations.

Proposals need to plan effort for:

- Ad-hoc participation in the European Commission New Entries working group.
- Developing the European Concept of Operations for Higher-Airspace operations, or supporting its development if such an initiative has already commenced in the context of the European Commission New Entries working group.
- Addressing the link with the European ATM Mater Plan and the SESAR Concept of Operations.

Proposals addressing this application area must plan the following milestones:

- A public deliverable should be delivered to the SJU 12 months after the start of the project describing the current global demand for higher-airspace operations, how States and businesses are addressing it, and their interface with space agencies and operations, with the aim of generating a detailed picture of demand, barriers, opportunities and possibilities. This deliverable should be presented in a public event with the objective of collecting feedback on how this demand can be best addressed.
- A public deliverable with the report of the project's analysis of the feedback collected during the event with recommendations for further work in the area should be delivered 14 months after the start of the project.

The work in the last ten months of the research activities should be focused on developing or supporting the development of the European Concept of Operations for Higher-Airspace operations, potentially including in-depth concept development to address one or more of the challenges that are specific to high-level operations.

Application area 2: Moving from magnetic to geographic bearings

Even though the magnetic compass is not as essential to navigation as it used to be, magnetic bearings are still the main reference in aeronautical charts and runway markings, and all aircraft feature magnetic deviation plates, and changes of deviation require periodic update of charts, plates and runway markings. It has been suggested that moving to geographic bearings may enable significant cost savings, and also be advantageous for operations in polar routes, for which demand has already increased and is expected to continue to do so. The research challenge is to investigate whether this would be a feasible alternative in the medium- to long-term future, and if so identify the operational changes that would be required and perform an initial high-level identification of the potential benefits.

Please note that this list of innovative areas is not intended as prescriptive; bids addressing alternative areas of innovation in air traffic services are welcome, provided adequate justification and background are provided in the bid.

Proposals must demonstrate operational knowledge of current operations, familiarity with the aspects of the SESAR concept of operations that will be impacted by the innovative concept and an understanding of the innovative concept and the related state-of-the-art.

It is expected that the development of the new concept of operations will need to start with an in-depth analysis of the state-of-the-art through literature review and interviews to relevant experts, followed by workshops with experts and stakeholders to discuss the future operational concept. The conduct of model-based simulations should neither be the main objective of the project nor take most of the effort, limited model based simulations may be used if adequately justified, e.g. to support quantification of benefits of formation flying.

The output of the project must be a high-level concept of operations describing an innovative air traffic service application. The objective of the concept of operations is to provide a vision of how the innovative concept will work within the current system and how it will change the operations from the point of view of all stakeholders. By its nature, the final concept of operations deliverable must be public. It is expected that intermediate deliverables supporting the development of the concept of operations (e.g. literature reviews, reports of workshops or interviews) will usually also be marked as public unless there is a specific reason for not doing so. Proposal including any deliverables as confidential are strongly advised to provide adequate justification for the need for confidentiality.

Expected impact:

Research in innovative Air Traffic Services concepts will support the development of the SESAR concept of operations in support of the objective of the ATM Master Plan and ACARE Strategic Research and Innovation Agenda.

Type of action:

Research and Innovation Action (RIA).

3.3.3 SESAR-ER4-20-2019: ADSB-in applications

Specific challenge:

ADS-B-in equipage delivers precise information of the surrounding traffic in the cockpit. Airlines have already starting equipping their fleets with ADS-B-in in order to take advantage of the initial applications that are already operational (ATSAW and Oceanic ITP). A number of additional ADS-B-in applications are currently under research in the Industrial Research Programme. The objective of this topic is to investigate additional applications beyond what is covered in IR to leverage ADS-B-in equipage.

Scope:

The SESAR concept of operations is ground-based, but even in a ground-based concept ad-hoc delegation of separation responsibility from controllers to pilots may bring benefits. Airborne Spacing – Interval Management (ASPA-IM) and CDTI Assisted visual separation (CAVS) are currently under research in the Industrial Research Programme. In addition, the industrial research programme also consider use of ADS-B-in capabilities by airborne safety nets, SURF-A and ACAS X (extended hybrid surveillance). Bids in this topic should propose a new ADS-B-in application and propose a plan to develop a high-level concept of operations and an initial validation (from TRL0 to TRL2) with the objective of assessing whether there would be value in including it in the ATM Master Plan.

The following two innovative applications of interest have been identified by the SJU:

Application area 1: Formation flying

In formation flying operations, an aircraft is positioned in a specific area closely behind another aircraft on the same route, where the wake vortices generated by a leading aircraft push air upwards, so the follower aircraft can benefit from this lift and therefore reduce the engine thrust and, at the same speed, significantly reduce the fuel consumption (initial estimate is that savings for the follower aircraft can be up to 8-12%), with the associated reduction in CO_2 emissions. A positive impact in terms of increased airspace capacity (more aircraft in the same portion of airspace) may also be possible. It is envisaged that the concept will allow the creation of strings of aircraft, each benefitting from the wake of the previous aircraft. Fuel savings are realised in the follower aircraft, and the concept has neither a negative nor a positive impact on the operational performance of the aircraft being followed.

The avionics requirements for the follower aircraft are ADS-B-in with a station keeping capability for the follower aircraft to allow it to maintain the prescribed separation with the aircraft ahead. It is expected that the development of the station keeping capabilities will leverage previous SESAR research on airborne spacing, which already enabled a follower aircraft to stay a specified time or distance behind a leader. The leader aircraft does not require any equipage other than ADS-B-out, which is already a requirement by the regulation.

Management of the rendezvous, formation-flying phase and split of military formations is already routine in European skies, but the concept is not directly applicable to civil formations. There is a need to develop a high-level concept of operations of how to manage civilian formation flying. The concept may include some strategic planning (e.g. to allow reduced fuel upload requirements for a flight that is planned to take advantage of formation flying) or be exclusively tactical (i.e. controllers identifying opportunities for formation flying to equipped aircraft that have reported that they are looking for a leader for fuel savings purposes, potentially with the support of the ATC ground system). Like in military formation flying, the concept must include the delegation from controllers to the flight crew of the responsibility for separation between leader and follower.

Application area 2: Use of ACAS logic for separation

In the current SESAR concept of operations, aircraft can manoeuvre based on their picture of the traffic obtained from SSR or ADS-B-in only for collision avoidance when in an ACAS manoeuvre. Previous SESAR ER project AGENT [52] has examined the possibility of aircraft manoeuvring earlier, in the separation provision layer rather than in the collision avoidance layer, with clear criteria being established for allocating separation responsibility to either air or ground agents. Projects working in this application area may build on AGENT's approach, or take a different approach, e.g. a ground-based concept with ad-hoc ground-to-air delegation of separation responsibility.

Please note that this list of innovative areas is not intended as prescriptive; bids addressing alternative ADS-B-in applications are welcome, provided adequate justification and background are provided in the proposal.

The output of the project must include a high-level concept of operations describing an innovative ADS-B-in application. The objective of the concept of operations is to provide a vision of how the innovative concept will work within the current system and how it will change the operations from the point of view of all stakeholders. By its nature, the final concept of operations deliverable must be public. It is expected that intermediate deliverables supporting the development of the concept of operations (e.g. literature reviews, reports of workshops or interviews) will usually also be marked as public unless there is a specific reason for not doing so. Bidders for this topic marking any deliverables as confidential in their bid are strongly advised to provide adequate justification for the need for confidentiality in the bid.

Expected impact:

In the era of digital aviation, ADS-B-in applications will enable the involvement of flight-crews in the air traffic control task by taking advantage of the digital vehicle-to-vehicle connectivity. Leveraging ADS-B-in equipage will allow airlines to get best value for money for their investments in avionics.

Type of action:

Research and Innovation Action (RIA).

3.3.4 SESAR-ER4-21-2019: Long-term Evolution of Air/Ground Synchronisation

Specific challenge:

Automatic air-ground trajectory synchronization is a cornerstone of the SESAR vision. This topic explores the evolution of the operational concept of air-ground synchronisation concept beyond what can be achieved with ATN B2.

Scope:

The automatic sharing of data between the airborne systems and the ATM ground systems in the Industrial Research programme is limited to what is possible with the ATN B2 standard; it includes the downlink of the Extended Projected Profile (EPP) and the interrogation/reply related to the ETA min/max window over a waypoint, as well as the data that are downlinked via SSR Mode-S. The evolution from ATN B2 and current Mode-S will further extend the scope of automatic air/ground data exchange. This could include, for example:

- Automatic update of the FMS trajectory with the ATC ground plan when a clearance is not yet possible, allowing the airborne systems to better optimise against that plan (e.g. more efficient descent profiles thanks to the information on the ground expected clearance).
- Automatic uplink and update of the AMAN planned times, so that the flight crew can be aware at all times of what the arrival time that ATC has planned for them, and optimise the flight accordingly.
- Automatic uplink and update of the relevant arrival and departure sequence, to increase the situational awareness of the flight crew (so that they know who their flights preceding and succeeding them on the sequence are) and facilitate ADS-B-in applications (no need for the controller to give aircraft-to-follow callsign).
- Automatic “instantaneous” (e.g. via Mode-S or ADS-B) downlink of the flight-mode (managed-manual/selected), to improve the interpretation by the ground-system of the EPP information, e.g. for the ground to be able to predict the next level-off.
- Evolution of the EPP standard, e.g. to include the vertical constraints that have been entered in the FMS, selected approach procedure, planned stabilisation speed (in support of compression management on final approach).

