SESAR JOINT UNDERTAKING

H2020-SESAR-2019-1 IR VLD WAVE 2 Call Technical Specifications

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Abstract

This document defines the Technical Specifications for the SESAR 2020 IR VLD Wave 2 Call (H2020-SESAR-2019-1 IR VLD WAVE 2).

The document is designed to offer to potential applicants a more detailed description of the Call specifications than can be found on the European Commission Research and Innovation Participant Portal. It contains detailed descriptions of all Topics to be awarded under the Call.

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Document history

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1 Introduction

1.1 Purpose of the document

This document constitutes the Technical Specifications for the IR VLD WAVE 2 restricted call (H2020-SESAR-2019-1 IR VLD WAVE 2).

It captures the set of requirements that the potential applicants shall comply with and to offer a more detailed technical description of the Call requirements, which complements the information that can be found in the SPD 2019-2021 and on the European Commission Research and Innovation Participant Portal. It contains comprehensive descriptions of all Topics to be awarded under the Call.

1.2 SESAR programme objectives and scope

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

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 members or other appropriate mechanisms following proposals to achieve specific programme objectives (in accordance with Regulation 1271/2013).

The Programme for SESAR 2020 is structured, as shown in figure 1, into three main research phases:

- Exploratory research: is focused on the investigation of relevant scientific subjects and on conducting initial definition and feasibility studies looking for potential application areas in ATM. It covers both fundamental scientific and application oriented research activities. The final goal is to transfer mature exploratory research results (typically at V1/TRL2 level) to the next phase, industrial research;
- Industrial research activities (executed within a Public-Private-Partnership (PPP) framework) encompasses the required validation and development activities to progressively mature SESAR solutions up to V3 / TRL6, providing the required evidence to support the decision for further industrialization and deployment.;
- Finally, demonstration activities at large scale (VLD) showcase the SESAR solutions (concepts and technologies) in representative environments, confirm the performance benefits and

identify the potential risks for the deployment of SESAR solutions delivered by the industrial research phase.

- In addition, and spanning these phases, there is a need for transversal activities working across the phases to ensure consistency, coherency and completeness and including aspects such as the ATM Design, performance framework and assessment and the maintenance of the European ATM Master Plan.

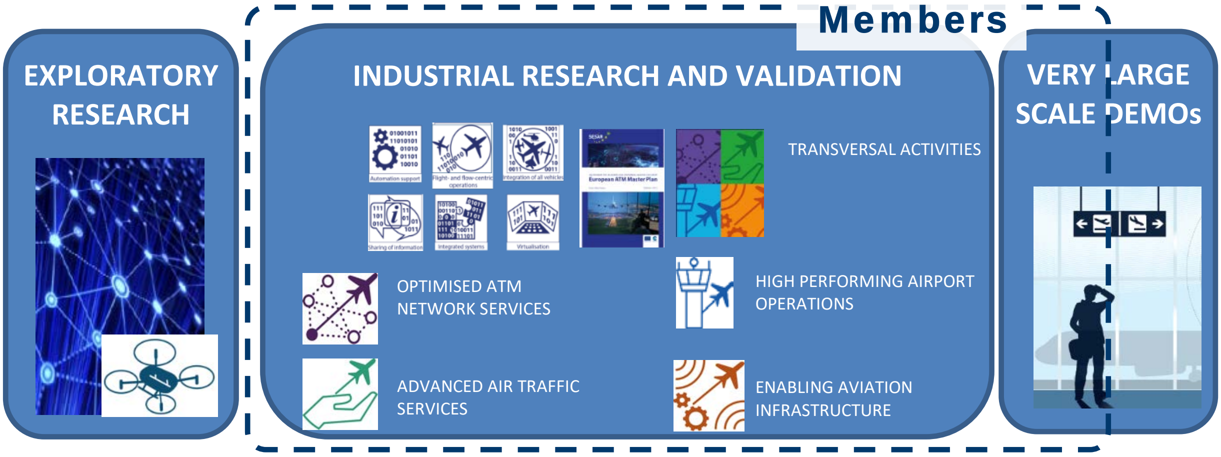

Figure 1 SESAR 2020 programme structure

This call covers Industrial Research activities and Very Large Scale Demonstrations activities.

<u>**SESAR Industrial Research and Validation (IR)**</u>

The industrial research activities in SESAR are designed to encourage the migration and development of ideas from Exploratory Research to higher levels of maturity, from concept definition, to operational and technical feasibility and finally to pre-industrial development. All the SESAR solutions follow a defined solution development lifecycle, which represents a sequence of major events enabling the research and development of proposed SESAR Solutions from their initial definition to their confirmed readiness (e.g. validated performance benefits) for further industrialisation and deployment.