The main output of this project must be a high-level “Automatic air-ground trajectory synchronization CONOPS”, which must be included together with its supporting documentation in a deliverable marked as open for public dissemination. The “Automatic air-ground trajectory synchronization CONOPS” will be used as an input to the SESAR concept of operations, and also as an input for the future industrial research projects working in these areas.

The exchange of information that is not directly related to the ATC plan for the flight or to the trajectory itself is out of scope, e.g. downlink of aircraft as a sensor information is out of scope.

The project team must include both technical and operational expertise. Bids must demonstrate basic awareness of the future A/G communication infrastructure (which is supported by LDACS, Satcom and AeroMACS operating under a multilink approach) and which will support the future A/G voice and Data Link communications.

There is a dependency between this CONOPS and the controller-pilot communications CONOPS, which will be developed by a project in this call awarded under topic 23 Proposals addressing this topic should plan effort to coordinate with projects potentially awarded under topic 23. The project must also plan effort to bring the output of their research to ICAO as part of the dissemination of their work.

Expected impact:

Improved automatic air-ground synchronization will increase the predictability of flight operations on the ground, enable the optimisation of flight profiles in order to reduce fuel consumption and contribute to a more efficient organisation of the entire mobility system [12].

Type of action:

Research and innovation action

3.3.5 SESAR-ER4-22-2019: Digital Evolution of Separation Minima in En-route and TMA

Keeping aircraft separated from each other is one of the core functions of ATM. In the SESAR concept, ground automation supports air traffic controllers in their task of providing separation management. Separation management starts by strategically limiting the density of potential separation conflicts (i.e. limiting traffic density and traffic complexity), but is ultimately ensured tactically by keeping aircraft separated at or above the pre-defined separation minima. The RECAT and Time Based Separation (TBS) activities in SESAR [22] [53] have made it possible to update the separation minima between successive aircraft on final approach, thereby increasing runway throughput and safety. Further refinement of separation minima between aircraft on final approach (Pair Wise Separation RECAT-2) and between departures is ongoing in SESAR 2020 Wave 1 solution PJ.02.01, with important results expected to become publicly available at the end of 2019. However, in en-route and TMA, the tactical separation minima are essentially the same as they were decades ago.

Specific challenge:

Previous research SESAR exploratory research (R-WAKE project [54]) has developed an initial concept for updating the wake separation minima scheme applicable in en-route and TMA (except where RECAT applies), and a new operational improvement is in the process of being added to the European ATM Master Plan. The objective of this topic is to build on R-WAKE's work to progress on the definition and initial validation of this concept.

Scope:

It is anticipated that this work will support the development of a future SESAR solutions that will make it possible to move away from 'pre-determined' one-size-fits-all minima that are in use in current operations towards a more dynamic view of separation minima, whereby ATC separates aircraft to an assured minimum risk (dynamically determined for each pair of aircraft depending on the aircraft types, the geometry of the encounter and the atmospheric conditions) rather than a defined distance standard'.

The new separation scheme may include the consideration of reduced vertical separation minima, potentially including the possibility of using a minimum vertical separation of 500 ft. from the ground to unlimited, which may allow the use of intermediate flight levels, e.g. 275, 285, 295, 305…. This reduced vertical separation scheme is referred to as RVSM 2.0, and would dramatically increase airspace capacity both in en-route and the TMA. The new separation scheme may also consider the use of combined separation minima (i.e. XXX feet vertical *and* YY NM horizontal) in order to increase flexibility and make maximum use of airspace capacity.

In the current environment, the 1.000 ft. or 5NM separation minima prevent most wake encounters, but wake encounters are still possible between aircraft that are separated above the prescribed minima [55]. The new separation scheme may also increase the separation minima above what is applied today (e.g. to 1.500 ft. instead of 1.000 ft.) in certain cases in order to reduce the instances of wake encounters between aircraft that are correctly separated above the minima, thereby increasing safety.

It is anticipated that the development and implementation of new separation minima for en-route will follow a similar step-wise approach to RECAT [56], in which at first the new minima would be dependent on static aircraft characteristics, and in the future it may be possible to define dynamic minima dependent on dynamic aircraft characteristics (weight, atmospheric conditions, etc.). It is expected that the new static minima would be dependent on the geometry of the encounter and the wind and other atmospheric characteristics (e.g. height of the tropopause).

This concept presents key human performance challenges and for this reason the human performance aspects related to the applicability of a new separation scheme will need to be considered. Like for RECAT-2, it is expected that ATCOs will need support tools in order to be able to apply a more complex separation scheme. It is expected that RECAT EU and RECAT-2 experience and lessons learned in human performance and development of Optimised Runway Delivery (ORD) tools will be useful.

Proposals shall consider altimetry requirements, potentially considering the use of GNSS based geometric altimetry in combination with barometric altimetry to support the reduction of vertical separation minima.

Although the key objective is the redefinition of the wake minima, there is also the need to start researching the potential for reduction of MRS, because where the newly defined minimum wake separation (MWS) is lower than the applicable minimum radar separation (MRS), the new reduced wake minima will only be applicable if MRS can be safely reduced. For this reason, the reduction of the radar separation minima scheme is also in the scope of this topic. This may need to consider minimum surveillance performance requirements, and vertical navigation performance requirements. The new MRS may also be geometry dependent (e.g. reduced separation when in-trail) or include combined separations (e.g. 500 ft. *and* 1 NM).

The consideration of separation minima between IFR RPAS or between IFR RPAS and manned aircraft is out of scope for this topic.

It is anticipated that the development and implementation of a new separation scheme will be a lengthy process. The solution may develop an interim concept to predict encounters where two aircraft that are separated above the current minima will cross with a geometry where preliminary research results indicate that there is an increased risk of a wake encounter. The research of such an interim concept may need to evaluate the emerging legal/liability aspects.

It is anticipated that the research may require live data collection, big data analysis and use of machine learning.

<u>Expected impact:</u>

The new separation scheme for en-route is expected to bring large benefits in terms of airspace capacity, in many cases literally allowing capacity to be doubled thanks to Reduced Vertical Separation Minima (RVSM) 2.0, which will make it possible to use of the intermediate flight levels (…,275, 285, 295, 305,…). Safety will also be increased, by reducing the instances of en-route wake encounters by prescribing new separation minima under certain atmospheric conditions and/or between certain specific aircraft pairs.

Type of action:

Research and innovation action

3.3.6 SESAR-ER4-23-2019: Increased Capacity for High Density operations by Evolution of Controller/Pilot communication

This topic explores the evolution of controller/pilot voice and datalink communication concept beyond what is currently covered by the industrial research programme.

Specific challenge

In the area of voice communications, the current controller-pilot voice communications concept of operations is a de facto result of the way of working and of the performance of the legacy system (i.e. mainly the analogue DSB-AM VHF radio system). In the area of datalink, the current CPDLC is applicable only above FL285.

The research challenge is to develop the high-level global A/G communication concept of operations addressing how voice and data will be combined in the future to support the future ATM concept, what will be the role of voice exchanges and how they will be managed, and the concept of operations for the extension of datalink below its current scope.

Scope

The output of this project must be the future global[3] A/G communication concept of operations (CONOPS). The future controller-pilot global A/G communications CONOPS shall cover both the future voice and the extension of datalink communications below FL 285. This CONOPS will be used as an input to the SESAR concept of operations, and also as an input for the future industrial research projects working in these areas.

It is anticipated that the development of the voice and datalink concept of operations will require the involvement of technical experts external to the consortium (e.g. through technical workshops), with the consortium's main role being that of providing the background information, the operational view and framework, and facilitating the workshops and consolidating the results to produce concept or concepts of operations as the final technical deliverable of the project.

It is expected that the following SESAR Wave 2 industrial research solutions will contribute experts to the CONOPS:

- Solution 8, "Dynamic E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations";
- Solution 21, "Digital evolution of integrated surface management";
- Solution 56, "Improved vertical profiles through enhanced vertical clearances";
- Solution 57, "RBT revision supported by datalink and increased automation".

[3] "global here means voice and data

- Solution 73, “Flight-centric ATC and Improved Distribution of Separation Responsibility in ATC”; and
- Solution 77, “FCI Services”.