Industrial research related activities are undertaken against a common structured framework to support the development of those SESAR solutions relevant for Air Transport evolution in an integrated manner, thus ensuring they are consistent, coherent and aligned with the ATM Master Plan vision and performance ambitions. This framework relies on a number of programme references such as the SESAR Concept of Operations or the SESAR Performance Framework, available in the programme library. Overarching and transversal activities are being conducted on a continuously iterative basis throughout the SESAR Programme Lifecycle and feedback from Deployment is desirable to help ensuring on-going robustness. The industrial research activities need to take also into consideration the ICAO Global Air Navigation Plan and relevant ICAO material, and relevant standardisation and regulatory activities, and for this reason, the SJU has established specific coordination links including the Members to these various organisations.

SESAR Very Large Scale Demonstrations (VLD)

Regulation 409/2013 calls for the maturity of ATM functionalities i.e. SESAR solutions to be demonstrated, inter alia, on the basis of the results of validation carried out by the SESAR Joint Undertaking, the status of standardisation and certification processes and an assessment of their interoperability.

The role of Very Large Scale Demonstrations (VLDs) is to bridge the research & innovation with deployment, and not to replace either type of activity. VLDs use early versions of end-user systems and include the integration of new technology elements into existing systems when needed and possible. The demonstration activities take also into consideration the ICAO Global Air Navigation Plan and relevant ICAO material. In particular, VLDs objectives are to:

- Generate further confidence to support buy-in from main stakeholders including regulators for future deployments;
- Significantly reduce the business risks for both operational stakeholders and industry, in particular for changes included in the Common Projects;
- Provide further inputs to related standardisation activities;
- Raise awareness regarding SESAR activities related to ATM performance issues and their results;
- Accompany SESAR pioneers all the way to pre-deployment;
- To assess full-scale deployment readiness.

Some of the proposed VLDs may require the contribution from Airspace Users (AUs) who are not members of the SESAR JU. Unlike in the Wave 1 IR VLD call it is expected that the SESAR JU members will subcontract the required AU contribution for the VLDs described in this section. (therefore the VLD open call is not intended to complement the VLDs in this Wave 2 IR VLD call).

1.3 Context

Maximising the potential of digitalisation is key to the future success of aviation throughout Europe and will be the overall theme of the next ATM Master Plan update campaign. The aviation industry is being transformed by digitalisation with increasing automation, and exchange of data amongst all parts of the Aviation value chain. But this is only the start and digitalisation will play an increasingly important role in the future safety and efficiency of the aviation industry. SESAR 2020 Wave 2 has to mark a first significant step for the key European aviation stakeholders who must work together to ensure that the digital transformation of aviation does not become fragmented and pursue game changing ideas to meet the objectives of the EU's Single European Sky and Aviation Strategy.

The SPD 2019-2021 contained the list of research areas that framed the content to be developed under the scope of this IR/VLD Wave 2 Call (H2020-SESAR-2019-1). The scope for the IR VLD WAVE 2 is described in sections 2, 3 and 4 of this document. The final call conditions are documented in the Single Programming Document 2019-2021.

The execution of IR VLD Wave 2 projects will take place during the period 2019- 2022. This second IR VLD call enables the flexibility needed to align future research with the results of Wave 1 and with the most promising results from Exploratory Research, re-assessing the priorities in line with the ATM Master Plan update in 2018 and ensures the best value-for-money for the EU and delivery against SES goals.

It consists of two Work Areas (WA) with a clear scope of activities structured at the level of Topics:

- WA 1: Industrial Research activities with 13 topics covering coordination and support actions (2 topics) and research and innovation actions (11 topics);
- WA 2: Very Large Scale Demonstrations (VLD) with 5 topics covering SESAR Solutions demonstrations.

1.4 Overall scope

The results from the IR/VLD Wave 2 will provide the basis to set up a changed ecosystem for aviation and more specifically modernising the underlying air traffic management infrastructure.

This ecosystem will be mainly build upon ATM solutions characterised by:

- Higher levels of autonomy and connectivity of all air vehicles coupled with a more automated management of the traffic;
- Digital and automated tools provided on board of the air vehicle itself or as part of the ground-based infrastructure;
- Virtual technologies to decouple the physical infrastructure such as sensors, communication or navigation devices from the services that are provided to manage the airspace;
- Big data analytics and open source data usage to encourage the creation of new services;
- System modularity to allow scalable and easier upgrades and greater interoperability.

1.4.1 WA 1: Industrial Research

This Work Area comprises both “Coordination and Support Actions” and “Research and Innovation Action”.

<u>Coordination and Support Actions (CSA):</u> will support the SJU to steer the work in the programme and to consolidate the results produced by SESAR Solution projects, with the aim to strengthen the top-down view and ensure coherence and consistency of the results.

The following two topics are proposed for “Coordination and Support Actions” (CSA):

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ20 W2 Master Planning”;
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ19 W2 Content Integration, Performance Management and Business Case Development”.

<u>Research and innovation Actions (RIA):</u> there are 11 topics that will validate, mature and deliver a number of SESAR solutions :

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ01 W2 Enhanced Arrival and Departures”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ02 W2 Airport airside and runway throughput”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ04 W2 Total airport management”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ05 W2 Digital technologies for Tower”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ07 W2 Optimised airspace users operations”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ09 W2 Digital Network Management Services”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ10 W2 Separation Management and Controller Tools”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ13 W2 IFR RPAS”
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ14 W2 Integrated CNSS”

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ17 W2 SWIM infrastructure"
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ18 W2 4D skyways"

The candidates solutions covered by these topics have been selected due to their high potential on:

- ATM digitalisation: in areas such as innovation advancing automation, connectivity, information sharing, virtualisation, integration of all vehicles, flight- and flow-centric operations, lean and modular systems, etc.;
- ATM performance improvement: in areas such as environmental sustainability, capacity, cost-efficiency, operational efficiency, safety and security.

1.4.2 WA 2: Very Large Scale Demonstrations

As Very Large Scale Demonstrations are designed to help bridging the gap between Industrial Research (development phase) and industrialisation / deployment. Therefore, they need to have clear links with the relevant delivered SESAR solutions (and the relevant data packs) that they intend to demonstrate. VLDs enable larger exercises to be conducted than those that are possible during IR validations, and multiple solutions can be demonstrated together. This tests solution scalability and increases buy-in from relevant stakeholders. Note that demonstration activities represent as well an opportunity to perform integrated validation for a number of SESAR solutions that have been validated individually until V3/TRL6 as part of Industrial Research.

An important aspect of the VLDs is the development of the local safety case in support of the introduction of the new concept in live operations, which may require regulatory approval. VLDs must follow the processes in the SESAR proof-of-concept document, and include in their demonstration report a description of any issues found along the way and how they were overcome.

This Work Area includes 5 topics that cover "Innovation Actions" (IA):

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD01 W2 GBAS/SBAS precision approaches including variable approach paths"
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD02 W2 Airport Surface Management, Airport Safety Nets and ATSAW"
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD03 W2 Improving runway throughput in one airport"
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD04 W2 Advanced Rotorcraft and Business Aviation (BA) Operations"
- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD05 W2 Virtual Centre"

2 Overall requirements

2.1 Selection of candidate SESAR solutions and justification principles

The proposed candidate SESAR solutions per topic have been classified in two different lists (list 1 and list 2) through the consultation process with the SJU members as described in the SPD 2018 in order to provide as much flexibility as possible considering the budget available for Wave 2.

The two lists of SESAR solutions per topic are shown below: List 1 solutions are highlighted in green while List 2 solutions are highlighted in blue.

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ01 W2 Enhanced Arrival and Departures"

List 1:

- **Solution PJ.01-W2-08 Dynamic E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations**

List 2:

- **Solution PJ.01-W2-01 Next generation AMAN for 4D environment**
- **Solution PJ.01-W2-06 Advanced rotorcraft operations in the TMA**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ02 W2 Airport airside and runway throughput"

List 1:

- **Solution PJ.02-W2-14 Evolution of separation minima for increased runway throughput**
- **Solution PJ.02-W2-21 Digital evolution of integrated surface management**

List 2:

- **Solution PJ.02-W2-04 Advanced geometric GNSS based procedures in the TMA**
- **Solution PJ.02-W2-17 Improved access to secondary airports**
- **Solution PJ.02-W2-25 Safety support tools for avoiding runway excursions**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ04 W2 Total airport management"

List 1:

- **Solution PJ.04-W2-28 Enhanced Collaborative Airport Performance Planning and Monitoring**
- **Solution PJ.04-W2-29 Digital Collaborative Airport Performance Management**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ05 W2 Digital technologies for Tower"

List 1:

- **Solution PJ.05-W2-35 Multiple Remote Tower and Remote Tower Centre**
- **Solution PJ.05-W2-97 HMI Interaction modes for Airport Tower**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ07 W2 Optimised airspace users operations"

List 1:

- **Solution PJ.07-W2-38 Enhanced integration of AU trajectory definition and network management processes**
- **Solution PJ.07-W2-40 Mission trajectories management with integrated Dynamic Mobile Areas Type 1 and Type 2**

List 2:

- **Solution PJ.07-W2-39 Collaborative framework managing delay constraints on arrivals**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ09 W2 Digital Network Management Services"