The integration of the technical and operational point of view is essential for the success of this project. The consortium must therefore have both operational and technical expertise, and the proposal must demonstrate how the work plan will ensure the continuous coordination between operational and technical experts.

Proposals are expected to first define the global A/G communication concept of operations considering voice and datalink working in combination in the long term (i.e. beyond 2030+), addressing all phases of flight. The research activities will assess how exchanges between pilots and controllers will be performed including which types of exchanges will use voice medium and which types of exchanges will use Data Link medium (i.e. CPDLC services and its future evolutions of CPDLC or equivalent services), in which circumstances each medium will be used and how datalink and voice will be combined in different environments.

Once the global A/G communication concept will be clarified, the project is expected to define in more details the A/G voice (sub-) concept of operations and will provide insight into the following operational questions:

- How the future A/G voice communications will be managed (e.g. will they still operate under a broadcast principle? Is the party-line effect still required (like as provided by the current VHF system)? Or future A/G voice communication will be under a point-to-point principle and in which case how a communication will be established? Would A/G communications be a mix of broadcast and point-to-point? Would pilot to pilot voice communication be a requirement?
- What will be the performance requirements (e.g. latency, continuity)?
- How current and future voice “technologies” will be mixed during transition periods so that it is transparent to pilots and controllers (e.g. within the same areas when transitioning from legacy to new; between two areas (equipped and not yet equipped); supporting a mix of aircraft equipage)?
- Which level of security will be required (e.g. encryption, authentication)?
- What are the wide-area communications needs (e.g. should voice communication sessions be maintained during a flight between a pilot and the “in-charge” controller in case the flight centric concept would be applied)?
- Which are the future automation needs connected to voice communications (e.g. speech recognition, handover, priority call…) and which operational requirements they would support?

Proposals will also address the extension of datalink (including below FL285 and considering the global A/G communication concept of operations as addressed at project start) and how it will make possible to maximise the benefits of many of the concepts currently being researched in the industrial research programme, e.g. dynamic uplink of custom or standard instrument departures (SID) during taxi, dynamic uplink of custom or standard arrival routes when the aircraft has already initiated descent, uplink of enhanced vertical clearances with one or multiple vertical constraints along the way for aircraft flying at any level. However, important challenges have been identified in this area, e.g. increased head-down time for pilots, need for lower latency in the more dynamic lower airspace and airport environment, etc.

The CONOPS for the extension of datalink should provide insight into the following operational questions:

- How can the increased flight-crew head-down time be mitigated (e.g. autoload clearances only, HMI improvements, voice-recognition, reduced number of technical/system messages…)?
- What would be the acceptable performances (e.g. latency) in the different environments?
- Which level of automation should be further introduced? E.g. should in some environments hand-over between different ATSUs become seamless from the flight crew point of view (e.g. connected to ATC, with hand-over being transparent to ATC – no new log-on required when going from one ATSU to another)? Should coupling between Data Link and voice be introduced (e.g. change of voice "channel" be induced through datalink commands)?

Proposals must demonstrate awareness of the future A/G communication infrastructure (which is supported by LDACS, Satcom and AeroMACS operating under a multilink approach) and which will support the future A/G voice and Data Link communications. The selected team will work with A/G communication IR solutions (e.g. Solution 77 which will be the interface with other technical solutions e.g. LDACS) to consider the technical feasibility and technical impact that the choice of the concept of operation choices and each of the operational requirements would have on the future A/G communication architecture. The common operational and technical assessment will consider reducing requirements on aircraft configuration (e.g. reducing the number of or completely removing legacy avionics when installing avionics supporting new concepts).

Bids must demonstrate access to operational data related to the current datalink implementation in higher airspace in Europe and/or the US. A task should be planned earlier in the project to produce a report with the lessons learned from the implementation in the higher airspace and an analysis of what they may need to take into account in the datalink extension. Please note that the analysis of lessons learned should be restricted to the operational aspects (technical lessons-learned are explicitly out of the scope of this topic).

Proposals must also demonstrate awareness of the previous SESAR research in the area of extension of datalink [57]. In particular, the output of the ATC Full datalink (AFD) demonstration project [58] must be considered.

For the voice concept of operations, all operational environments where ATC is provided must be considered, including: en-route in high and low density (including both day and night shifts with band-boxed sectors), oceanic, polar, tower, TMA and approach. Both traditional ATC service based on geographical sectors and flight-centric (sector-less) ATC must be considered.

For the datalink extension concept of operations, all the operational environments of interest must be considered. The operational environments of interest are en-route airspace below flight level 285, TMA and approach and airport surface for operations at the apron after push-back and on the manoeuvring area. Use of datalink for clearance delivery while the aircraft is still at the gate (before push-back) shall also be considered.

Proposals must plan effort to bring the output of their research to ICAO as part of the dissemination of their work.

Expected Impact:

The move towards new ways to support voice exchanges and the extension of the use of datalink beyond what is possible today are part of the digital aviation vision. They will enable the sustainable growth that is necessary to meet the capacity challenge that is described in the ATM Master Plan.

Type of action:

Research and innovation action

3.4 Sub Work Area 2.4: Enabling Aviation Infrastructure

The research activities under enabling aviation Infrastructure will include research on concepts and methods for enhancing and securing CNS as well as approaches for integrated performance based CNS.

Furthermore, the infrastructure required to support digitalised ATM applications will itself need to evolve; in particular, the secure exchange of information in a deterministic time is an essential characteristic of the future infrastructure. An efficient security framework for data exchange is an essential component of the future digitalised ATM architecture. Methods to achieve this by exploiting best-practice techniques from other sectors is required.

3.4.1 SESAR-ER4-24-2019: Innovation in CNS to enable Digitalised Operations

Specific challenge:

Communication, Navigation and Surveillance (CNS) is one of the fundamental enablers of the ATM as it supports locating and identifying air vehicles, and exchanging information with and between air vehicles. The research and development for the evolution of the legacy Integrated communications, navigation and surveillance systems to a new integrated approach (iCNS) is already under way in the SESAR IR programme. The iCNS will bring ATM to the next level, with a resilient architectural design that combines satellite and ground-based services. The exploratory research challenge is to develop applications that complement or further develop the work under way in IR, with a particular focus on making it possible for a wider AU community (including GA, drones and the military) to access the most advanced iCNS services. There is also a need to plan how to ensure that the future increased demand for connectivity can be fulfilled.

Scope:

The full range of research that could be covered in this topic is broad; the application areas mentioned here are merely indicative. Projects may target implementation in the mid-term or could address timeframes up to those of the Flightpath 2050 vision document [4].

Please note that this is an application-oriented research topic. Proposals for this topic must describe a concrete new CNS enabler for ATM or a new CNS use for ATM of an existing enabler and describe how they will undertake its initial validation, with the ultimate goal of either proposing its inclusion in the ATM Master Plan for further development or discarding it.

The SJU has identified the following application areas of interest:

Application area 1: Low cost alternative Position, Navigation and Timing (A-PNT) for General Aviation and drones

The research aims at defining, developing and validating a concept of alternative positioning, navigation and timing (A-PNT) for small aircraft (GA, Ultra-Light (UL) Aircraft, Very Light Aircraft (VLA), Remotely Piloted Aircraft Systems (RPAS) or Unmanned Aerial Vehicles (UAV)) to meet the requirements in PBN/RNP operations in case of a GNSS degradation or outage. This standard and low-cost A-PNT concept and system would allow the integration of these airspace users in an efficient and non-discriminatory manner while ensuring safety and security levels and the desired performance gains in terms of resilience and cost efficiency.

The research may address, for example:

- The assessment of innovative technologies such as inertial systems, low cost atomic gyroscopes and accelerometers and radio altimeters that allow consolidating the on-board computed position as well.
- The development of Innovative new vision based navigation system for these AUs consisting of image processing algorithms and their potential combination with GNSS to increase access.
- The potential civil-military interoperability and synergies. The potential use of low-cost on-board solutions that meet PBN requirements, on the basis of the reutilisation or adaptation of currently available capabilities, is of utmost importance for State aircraft operations;
- The specific requirements for auto land for smaller independent on ILS system, based on GPS, inertial positioning and other sensors to increase the vertical accuracy e.g. radar tracker, LIDAR, radio altimeters or vision based navigation. This shall take into consideration work under WG-105.

This research in this application area may build on previous SESAR ER project NAVISAS [59] or propose alternative approaches. Proposals for work in this area must explain how their work is positioned.

Application area 2: Improving security and resilience against GNSS threats
For the medium and long term, it is expected that Global Navigation Satellite System (GNSS) will become the primary means of aircraft navigation. However, satellite navigation receivers are vulnerable to intentional or not-intentional threats/interferences (especially to jamming and spoofing) which may cause the total loss of navigation with the subsequent implications for the navigation services based on GNSS (or its augmented derivatives).