List 1:

- **Solution PJ.09-W2-44 Dynamic Airspace Configurations (DAC)**
- **Solution PJ.09-W2-45 Enhanced Network Traffic Prediction and shared complexity representation**
- **Solution PJ.09-W2-47 Network optimisation of multiple ATFCM time based measures**
- **Solution PJ.09-W2-49 Collaborative Network Performance Management**

List 2:

- **Solution PJ.09-W2-48 Digital Integrated Network Management and ATC Planning (INAP)**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ10 W2 Separation Management and Controller Tools"

List 1:

- **Solution PJ.10-W2-73 Flight-Centric ATC and Improved Distribution of Separation Responsibility in ATC**
- **Solution PJ.10-W2-93 Delegation of airspace amongst ATSUs**
- **Solution PJ.10-W2-96 HMI Interaction modes for ATC centre**

List 2:

- **Solution PJ.10-W2-70 Collaborative control and Multi sector planner (MSP) in en-route**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ13 W2 IFR RPAS"

List 1:

- **Solution PJ.13-W2-111 Collision avoidance for IFR RPAS**
- **Solution PJ.13-W2-115 IFR RPAS accommodation in Airspace Class A to C**
- **Solution PJ.13-W2-117 IFR RPAS integration in Airspace Class A to C**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ14 W2 Integrated CNSS"

List 1:

- **Solution PJ.14-W2-60 FCI Terrestrial Data Link and A-PNT enabler (L-DACS)**
- **Solution PJ.14-W2-61 Hyper Connected ATM**
- **Solution PJ.14-W2-76 Integrated CNS and Spectrum**
- **Solution PJ.14-W2-77 FCI Services**
- **Solution PJ.14-W2-79 Dual Frequency / Multi Constellation DFMC GNSS/SBAS and GBAS**
- **Solution PJ.14-W2-81 Long-term alternative Position, Navigation and Timing (A-PNT)**
- **Solution PJ.14-W2-107 Future Satellite Communications Data link**

List 2:

- **Solution PJ.14-W2-83 Surveillance Performance Monitoring**
- **Solution PJ.14-W2-84 New use and evolution of Cooperative and Non-Cooperative Surveillance**
- **Solution PJ.14-W2-110 Aircraft as an AIM/MET sensor and consumer**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ17 W2 SWIM infrastructure"

List 1:

- **Solution PJ.17-W2-100 SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing**

List 2:

- **Solution PJ.17-W2-101 SWIM TI Green profile for G/G Civil Military Information Sharing**

- H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ18 W2 4D skyways"

List 1:

- **Solution PJ.18-W2-53 Improved Ground Trajectory Predictions enabling future automation tools**
- **Solution PJ.18-W2-56 Improved vertical profiles through enhanced vertical clearances**
- **Solution PJ.18-W2-57 RBT revision supported by datalink and increased automation**

List 2:

- **Solution PJ.18-W2-88 Trajectory Prediction Service**

The proposals shall cover, per topic, a minimum "must have " number of SESAR solutions. Note that these solutions shall be selected, per topic, from those included in List 1, as per the table below:

Topic	"Must have" number of SESAR solutions to be selected from List 1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ01 W2 Enhanced Arrival and Departures"	1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ02 W2 Airport airside and runway throughput"	1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ04 W2 Total airport management"	1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ05 W2 Digital technologies for Tower"	1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ07 W2 Optimised airspace users operations"	1

H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ09 W2 Digital Network Management Services"	3
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ10 W2 Separation Management and Controller Tools"	3
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ13 W2 IFR RPAS"	2
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ14 W2 Integrated CNSS"	4
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ17 W2 SWIM infrastructure"	1
H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ18 W2 4D skyways"	2

Once the "must have" number of SESAR solutions have been selected, additional ones (either from List 1 or List 2) could be included in the proposals should efforts remain available.

In line with the ATM Master Plan 2015, the selection of the SESAR solutions covered by the proposal shall be justified according to the following set of principles:

- Demonstrating added value for the ATM network in particular about:
    - Defragmentation of service provision: promoting a common service architecture across the European ATM system;
    - Interoperability: enabling the seamless exchange of information between systems;
    - sharing of infrastructure: promoting the efficient and shared use of infrastructure such as CNS;
    - Scalability: delivering Solutions that enable the ATM System to be enlarged, to easily adapt operational capacity to meet demand.
- Demonstrating contribution to increasing network capacity and/or access to airports including regional/secondary airports;
- Demonstrating that the solution development will ensure a deployment oriented outcome.

The justifications provided for the selection in the proposals will be verified by the SJU and independent experts and will then be used during the evaluation under the 'Impact' award criteria, where the impact on performance is covered: "Degree to which the proposal demonstrates that the research will contribute to achieve the performance benefits outlined in the European ATM Master Plan.

2.2 CNSS requirements

A close collaborative approach between the development of the candidate SESAR solutions and PJ14 W2 Integrated CNSS shall be ensured and described in the proposals in order to:

- Identify Operational and Performance Requirements for Communication, Navigation, Surveillance and Spectrum;
- Ensure that the ATM Solutions plan and execute V&V activities with due consideration of CNSS Performance capabilities e.g. potential impact of challenging traffic forecast on CNSS capabilities;

Also and as detailed in section 3, VLDs may cover elements of CNSS solutions to complement the solutions development in order to achieve TRL-6. These CNSS solutions may or may not be addressed by the proposals for PJ.14 W2.

If the solution is also addressed by the proposal for PJ.14 W2, then the activities covered in the VLD on the same solution shall be complementary, avoiding any overlap. The proposal in the VLD shall provide evidence of this complementarity. The results of the work performed under the VLD project shall be documented in a DEMOR as a contribution to the solution datapack to be delivered under PJ.14-W2.

If the solution is only covered by the VLD, then the VDL project shall document the outcome of this work in a typical solution datapack in industrial research e.g. TS/IRS and CBA.

2.3 Cybersecurity

As the SESAR Target Concept is based on increased automation and system integration based inter alia on the use of COTS components and standard protocols, it is important to consider how potential cyber-threats could affect SESAR developments so that can be effectively mitigated.

In this context Cyber-Security will require adapted operational and technical improvements in the aim when implementing, to be ready to detect and analyse possible attacks as early as possible, and respond effectively to avoid their escalation. It is essential that the development of cyber-security is performed in parallel to the development of the technical enabler, and that cyber-resilience measures are considered in a systematic and joined-up manner.

2.4 Standardisation and regulation

Early engagement with the regulator during the solution development and validation process can significantly de-risk subsequent issues related to regulatory needs, approvals, safety assessments etc. for an ATM or technological solution. With this in mind EASA and/or NSA involvement through the partners shall be envisaged at the level of advising on the suitability of the safety assessments as well as risk and hazard identification and mitigation approaches required for the solution. The potential need for future rulemaking to support the eventual implementation of the solution shall be identified along with the need for standards development in support of any required means of compliance. The work of the project shall then be appropriately focused on delivering the material that could form the basis for this standardisation and regulatory development.

The execution of validation activities and the elaboration of solution datapacks e.g. SPR-INTEROP/OSED and TS/IRS (that represent an integral part of the solution projects work) constitute their key contribution to the development of the relevant standardisation needs. Projects shall propose where standardisation is expected, and target the necessary activity and specific deliverables that will contribute to achieving a coherent link between the SESAR projects and the related standardisation development work/activities.

2.5 Programme Execution Framework

The projects shall operate under the principles as outlined in the SESAR 2020 Project Handbook. The "SESAR 2020 project handbook" provides guidance explaining how SESAR 2020 projects shall be executed within the framework of the SESAR 2020 Research and Innovation (R&I) programme.

The main objective of the handbook is to provide a single entry point into the SESAR 2020 development framework for any SESAR 2020 project (selected as part of the IR/VLD wave 2 call for tender). In doing so the handbook aims to give an overview of what is expected from the project manager/solution leader and his/her team when defining, validating and reporting upon the development of SESAR Solutions in the context of SESAR 2020. The aim is to ensure an agreed and common approach across all projects to deliver the vision of ATM MP, allowing a uniform way of monitoring project execution as part of the overall programme, as well as supporting programme-level decision making.

In addition to the process described in the "SESAR 2020 project handbook", the following elements shall be considered :

- Technical baseline documentation

  Proposals shall identify the reference documentation that will be used as the baseline for the research and development activities in wave 2.

- Initial and target maturity levels

  Section 3 provides, per SESAR solution, the expected target maturity level at the end of Wave 2 that are captured in the Extended Release Strategy. The proposals shall define the required activities e.g. validation exercises to achieve this target maturity level. The proposals may deviate with respect to the proposed target, but shall clearly justify the reasons for this deviation with respect to the proposed target.

  Similarly, section 3 also proposes an indication of the initial maturity level expected at the start of Wave 2 activities. For those SESAR solutions that continue from Wave 1, this initial maturity level is based on the assumed progress of relevant projects at the end of Wave 1 that may not be finally confirmed. Proposals shall clearly state the initial maturity status and explain why the initial maturity is different from section 3.

- Deliverables confidentiality classification

  For the RIA actions in Working Area 1, all solution datapacks (and the deliverables contained within) and the VALR shall be identified as "public" in the proposals.

  For the IA actions in Working Area 2, the demonstration report shall be identified as "public" in the proposals.