The research shall:

- Propose solutions to improve security and enhance resilience against these threats;
- Develop a new concept for the GNSS interference air navigation threat's management, based on implementing detection and localization of jamming and spoofing on-board the aircrafts.
- Assess and validate the proposed algorithms to detect and localize the interference.

The research shall take into consideration the work and results GATEMAN [60] is expected to provide up to the end of 2019.

Application area 3: Improving cybersecurity on CNS services
In anticipation of future more secured performance based CNS, there is a need to make CNS services more secure and resilient against cyber-threats. The research may propose effective and automated solutions for intrusion detection and identify security controls and associated security requirements. The research shall also propose potential mitigation measures in case CNS services are breached.

The solution shall consider (if applicable) the work performed by SESAR solutions on cyber-security as an input to the study and consolidate their analysis on existing and future vulnerabilities.

The scope of the work may be limited to a few selected services e.g. PBN services, surveillance service, etc. and shall complement the top-down vision as defined in Industrial Research activities e.g. PJ.14-01-01 [13] and PJ.14-W2-76 [14].

Application area 4: Manned and un-manned aircraft protection from non-cooperative targets
The increasing number of drones is causing safety and security concerns within the aviation industry. A number of collisions between aircraft and drones have been already reported worldwide, and this number will likely increase in the coming future if nothing changes. This research area covers the development of non-cooperative detection. Proposals for work in this area must demonstrate knowledge of the state-of-the-art in sensors for non-cooperative detection, propose an innovative detection application, and describe how they will undertake its initial validation. The proposals must explain the high level performance requirements they will validate their innovative against and how they relate to an operational need. The work plan must include the derivation of lower level operational requirements and the initial validation of the application. The validation of the avoid manoeuvres is out of the scope for this CNS topic.

Please note that SESAR has previous ER work in this area by project PercEvite [61], which is ongoing. Proposals for work in this area should review PercEvite's publicly available material and explain how their proposal is positioned with respect to PercEvite. The proposed work should either build on PercEvite's work or be complementary to it, but should avoid the repetition of PercEvite's work. Proposals for work taking a completely different approach from PercEvite are welcome.

Application area 5: Use of 5G for ATM purposes
5G technology is one of the areas that have been more rapidly evolving; it may represent a game changer for connectivity if applied to ATM. Ground-based 5G can release the full potential of satellite based communications, while satcom has also useful properties for 5G in terms of security, resilience, coverage and delivery of broadband. Proposals for work in this application area must propose a satellite and/or ground based 5G application for ATM.

The research in this application area must take into consideration the work done by PJ.14-02-05 [13] on LTE/4G/5G for General Aviation in industrial research and project DroC2om that is working on 4G/5G (and Satcom) in the framework of UAVs. Results from both PJ.14-02-05 and DroC2com are expected at the end of 2019. Projects working in this application area are expected to plan effort to analyse their results and consider how they relate to their work.

Please note that the above list of application areas is not intended as prescriptive. Proposals for work in alternative application areas are welcome, provided adequate justification and background are included in the proposal.

All proposals for work in this topic must consider the top-down iCNS view that is being defined in SESAR's Wave 1 Industrial Research activities e.g. PJ.14-01-01 [13], whose final publicly available deliverables are expected at the end of 2019, and PJ.14-W2-76 [14]. Projects should reserve effort to analyse the output of these IR projects and incorporate them in their research.

<u>Expected impact:</u>

Successful research in this topic will have the potential to generate high positive benefits for ATM in terms of resource efficient and fit-for-purpose CNS capabilities as well as improvements in security, improved predictability of data link performance, reduced level of air-ground communication issues and improved efficiency of ATM services delivery.

<u>Type of action:</u>

Research and Innovation Action

3.5 Sub Work Area 2.5: ATM Operations, Architecture, Performance & Validation

This research area will include research activities about performance and improved indicators and performance measuring methods for digitalisation, resilience, multi-model performance, environmental impact and cybersecurity. Further, it will include research activities to advance validation methods like E-OCVM [63] and enhance approaches to detect emergent behaviour. Additionally, this research area will include topics addressing the digitalisation of the ATM Architecture and applying methods for enhancing cybersecurity of the ATM system.

The development of a scalable and secure target ATM Architecture is a necessary part of the vision towards 2035. Proposals that address a viable approach to achieving this ambition are encouraged.

The results from the research activities under this topic will directly contribute to the overall SESAR 2020 transversal activities of ATM design & integration, performance management, validation, verification & demonstration infrastructure and ATM Master Plan maintenance.

3.5.1 SESAR-ER4-25-2019: Measuring and Managing ATM Performance

Specific challenge:

The objective of SESAR is to improve the performance of the ATM system. This topic is aimed at the development applications that improve the assessment and management of the performance of ATM in operations beyond what is already covered by the IR programme. The improvement of the assessment of the performance of ATM concepts during the full R&D cycle is also in scope.

The exploratory research challenge is to propose an improvement to the assessment or to the management of performance in ATM and undertake its initial validation. All proposals must consider how their proposed improvement relates to both the current SESAR Performance Framework and the SES performance scheme [64] [65].

Scope:

Proposals submitted for this topic should clearly describe an ATM performance assessment or an ATM performance management concept and describe what the expected benefits would be and how they will undertake its initial validation. Proposal should take previous work into account, in particular [66] [67].

The following non-exhaustive list of potential candidate application areas has been identified as being of interest by the SESAR Joint Undertaking:

Application area 1: Development of digitalization indicators for ATM
SESAR contributes to the EC's digitalization objectives by bringing digitalization to ATM, in accordance with the Aviation Strategy for Europe [2]. The challenge is to propose and validate digitalization indicators that are relevant for ATM and can be used to assess progress. The research must consider how the proposed ATM digitalization indicators compare to those used by other industries, as well as to the more cross-industry generic indicators and to the ATM digitalization indicators that will be proposed in the next ATM Master Plan (publication expected during 2019).

Application area 2: Improved consideration of resilience by the SES/SESAR performance framework. Resilience can be defined "as the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedback" [68]. The consideration of resilience is part of the SESAR safety reference material, but the consideration of resilience beyond safety in SESAR is limited to the measuring of resilience to capacity (as percentage of capacity loss in non-nominal situations), which is used by projects working on concepts that support disruption management. Delay, fuel efficiency, punctuality and predictability indicators are the same for nominal and non-nominal situations, and SESAR ambitions [3] and validation targets [69] are set based on average values measured in real operations, where outliers may have a disproportionate impact. Likewise, the SES performance scheme [64] [65] sets targets against average values, without differentiating between nominal and non-nominal situations. Research should propose a way forward to improve the consideration of resilience by suggesting different indicators and/or targets for nominal and non-nominal situations, and undertake an initial validation (e.g. show how the assessment of performance would be more meaningful with their proposed methodology). The indicators should be able to capture the three the three complementary resilience capacities: absorptive capacity, restorative capacity and adaptive capacity [15]. Proposals for work in this area must describe how their work is positioned with respect to the research project RESILIENCE 2050 [71].

Application area 3: Development of multi-modal performance indicators and ambition
The Flightpath2050 [4] has set a goal for a maximum of four hours of door-to-door travel time in Europe by the year 2050. There is a need to better understand how to work towards the achievement of this ambition, by breaking down the total travel time indicator between different modes of transport and different phases of travel within each transport mode (e.g. for air travel total travel time could be broken down into check-in time, baggage collection time, in-airport walking time, travel time to and from the airport...), and then benchmark each of the phases and set ambitions for each of them. Proposals must focus on measurements that affect air transport, but may include the consideration of other modes of transport if their relevance to ATM is justified in the proposal (e.g. travel to and from the airport, travel times in other modes of transport for comparison with flight-times and potential consideration by ATFM or for the route charging scheme). The consideration of the trade-offs in performance between passenger travel time and transport mode travel time is also in scope for this topic, e.g. to consider when an aircraft waits for delayed connection passengers (arriving by air or by another transport mode) the trade-off between the increased delay of the flight and the decreased delay of the passengers (compared to whether the flight had not waited for them and they had had a longer wait until the next flight).

Proposals in this area must plan effort for coordinating with projects awarded under topic - Innovation in Airport Operations" - working on the improvement of airport operations in contribution to multimodality and projects awarded under topic - "ATM Role in Intermodal Transport".

Application area 4: Development of environmental indicators
The objective is to further develop the assessment of the impact on the environment of aviation, measuring noise, air quality and pollution beyond what is currently considered by the SES regulation [64][65] and the SESAR performance framework [70]. Indicators may assess, for example, noise impact from traditional aviation and/or drones, NOX, contrails and their impact, local air quality, etc. Projects working in this area should consider how their proposed approach compares to the approach by Clean Sky [62] and refer to the European Aviation Environmental Report [72].

The research activities may also review the interrelation of the environmental targets set by the SES Performance Scheme [65] for the second reference period (RP2), the PRB Advice to the Commission in the setting of Union-wide performance targets for RP3 [73], the environmental ambition in the ATM Master Plan for 2035 [3], the SESAR Programme validation targets [69] and the environmental ambitions set by Flightpath2050 [4] ACARE for 2050 in order to provide insight on how they complement each other and how the metrics used in SESAR may evolve to best support the achievement of all the aforementioned ambitions and targets.

Application area 5: Further development of the concept of unconstrained reference trajectory against which to calculate additional track-miles or flight-time in the TMA
For the calculation of additional arrival flight-time in the TMA, the current SES regulation [64][65] uses as a reference the unimpeded trajectory from a distance of 40NM around the airport [74], which is calculated as the statistical minimum for each aircraft category. For en-route, the reference trajectory is the great circle distance.

The objective of the research is to study potential evolutions of the current SES indicator in order to overcome some of the current limitations, for example:

- Limitations due to the reference a trajectory in the TMA being calculated statistically, which may result in situations where an average improvement in track miles counts as a decrease in performance and vice versa.
- Limitations due to the great circle not considering the ARES demand that affects the trajectory, which may result in an increase in ARES demand resulting in a decrease of the performance of the ANSP.
- Limitations due to the additional time in the TMA not considering departures.
- Limitations of the one-size-fits-all 40NM limit between en-route and TMA used in the SES not being tailored for each airports.

Application area 6: Development of arrival delay indicators and targets
From the point of view of the passenger, "on-time" arrival is a key performance ambition, Arrival predictability is also considered key for the efficient management of airport resources. However, neither the SES performance scheme [58] [59] nor the ATM Masterplan, SESAR performance framework [70] or the SESAR Validation Targets [69] include arrival delay metrics, ambitions or targets. Measuring arrival delay is challenging, because of the difficulty of finding a valid reference (e.g. airline schedules often include buffers). Moreover, limiting the number of flights arriving outside a certain interval is more relevant than measurements of mean or variability, but the interval of interest may be different depending on the stakeholder (e.g. from the passenger perspective, arriving a few minutes early is not a problem, but early arrivals may disrupt airport operations). Improvements to the predictability of the in-block time may not only come from aircraft flying closer to their planned trajectory, but also from improvements in the planning that make it more realistic (e.g. planning that considers the SID or the STAR, planning that considers the statistical flight-time with usual DCTs…). Project working in this area must consider all stakeholders, and also consider how their proposed approach compares to the FAA's fifteen-minute delay criterion (where aircraft arriving earlier than fifteen minutes after their scheduled time are considered to be on time) [75]. In order to cater for different stakeholder needs and priorities, multiple indicators and targets may be proposed and validated.

Application area 7: Further development of civil-military cooperation and coordination indicators
Civil military cooperation and cooperation indicators in the SESAR performance framework [70] allow a limited assessment of the improvement of civil-military coordination concepts in terms of increased civil and military flight efficiency, as well as of the effectiveness of the coordination processes (by

measuring the volume of reserved airspace that is not used) and the effectiveness of the process from the military mission perspective (for optimizing the ARES volume). There is a need to further develop these indicators, as well as to research into the interaction between the impact of the demand of reserved areas on the achievable flight efficiency. In addition, there is a need to understand the apportionment of SESAR ambition [3] to increase flight efficiency between projects working on the improvement of civil-military coordination processes and projects working in other areas.

Application area 8: Development of flexibility metrics, ambitions and targets
The flexibility KPA has indicators aims at measuring the flexibility of the ATM system, e.g. measuring the delay for late-filing flights or flights which request a change over their original plan, or allocation of airspace reservation at short notice. There is a need to further develop flexibility metrics and targets. Research in this area should identify demands for flexibility among stakeholders, propose and validate relevant metrics and perform a preliminary benchmarking.

This list of potential application areas is not prescriptive; proposals addressing application areas beyond those listed above are welcome, provided adequate background and justification are provided in the proposal.

Expected impact:

Improvements in the area of performance assessment, benchmarking and ambition/target setting and trade-off between indicators will enable an improved management of the performance of the ATM system in operations, and a better assessment of performance in R&D.

Type of action:

Research and Innovation action.

3.5.2 SESAR-ER4-26-2019: ATM Validation for a Digitalised ATM

Specific challenge:

Although the European Operational Concept Validation Methodology (E-OCVM) [63] has been successfully applied in industrial research activities in SESAR, there is a need to explore potential improvements to the methodology in order to ensure a more flexible and adaptable approach that could facilitate a rapid development and progress towards the future ATM. The vision for this future ATM considers significantly higher levels of connectivity and automation than today and this may need adaptations in the current human performance methodologies to be able to address these challenges.

Scope:

The scope of this topic covers the following aspects:

Application area 1: Macro-modelling applied to Air Traffic Management
A macro-model is a theoretical or conceptual model that is able to reproduce the behaviour/trends of the whole system, rather than that of its individual elements, and that aims at addressing large-scale, global and/or systemic factors.

Research activities shall develop potential solutions that are able to use in practice the knowledge on emergent behaviour detection and overcome the limitations in this area of the current E-OCVM. In particular, the research may address the following areas:

- Investigate new methodologies and techniques/tools for macro modelling and assess their feasibility and applicability to ATM identifying main advantages and limitations.
- Develop a macro-model of the ATM system (using techniques/tools identified above) and demonstrate:
    - The model capability to assess the potential performance impact of future concepts/solutions (still under validation in Industrial Research, under Exploratory Research, or new ones) at ECAC level The proposal shall describe the reference scenario (ATM system without implemented solutions) and the solution scenario(s) (ATM system with implemented solution(s)) that are intended to be used as test cases to validate the model and demonstrate its capabilities.;
    - The model capability to address trade-offs between alternative concepts/solutions, between KPAs and stakeholders;
    - The model capability to support the decision making process.
    - The capability to address emergent behaviour analysis, in order to allow analysis of impact of new concepts on all stakeholders at the same time, and macro-safety cases based on the emergent behaviours that are detected with the new methodology.

  Relevant simplifications and assumptions made for building the macro model should be documented and be delivered with the modal.
- Assess the potential use of models (e.g. agent-based models) in order to consider how uncertainty can impact the output of R&D activities: Run model-based simulations to quantify potential rare event instances (in particular for non-nominal situations) and consider how this can be used in the development cycle in order to identify where uncertainty must be reduced to obtain the target safety level;
- Align to key reference material from SESAR programme i.e. SESAR Performance Framework [70] and SESAR Solutions catalogue (e.g. if the solution is already under development in ER or IR, the proposal shall be aligned to the latest applicable solution description or document any deviation with respect to that baseline). The research may deviate from these references but any deviation shall be documented and its impact on the results evaluated;
- The proposal shall build on the results and work under exploratory projects such as Domino [76], evoATM [77], and VISTA [78] , etc. where relevant.
- The technical proposal shall facilitate an iterative and incremental approach towards the objectives, to allow (if required) re-orientation or adaptation of scope, objectives, etc.

Application area 2: Evolution of European Operational Concept Validation Methodology (EOCVM) for ATM

The research aims at performing a critical review of the European Operational Concept Validation Methodology (E-OCVM) [63] and propose concrete improvements to the methodology. These improvements should be well detailed in order to facilitate the transfer, integration and training activities.

In particular the research shall:

- Consider the applicability to ATM of other validation methodologies (that may be used in other domains) e.g. principles of agile development for reducing the duration of R&D phase in ATM, facilitate the identification of emerging solutions that could quickly progress from low maturity levels (V0/V1, typically under the scope of exploratory research) to higher maturity levels (V2/V3, typically under the scope of industrial research) and then towards deployment;

- Critically assess the E-OCVM case based approach, and in particular the safety case, and propose the required improvements so through the application of the methodology it would be possible to identify as soon as possible any safety issue that if un-detected may imply important costs at a later stage e.g. deployment;
- Review the roles and responsibilities in the validation methodology e.g. between development and validation roles;
- Propose ideas to better integrate technical validation of technological solutions (enablers) and technology readiness levels (TRL) into E-OCVM;
- Review the SESAR maturity criteria [79][80] and propose improvements to the list of criteria and the means of compliance;
- Address the analysis of differences between the validated results e.g. performance benefits at the end of the validation cycle (V3/TRL6) and what happens when solutions are finally implemented and in operations, and extract lessons learnt that could help to improve the E-OCVM and the validation process in general;
- Explore how pilot implementation projects could be used to collect operational data and detect emergent behaviours that could be used to provide feedback to solutions/concepts at lower level of maturity.