Any deviation from this principle e.g. deliverables defined as “confidential” shall be duly justified, and the proposal shall provide alternative means to ensure the required dissemination of the relevant results obtained under the execution of the action.

- Airspace Users contribution

  Some of the proposed topics may require the contribution from Airspace Users (AUs) who are not members of the SESAR JU. It is therefore expected that the SESAR JU members will subcontract the required AU contribution for these topics.

  Note that this is of special interest for the VLDs, given that, unlike in Wave 1, the VLD2 open call is not intended to complement the VLDs in this Wave 2 IR VLD call.

3 Requirements Work Area 1: Industrial Research

This section provides long descriptions of the topics and relevant candidate SESAR solutions to be addressed under Industrial Research.

3.1 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ01 W2 Enhanced Arrival and Departures”

3.1.1 Problem statement and R&D needs

With the extension of Arrival Management (AMAN) systems horizons, En-Route sectors are affected by concurrent arrival management strategies due to the overlapping AMAN horizons of several independent Terminal Manoeuvre Areas (TMAs). The interaction between traffic synchronisation and demand-capacity balancing (DCB) within the extended horizon needs to be addressed, and potential information integration needs and balancing mechanisms need to be investigated and developed to ensure delivering the optimal capacity. Complex interacting traffic flows in the TMA (including from/to multiple airports) need to be more actively managed to increase safety and improve fuel efficiency whilst capacity is increased. Continuous climb and continuous descent operations (CCO/CDO) at near idle thrust are environmentally friendly, because they are more fuel efficient and also minimize the time that aircraft have to be at low altitude, thereby reducing their noise impact. However, controllers often need to use intermediate level-offs in order to ensure separation. Use of stepped climbs and descents should be reduced at the same time as optimising flights laterally and with appropriate speed management, and optimising the overall Air Traffic Control (ATC) task. Multiple arrival management systems need to ensure a more regular flow of arriving aircraft managed for TMA optimisation as well as runway optimisation. Multiple departure management systems are required to enable a more consistent delivery of departures into the TMA and ultimately to En-Route sectors. Improved flows will help to facilitate optimised profiles for aircraft, with dynamic route structures able to provide additional solutions integrated with the management of queues. IFR Rotorcraft operations are constrained to use same approach/departure procedures as fixed wing aircraft and due to their lower speed profiles, runway throughput is very often negatively impacted at busy airports. Specific rotorcraft procedures need to be defined in particular in adverse weather conditions to assist rotorcraft pilots by extending landing to degraded visual conditions.

3.1.2 Performance expectations

The solutions to be addressed under this topic are expected to have a positive impact on the Network improving:

- Airspace capacity (improved throughput / airspace volume & time) and airport capacity (improved runway throughput flights/hour) thanks to the synchronisation of the arrival and departure sequences to and from airports using extended AMAN overlapping operations;
- Environmental sustainability and fuel Efficiency thanks to the implementation of continuous descent and climb profiles;
- Predictability with the increased accuracy of the AMAN data;
- Cost-efficiency (reduced direct ANS cost per flight);
- Safety, in particular, assisting rotorcraft pilot for landing in bad weather conditions.

3.1.3 List 1 SESAR Solutions

The proposals shall address, as a minimum, the solution:

3.1.3.1 Solution PJ.01-W2-08 Dynamic E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations

Continuous Climb and Continuous Descent Operations (CCO/CDO) at near idle thrust are environmentally friendly, because they are more fuel efficient and also minimize the time that aircraft have to be at low altitude, thereby reducing their noise impact. However, controllers often need to use intermediate level-offs in order to ensure separation. The objective of this solution is to improve descent and climb profiles in busy airspace (as close as possible to near idle CDOs and CCOs), as well as the horizontal flight efficiency of arrivals and departures, while at the same time ensuring traffic synchronization (for optimum use of runway capacity), short-term DCB (to ensure best use of ATC capacity) and separation. This challenging objective requires a very broad scope, which includes advances in airspace design, development of ground and airborne tools, and development of ATC and airborne procedures.

The research on the dynamic allocation of routes builds on previous research on static PBN structures for arrivals and departures (trombones, point merge, structures for TMAs with parallel runways developed by solution #01-03A in wave 1), the work in solution #01-03B, as well as on the work on traffic synchronization performed in Wave 1 by solution #01-02. The objective is to dynamically allocate arrival and departure routes to aircraft in order to support traffic synchronization and short-term DCB. The dynamically allocated routes could be either pre-defined SIDs or STARs or, in a more advanced concept, be flight-specific arrival or departure routes (a 2D route created by the controller specifically for one flight, which could have altitude constraints along the way). The dynamically allocated routes will support the transition from FRA into the TMA where FRA is in operation.