Application area 3: Evolution of Human Performance Assessment methodology
This research area aims at developing and validating concrete improvements to the SESAR Human performance Reference Material [81][82] that can be input in the next cycle of Industrial research, in particular considering environments with higher degrees of automation. Note that Human performance is not only linked to safety but also related to training needs, cost efficiency and workload and that is why this is kept separated from the previous application area. The improvements could cover, for example:

- less invasive techniques for collection of HP data; large-scale data collection of impact of automation on HP;
- innovative use of human performance data collection techniques e.g. speech recognition, brain wave measurements, eye-tracking, etc.;
- human behaviour modelling, e.g. for Fast Time Simulation Fast Time simulation (FTS).

The research shall address the potential use of more advanced HP assessment tools in future R&D work. The research may consider as well behavioural sciences.

Note that the research shall take into consideration both SES performance scheme [58] [59] and SESAR performance framework [70], and latest applicable version of the SESAR Human Performance Reference Material (HPRM) [81][82] as the ”as-is” reference.

Expected impact:

It is expected that the research in this topic will identify concrete improvements to the methodologies applied in industrial research in SESAR in order to: better consider the challenges derived from the future vision for ATM, to optimise the validation process and to allow the rapid put into operations of innovative ideas with high potential performance benefits.

Type of action:

Research and Innovation action.

3.5.3 SESAR-ER4-27-2019: Future ATM Architecture

Specific challenge:

The future ATM architecture is distributed, and will make extensive use of digital technologies to enable a more efficient organisation of the entire mobility system [12]. The implementation of this model provides opportunities for increased efficiencies through the consolidation of services, and increased resilience by increasing the flexibility in the design of fall-back solutions but will face challenges that need to be addressed e.g. cyber security. Securing the confidentiality, integrity and availability of all ATM operations, in particular in the face of rapidly increasing cyber security risks, will be an inherent and collaborative element for civil and military stakeholders in the design, development, deployment, operations and maintenance of ATM capabilities.

Scope:

Proposals must describe a specific application supporting the improvement of the ATM architecture, with a particular focus on adapting it to better support digital technologies. Proposals must also describe a work plan to undertake the initial validation of their proposed improvement.

The following application areas of interest have been identified by the SJU:

Application area 1: ATM cyber-crisis management
The cybersecurity requirements of the ATM data systems are very high, but it is nevertheless necessary to ensure that if a cyberattack were to be attempted, the system would be ready to ensure the safety of the system at all times, and resume normal operations as soon as possible. Bids must propose one or more cyber-crisis management strategies that include the whole crisis lifecycle (readiness, response and recovery), and a plan to validate them. It is expected that the network analysis models used in other industries can be useful for ATM. Projects working in this area must consider the business aspects of their proposed applications.

Application area 2: ATM data management
The decentralization of the ATM system will bring with it the distribution of data management responsibilities among multiple actors. There is a need to establish requirements that ensure that the data are correctly stored and that the transmission of data is carried out in a secure and fully traceable way. Bids should describe a specific ATM data management challenge and hypothesize one or more novel ways to store and transmit ATM data so that the security and traceability is improved above what is considered in IR (with the SWIM profiles), and propose a plan to validate their hypothesis. It is expected that the generic data encryption solutions that are in use in other industries (e.g. block-chain, smart contracts, quantum-based cryptography, etc.) will be useful for ATM.

Application area 3: Collaborative cybersecurity awareness
The concept of the aircraft downlinking to the ground CNS cybersecurity status information (e.g. jamming, spoofing) is included in the scope of IR Wave 2 (Candidate Solution 110). Bids could propose additional applications that extend this concept, e.g. aircraft sharing cybersecurity status with other aircraft rather than the ground, or to a commercial cybersecurity monitoring service (not necessarily the ATM system).

Application area 4: Interaction between cybersecurity management and safety management in ATM
Similarly to what is done through safety management systems in the area of safety, there is a need to share cybersecurity information in order to ensure that the information and lessons learned from previous incidents is used for the continuous improvement of the system. However, unlike for safety, access to cybersecurity-related information needs to be controlled in order to avoid that sensitive information ends up in the hands of potential attackers. In addition, in the aviation there is a need to consider the trade-off between security measures and safety requirements, e.g. an encrypted ADS-B-in may be more secure if used by the ground, but may become unusable by other aircraft for ADS-B-in applications. Bids should elaborate on one or more of the challenges posed by the interaction between cybersecurity and safety in ATM, hypothesize one or more potential solutions and describe a plan to validate their hypotheses. The output of the project should be a public deliverable with detailed guidance material on how to address these issues.

The above list of potential applications is not intended as prescriptive; bids addressing applications not listed above are welcome, provided adequate background and justification are provided in the bid.

Expected impact:

It is expected that the research in this topic paves the way for a future distributed, service oriented ATM architecture that will make extensive use of digital technologies while respecting agreed safety targets and defence and security needs.

Type of action:

Research and Innovation action.

3.6 Sub Work Area 2.6: IFR RPAS

This research area will address concept elements related to the control of IFR RPAS in the TMA, integration aspects further than those already covered in IFR RPAS topic in IR and reduced crew operations contingency management, in support of the full integration of IFR RPAS with manned aviation.

3.6.1 SESAR-ER4-28-2019: Control of IFR RPAS in the TMA

Specific challenge

Even though the remote pilot of an IFR RPAS may be located anywhere in the world, control from a ground station that is not in direct radio line-of-sight will generally increase communication latency, which may require ATC to apply extended separation buffers for RPAS, especially during approach, take-off and landing, where ATC is more dynamic, or it may even render TMA operations impossible. The challenge is to integrate IFR RPAS in the busy TMA and airport environments, beyond the level that is currently being research in the industrial research programme.

Scope

The industrial research programme is researching the accommodation and integration of IFR RPAS in the airspace and at the airport, with a focus on accommodation and integration of the demand expected in the 2025-2035 time-frame. Research being conducted in Wave 1 by PJ.10-05 [13] and the awarded scope of work in Wave 2 are expected to be publicly available at the end of 2019 [14]. This comprises almost exclusively IFR RPAS that operate from either military bases or dedicated airfields, where the remote pilot can control the aircraft via a radio line-of-sight C2 link. For take-off and landing, it is expected that large separation buffers may be required. The research that will be carried out in this exploratory research topic will pave the way for IFR RPAS to be able to fly to and from any airport in full integration with manned aircraft, i.e. eliminating or greatly reducing the separation buffers.

The aim of the research is to establish high-level requirements to allow the control of IFR RPAS for flight in the TMA, take-off and landing to allow enough flexibility for the IFR RPAS to safely operate in busy environments, even if some separation buffers above those applicable for manned aircraft are applied. The research must include the consideration of all the instructions that are usually issued by ATC in a busy airport (considering in particular take-off and landing clearances) and TMA environment (e.g. headings, speed control, approach take-off and landing clearances, stop-take-off instruction after take-off roll has been initiated, missed approach clearances, late go-around clearances, etc.).

C2 latency is always a key consideration for the integration of IFR RPAS in any airspace, because it has an impact on how quickly an ATC instruction can be implemented. In order to get low-latency control during take-off and landing, the traditional split operations concept requires the command and control for take-off and landing to be carried out by a local flight-crew using a line-of-sight C2 link. This system poses limitations to where the IFR can fly (a flight-crew and their supporting infrastructure must be line-of-sight from the departure and destination airports). The research could explore the possibility of establishing a C2 gateway at the airport to enable that the C2 communications be routed from a pilot located anywhere in the world via ground-ground communications into the airport RPAS C2 gateway, from which they would be routed through a line-of-sight radio link. This will enable the control of the aircraft from take-off at one airport to landing at another airport from a single ground control station, while enjoying line-of-sight C2 at both ends.

The research may also research the impact of RPAS using automatic take-off and/or landing systems, i.e. which added buffers may be needed for IFR RPAS that are untethered (no human-in-the-loop) during routine take-off and landing, but where a human may be available to intervene in non-nominal cases.

Research into DAA and RWC is out of the scope for this topic.

The output of this project must include the high-level operational requirements to support the operation of IFR RPAS in the (busy) TMA environment in integration with manned aircraft, and include performance quantification and a proposed technical architecture.

Consortia bidding for this topic must have both technical RPAS C2 expertise, operational RPAS expertise and air traffic control expertise. The research may include mock-up simulations/demonstrations involving controllers and remote pilots.

Expected impact:

It is expected that the research in this topic paves the way for the integration of IFR RPAS with manned aviation in the TMA and tower environment beyond what is currently being research in the industrial research programme.

Type of action:

Research and Innovation action.

3.6.2 SESAR-ER4-29-2019: Remain Well Clear for IFR RPAS Integration in Class D-G Airspace

SESAR industrial research is working on the accommodation and integration of IFR RPAS in airspaces A-C, where the separator is always ATC. This topic explores the integration in airspaces D-G, where for IFR aircraft the separator may not always be the controller.

Specific challenge

The aim is to provide the technical capabilities or procedural means to allow IFR RPAS to operate in airspace Class D to G where not all traffic may be known to ATC and/or where VFR traffic operates with less predictability (i.e. even if they are known their intentions may be unknown).

Scope

For an IFR RPAS to be able to safely operate in airspace classes D-G, cooperative and non-cooperative Detect and Avoid (DAA) systems are required for avoidance of other traffic, but there is no need to consider obstacles or weather, as these are covered by normal IFR provisions. The research must be focused on the development of the DAA functions that are required for IFR RPAS to be able to fly among manned VFR aircraft but are not required to fly among manned IFR aircraft.

Collision-avoidance work shall cover both cooperative and non-cooperative conflicts, including, where appropriate, interoperability with ACAS-Xu and TCAS. Research should consider the relay of resolution advisories to the remote-pilot station, as well as the possibility for the system to implement such advisories without reference to the remote-pilot station. In both cases, all aspects concerning system and link performance should be researched, as well as the technical and human implications of greater degrees of automation.

The capability that needs to be developed is the Remain Well Clear (RWC) function for IFR RPAS. RWC aims at allowing IFR RPAS to execute RWC manoeuvres to maintain separation against cooperative and potentially non-cooperative traffic. It must be noted that this RWC function is neither a safety net aimed at last-minute collision avoidance nor a mere display of the surrounding traffic for situational awareness, but an operational concept to allow IFR RPAS to self-separate from other aircraft just like VFR pilots separate from other aircraft based on their out-the-window view.

EUROCAE has published an operational concept [83] for how the RWC function for IFR RPAS will use these capabilities in airspaces D-G. Proposals must describe how their project will undertake the initial validation and refinement of the concept in EUROCAE document. The role of autonomous decision-making and the system performance requirements, including end-to-end requirements for the link (RLP), must be considered.

Please note that the RWC function addressed in this topic is not aimed at allowing the pilot to discharge the responsibility for the safety of its own aircraft described in ICAO Annex II [84], which refers to collision avoidance only and display of surrounding traffic information (also referred to as RWC, but not allowing the remote pilot to manoeuvre unless it is for collision avoidance purposes). The ICAO Annex II responsibilities for IFR aircraft are fully discharged with the collision avoidance solution is expected to be developed in IR Wave 2 [14] (candidate solution 111) being developed, which are being researched in the SESAR Industrial Research programme.

The research must consider how the European concept will be impacted by the existing difference between Europe and the USA concerning the responsibility of IFR pilots when operating with unknown VFR aircraft in class E. Both rotary-wing and fixed-wing RPAS must be considered.

The research may consider the definition of a new framework with different airspace classes for which there are different non-cooperative detection requirements, e.g. depending on the requirements for equipage for manned aviation or for non-IFR drones. Special considerations may be needed to accommodate drones that may transition from IFR flight rules to non-IFR rules to fly using U-space services or vice versa.

Development of non-cooperative detection is out of the scope of this solution (it is in the scope of topic 24, CNS)

The relevance of previous research undertaken in SESAR in the area of ASAS and CAVS will be considered.

The research will need to develop minimum performance requirements for non-cooperative detection, and may need to develop enablers that meet those requirements.

The project must consider the following references: EUROCAE WG-105 documentation, EUROCAE WG-75 documentation, documentation from EDA projects MIDCAS [85], DASA [86] and RPS [87], JARUS documentation and ICAO RPAS Panel. The output of this project should propose a refinement of the WG-105 DAA for airspaces D-G CONOPS (EUROCAE ED-258).

The project is expected to reserve effort to participate to standardization and ICAO working groups as part of their communication and dissemination activities.

Expected impact:

The integration of RPAS in all classes of airspaces is part of the European ATM Master Plan, and contributes to the access and equity key performance area, which aims at ensuring that all airspace users have equal access to the airspace.

Type of action:

Research and innovation action.

3.6.3 SESAR-ER4-30-2019: RPAS for Manned Flight Contingency Management

Increased automation will make it possible for airliners and large cargo aircraft of the future to fly with a single pilot on-board. The reduced crew operations concept requires that the aircraft can be safely brought down to a safe landing in the event that the single pilot be incapacitated during the flight.

Specific challenge:

Research in this topic will develop the procedures for the management of the contingency of an aircraft flown by a single pilot needing ground control support. The concept will contribute to the safety of the operations currently conducted with two crew members that are expected to be conducted by one crew member only, and also enhanced the safety of those flight operations that are today conducted by a single crew member.

Scope:

It is anticipated that the reduced crew operations contingency management concept will require the ATM system accommodation of flights transitioning from a routine manned flight to a flight with limited on-board human action and the management of the flight thereafter. The research must address the management of the transition from manned flight to a (completely or partially) remotely piloted flight from the air traffic management perspective, and the management of the flight until it lands safely in a dedicated aerodrome as soon as possible, rather than on mission completion.

The research should consider how concepts, procedures and technologies from development in RPAS integration could support this activity. Different levels of airborne support function (human monitoring, alerting, crosscheck/confirmation management, auto-emergency aircraft control) may be considered.

Consortia submitting proposals(s) for this topic must have human factors in the cockpit expertise and air traffic control human factors expertise. The research may include mock-up real-time simulations involving pilots, remote pilots and controllers. The research must focus on the ATM aspects only and in the manned to ground-managed contingency management only; research into the wider reduced crew operations concepts is explicitly excluded (note that this is considered in all projects researching the future ATM system).

Expected impact:

The reduced crew operations contingency management enhances the safety of flight operations with a single pilot.

Type of action:

Research and innovation

3.7 Sub Work Area 2.7: U-space

The activities to be performed under the sub work area 'U-space' need to take into consideration the outcomes of the on-going ER projects and lessons learnt from U-space demonstrations, which address U1 and U2 services. Automation principles originally developed for UAS traffic management in U-space may be a source of inspiration for application in Air Traffic Control. The concept elements that may be addressed include U3 services, U4 services, the interoperability of U-space service providers and U-space interface with ATM and manned aviation.

3.7.1 SESAR-ER4-31-2019: U-space

Specific challenge:

It is expected that the introduction of new delivery technologies such as drones, and mobility as a service will alter mobility which will result in large improvements in the quality of urban living [12]. These unmanned aerial systems (UAS) require new kind of services. U-space services provide services to UAS flying without services from ATM, but may take place in airspace shared with manned aviation, some of which may be receiving ATC services. This exploratory research challenge refers to the development of new U-space services (especially in the more advanced U3 and U4 service levels) [88], as well as to the linked regulatory challenges.

Scope:

Proposals must include research activities leading to further development of the U-space concept. The following non-exhaustive research areas of interest have been identified by the SJU:

Application area 1: use of U-space services by general aviation
The objective is to research if U-space services that are being developed for drones may also be useful for manned aviation, including general aviation. This could include access to local weather information,

dynamic obstacle data bases, information on planned or active drone activity, geo-fenced volumes or additional services provided to the drone community via a ground-based data communications network.

Application area 2: Common altitude reference
UAS must be able to keep clear of each other, and of manned aircraft using the same airspace. To ensure vertical separation from these aircraft, it is essential that they use the same altitude reference. They must also be able to keep clear of objects on the ground - buildings, cranes, trees, etc. - and of course people and property in general. Their pilots (or their on-board flight controllers) need, therefore, to be able to understand their height above the ground in an unambiguous way, to be able to relate this to databases of objects and terrain, and to the declared altitude of other aircraft.

EUROCONTROL and EASA have published a discussion paper [89] and describes potential solutions, while identifying areas for additional research. Work under this topic should examine the EUROCONTROL/EASA discussion paper and augment its analysis in the light of additional investigation. It should also present final conclusions that propose a justified and tested solution to the common altitude reference issue.

Application area 3: Urban airspace rules
The largest concentration of drones is expected over large populated areas. This has led to the proposal that airspace above urban areas (e.g. up to 1000 ft. above) be declared drone-only airspace, where rules of the air do not apply (because there are no manned flights). Manned flights would still be possible (e.g. security forces, emergency services), but they would need special authorization, and proposals should be described about how this could safely be done without adversely affecting priority manned aviation. There are important challenges associated to this concept, both from the operational point of view and from the societal point of view (noise impact, acceptable accident rate). Research should also cover urban-specific issues such as, *inter alia*, C2 performance in a heavily built-up area, GNSS performance and the potential impact of micro-climates. Finally, models for the design and management of drone trajectories – fixed or otherwise – should be proposed and analysed to support potentially large numbers of simultaneous drone operations. Bids should review the existing literature and describe how their proposed work would address the existing challenges.

Application area 4: flight-planning and demand and capacity balancing for drones
As demand for drones over populated areas explodes, there will be a need for limiting the density of flights. Research should explore the initial U-space DCB concept, which may require drones to flight-plan and get approval before departure.