The advanced traffic synchronization and short-term DCB concepts required for the dynamic allocation of routes have been researched in Wave 1 by solution #01-02. This Wave 2 solution will continue solutions #01-02 and #02-08work on the integration of arrival and departure management. Based on the predicted demand information provided by local AMAN and DMAN systems, the tools will identify sector/route over-demand or additional available capacity, and will resolve complex interacting traffic flows in order to balance sector/flow load (DCB aspect) and ensure optimum use of runway capacity (traffic synchronization aspect). The output of the tool will include the dynamically allocated 2D routes to arriving or departing aircraft, and potentially also additional constrains, e.g. allocated sector entry times or waypoint overflight times (presented to the ATCO as TTs, TTL/TTG, AMAN planned times, speed advisories, CTA or ground delay), proposed ROC/ROD constraints, vertical constraints along the 2D route, etc. The research may include the consideration of the potential benefits of up-linking a CTA when the AMAN planned time is later than the RTA max time. The solution may also address dynamic sectorization in the TMA or E-TMA in order to balance demand and capacity. The solution targets in particular high density/high capacity operational environments.

Where speed constraints are used along the dynamically allocated routes, the research must consider their impact on airborne speed management procedures (e.g. flap management, air-break management, gear-down procedures), and their impact on fuel burn. The research must also consider the trade-off between longer flight paths that are conflict free and therefore allow continuous climb/descent and shorter horizontal paths that are more likely to require level-offs. The research must consider the impact of the new concepts on the relevant SES PS (Single European Sky Performance Scheme) indicators, e.g. additional time indicators. In addition, the impact of the new concepts on flight efficiency for arrivals in terms of both fuel burn and temporal efficiency needs to be assessed by this project from before the aircraft is first intervened on for arrival management purposes (e.g. before speed control or re-route is applied for AMAN purposes), in order to provide a more holistic view.

The advanced traffic synchronization tools shall consider departure synchronization from multiple nearby airports. This may require the synchronization of TTOTs between different airports in order to regulate in real time the flow of aircraft through a waypoint located a few minutes after take-off, as well as the synchronization of AMAN planned times and TTOTs when arrival and departure routes must cross at similar altitudes. The concept should aim at regulating departures' TTOTs as far in advance as possible, in order to allow as much delay as possible to be absorbed at the gate. However, the use of short ground holdings (in the runway holding point) will probably also need to be considered in order to improve adherence to the TTOT when deemed necessary for synchronization purposes. It is essential that the research makes realistic assumptions on the expected TTOT accuracy, based on the characterisation of the current inefficiency and the target performance level.

The research must address the cross-border case, where the airports whose traffic is being synchronized are near the boundary between ATSUs, or coordination and synchronization is required between two airports located at two TMAs served by different ANSPs.

The solution will also investigate in close coordination with solution 57 the uplink from the ground to the aircraft of the dynamically allocated arrival and departure routes and their associated constraints (e.g. arrival management constraints), as well as the airborne functions related to the implementation of the uplinked route by the aircraft, including the consideration of auto-loading/integration of the routes and their associated constraints into the FMS for them to be flown as much as possible in managed mode.

The uplink of a dynamically allocated arrival route does not necessarily require that a descent clearance is issued at the same time, just as in current operations a clearance to a STAR only implies clearance to follow the STAR 2D route. However, it is acknowledged that clearance to the arrival route and profile ('descend via') would be preferable for descent optimization purposed. The research must study the issues identified during the SESAR 1 project "Optimised Descent Profiles (ODP)" descend via trials and investigate potential ways forward for making 'descend via' procedures possible in European airspace.

The purpose of the synchronization processes that result in the dynamically allocated routes and their associated constraints by managing the traffic flow is to avoid over-demand to any sector (DCB function) and ensure optimum use of runway capacity (traffic synchronization function), rather than ensure separation. However, the dynamically allocated routes may also impose some strategic de-confliction of traffic, in order to reduce the number of separation conflicts that need to be managed tactically. Where necessary, separation will be ensured tactically through the use of ad-hoc ATC clearances. Strategically imposed constraints that penalize the aircraft (increasing fuel consumption) should be removed tactically whenever it becomes clear that they are not required to ensure separation. The solution may also investigate the tactical separation provision processes in order to develop ground tools and ATC procedures that support ATCOs in using clearances that have as little impact as possible on fuel burn (e.g. tools that show ATCOs where to level-off an arrival and a departure in order to minimize the fuel impact of the level-offs, tools that show an ATCO which of two alternatives for solving a conflict is best from a fuel-burn perspective, etc.).