Application area 5: U-space separation management service
With increasing numbers of drones in flight, there may be a need to ensure that they remain separated from each other and from manned aviation. Note that this is distinct from the requirement to avoid collisions; this topic considers a formal process whereby drones are separated from other drones and manned aviation according to agreed concepts and minima, equating to the ICAO second layer of conflict management for manned aviation: separation provision. This research topic should consider under what circumstances separation provision will be necessary, and how it could be implemented. There is a need to establish who will be the separator (the drone itself or the U-space service), what the separation minima will be, and what the separation management processes will be. There is also a need to define when separation will be procedural (e.g. two drones on different routes can be deemed separated without needing to check their positions in real time), and when tactical separation will be applied (in which case the surveillance tracks must be separated beyond defined separation minima). For tactical separation, it is necessary to establish who will take the role of the separator (the

U-space service or the drone), and what are the performance requirements needed by communications, navigation and surveillance systems to support the provision of tactical separation. For procedural separation, navigation performance requirements will need to be developed. The research should also consider how such separation services should behave when airspace is shared with manned aviation, with and without ATC. Finally, it should consider how separation services relate to complementary collision-avoidance technologies and procedures.

Application area 6: Drone traffic management for airports
It is expected that large airports will operate fleets of drones in support of airport operations, e.g. for runway and lighting inspection. Research will develop an airport drone management concept that ensures that airport drones can perform their function without posing a risk to operations at the airport.

The research should assess the feasibility and potential benefits of large airports operating fleets of drones in support of airport operations (e.g. for transporting spare parts or high value cargo, for runway and lighting inspection, etc.)

In particular, the research must develop of how airport service drones could be managed, de-conflicted, in order to smoothly move around their allocated areas in a safe and efficient manner.

Please note that the development of geofencing aspects are out of the scope of this research topic (they are already covered by GEOSAFE [90]l). However, proposals in this area may develop geofencing requirements specific for airport service drones if they deem them necessary.

The U-space research areas described above do not constitute a prescriptive list; proposals addressing research outside of the research areas on the list are welcome, provided adequate justification and background are provided in the bid.

Projects working in this area must be willing to share information with one another and reserve effort for coordination with other projects in this area and with SJU activities that bring together all U-space research efforts (e.g. U-space demonstrations).

Expected impact:

Advanced U-space services will enable the safe and efficient operations of large numbers of drones without adversely affecting manned aviation.

Type of action:

Research and innovation action.

4 Acronyms and Terminology

Acronym	Long Name / **Definition**
4D	4 Dimensions
ACARE	Advisory Council for Aeronautics Research in Europe
ACAS	Airborne Collision Avoidance System
ACI	Airports Council International
ADS-B	Automatic Dependent Surveillance-Broadcast
AeroMacs	Aeronautical Mobile Airport Communications System
AFD	ATC Full Datalink
A/G	Air/Ground
AG	Attention Guidance
AI	Artificial Intelligence
AM	Amplitude Modulation
AMAN	Arrival Manager
AOC	Airline Operation Communication
AOP	Airport Operation Plan
A-PNT	Alternative Position, Navigation and Timing
ARES	Airspace Reservation/Restriction
ASAS	Airborne Separation Assistance System
ASMA	Arrival Sequencing and Metering Area
ASPA	Airborne Spacing
ASR	Automatic Speech Recognition
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management

ATN	Aeronautical Telecommunication Network
ATSAW	Airborne Traffic Situation Awareness
ATSU	Air Traffic Services Unit
AU	Airspace Users (Civil)
CASA	Computer Assisted Slot Allocation
CAVS	CDTI (Cockpit Display Of Traffic Information) Assisted Visual Separation
CDM	Collaborative Decision Making
CDTI	Cockpit Display Of Traffic Information
CNS	Communication, Navigation, Surveillance
CPDLC	Controller–Pilot Data Link Communications
CTOT	Calculated Take-Off Time
CWP	Controller Working Position
DAA	Detect and Avoid
DAC	Dynamic Airspace Configuration
DCB	Demand and Capacity Balancing
DMA	Dynamic Mobile Area
DMAN	Departure Manager
E-TMA	Extended-TMA
EASA	European Aviation Safety Agency
EDA	European Defence Agency
eFPL	Extended Flight Plan (FF-ICE / FIXM based FPL)
EOCVM	European Operational Concept Validation Methodology
EPAS	European Plan for Aviation Safety
EPP	Extended Projected Profile
ER	Exploratory Research
ETA	Estimated Time of Arrival
EU	European Union

EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FCI	Future Communication Infrastructure
FMP	Flow Management Position
FMS	Flight Management System
FOC	Flight Operations Centre
GA	General Aviation
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
H2020	Horizon 2020 Framework Programme
HALE	High Altitude Long Endurance
HMI	Human Machine Interface
HP	Human Performance
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICNS	Integrated CNS
IFR	Instrument Flight Rules
ILS	Instrumental Landing System
IoT	Internet of Things
IR	Industrial Research & Validation
KPA	Key Performance Area
LIDAR	Light Detection And Ranging
LTE	Long Term Evolution
MET	Meteorological / Meteorology
MRS	Minimum Radar Separation
MWS	Minimum Wake Separation
NM	Network Manager

NOP	Network Operation Plan
NSA	National Supervisory Authorities
NWP	Numerical Weather Prediction
OAT	Operational Air Traffic
PBN	Performance Based Navigation
PinS	Point in Space
PIREP	Pilot REPort
P-RNAV	Precision Area Navigation
PSR	Primary Surveillance Radar
PTR	Profile Tuning Restriction
R&I	Research & Innovation
R/T	Radio Telephony
RBT	Reference Business Trajectory
RECAT-EU	European Wake Vortex Re-CATegorisation
RIA	Research and Innovation Action
RLP	Required Link Performance
RNP	Required Navigation Performance
ROT	Runway Occupancy Time
RPAS	Remotely Piloted Aircraft System
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
RWC	Remain Well Clear
SBT/RBT	Shared Business Trajectory/Reference Business Trajectory
SES	Single European Sky
SESAR	Single European Sky ATM Research
SESAR 2020	The SESAR 2020 research and innovation programme, also referred to as the SESAR 2020 Programme or SESAR 2020 R&I programme. It is a coordinated set of activities described in this document and being undertaken by the awarded Beneficiaries and SESAR JU Members and is managed as a whole by the SESAR JU in accordance with

	the European ATM Master Plan, the EU Airspace Strategy and Single European Sky legislation.
SID	Standard Instrument Departure Route
SJU or SESAR JU	SESAR Joint Undertaking
SMS	Safety Management System
SPD	Single Programming Document
SRIA	ACARE's Strategic Research and Innovation Agenda
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
SVR	Slant Visual Range
SWA	Sub Work Area
SWIM	System Wide Information Management
TBS	Time Based Separation
TCAS	Traffic alert and Collision Avoidance System
TRL	Technology Readiness Level
TT	Target Time
TTOT	Target Take Off Time
UAS	Unmanned Aerial System
UFB	Unmanned Free Balloons
UPMS	User Profile Management Systems
VHF	Very High Frequency
VLD	Very Large-Scale Demonstration
WA	Work Area
WG	Working Group
WOC	Wing Operations Centre
XAI	Explainable Artificial Intelligence

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Appendix A Technology Readiness Level in SESAR 2020

The SESAR 2020 Programme covers the activities from Pre-TRL 1 research to system demonstrations of TRL 7. The level of achievement and consequent maturity at each level is described below:

Exploratory Research covers:

Pre-TRL1 Scientific Research: Fundamental exploratory research investigating relevant scientific subjects and conducting feasibility studies looking for potential application areas in ATM, concentrating both on out-reach to other disciplines as well as educating within.

TRL 1 Basic principles observed and reported: Exploring the transition from scientific research to applied research by bringing together a wide range of stakeholders to investigate the essential characteristics and behaviours of applications, systems and architectures. Descriptive tools are mathematical formulations or algorithms.

TRL 2 Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on very specific application area(s) to perform the analysis to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.

Industrial Research & Validation (outside the scope of this Call) covers:

TRL 3 Analytical and experimental critical function and/or characteristic proof-of-concept: Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies including verification of technical feasibility using early prototype implementations that are exercised with representative data.

TRL 4 Component/subsystem validation in laboratory environment: Standalone prototyping implementation and test with integration of technology elements and conducting experiments with full-scale problems or data sets.

TRL 5 System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems using partial integration with existing systems. While limited documentation is available, the Engineering feasibility is fully demonstrated in actual system application.

Very Large Scale Demonstration (outside the scope of this Call) covers:

TRL 7 System demonstration in an operational environment (ground, airborne or space): System demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test and with EASA proof of concept authorisation if necessary. Well integrated with collateral and ancillary systems, although limited documentation available.