It is acknowledged that some vectoring will remain necessary for efficiency and flexibility sake, and the solution must address how to mitigate the impact of the uncertainty in the trajectory introduced by vectoring in the descent profiles. For example, the solution may research a concept where aircraft are vectored but know their planned landing time and planned speed profile, and can enter this information in the FMS for planning their descent (this is an extension of the miles-to-go information provided at some airports to support airborne descent planning, which pilots use to calculate an approximate ROD). The solution may also develop an FMS 'automated resume' capability to support a smooth transition from selected/manual mode during vectoring back to managed/automatic mode when the aircraft is cleared to join a standard or flight-specific 2D route.

In addition to the dynamic allocation of routes and constraints, the solution shall also consider additional elements that may support improved descent profiles based on ground-to-air sharing of relevant information. This aspect builds on the research carried out in Wave 1 by #01-03b. This may include, for example:

- Air-to-ground sharing of AMAN planned times (e.g. so that aircraft can adjust their descent speed and profile in order to stay higher and/or save fuel by slowing down when the AMAN has planned delay for them, or simply can plan their descent – connected to the extension of the miles-to-go concept mentioned above, which may also be useful for aircraft that are not being vectored);

- Ground-to-air sharing of information that may support improved descent profiles (e.g. removing a vertical or speed constraint along an arrival or departure route). This concept is complementary to the dynamic allocation of routes, e.g. initially a STAR with a vertical or speed constraint is allocated and uplinked, and later if the constraint is not needed for ensuring separation the constraint is removed;

- Further to the above bullet, investigation of ways to allow that the descent can be as optimized as much as possible when some descent planning information can be made available to flight crews with little anticipation, e.g. at cruising altitude, but less than ten minutes before TOD, or even after the descent has been initiated (note that previous SESAR research activities - project 5.06.01 in SESAR 1 and solutions #01-03b and #18-02a activities - suggest that in current operations descent planning information must be available to flight crews ten minutes before descent in order to allow enough time for the information to be used for descent optimization purposes). This may need to develop and validate new FMS functions and flight crew procedures.

- Investigation of ATC speed management strategies to realise reduced overall fuel consumption during the descent, e.g. by imposing a standard descent speed to all traffic whenever traffic density is high enough to require frequent ATC intervention.

In addition to the environmental benefits, it is expected that the concepts researched by this solution will result in improved synchronization of the air and ground trajectories (thanks to the increased use of managed mode, resulting in improved relevance of the EPP downlink).

CPDLC has been validated for use only in en-route (the data link mandate is restricted to airspace above FL285). It is expected that this solution will research the use of CPDLC below FL 285, building on the activities of the SESAR 1 demonstration ATC Full Datalink (AFD) and the result of SESAR 1 exercise VP-805[1], which explored the potential use of datalink. It is expected that this will require considerable research in the airborne domain, both in terms of procedures and in terms of development of improved on board HMI and auto-load capabilities. This builds on the research on CPDLC performed by Link2000+) and PJ.18-02a, and should take into account the feedback from the ongoing implementation.

As the advanced use of datalink and the extension of datalink below FL285 will open new communication possibilities, it is expected that the use of datalink between controllers and pilots will increase and the use of voice decrease. For this reason, the development of the concept of operations for the advanced use of datalink is inextricably linked to the overall evolution of the controller-pilot communication and the evolution of the voice concept of operations. The following open questions on the future of controller-pilot voice communications have been identified:

- Would the future voice communications need to be point-to-point or multi-point (with a channel with party-line like current VHF frequencies)?
- Would a hybrid system be useful, i.e. point-to-point with no party-line but with a free/occupied indicator to prevent simultaneous incoming transmissions for the same ATCO?
- What would be the acceptable latency?
- Which would be the encryption and security needs?
- What are the wide-area communications needs?
- Which are the future automation needs connected to voice communications (e.g. remotely tune the system on another channel, handover, priority call…) and which operational requirements would be required to support them?

The future of controller-pilot communications requires a new concept of operations that includes voice and datalink. It is expected that this new “Controller-pilot communications CONOPS” will be developed by a separate SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The research in this solution has been identified as highly relevant for this CONOPS; consequently, this solution should plan effort to support the development of the “Controller-pilot Communications CONOPS”, e.g. by participating in the CONOPS development expert groups.

The solution may consider the use of supervised learning and/or machine learning in order to derive the rules for the dynamic allocation of routes. The solution must consider the potential benefits of using big data and machine learning techniques for the comparison of data from real operations

[1] VP-805 was run by SESAR 1 project 05-03 and its main focus the integration of CTA and ASPA, but also included several validation objectives related to CPDLC.

against the dynamically allocated routes, with the objective of continuously monitoring the degree of implementation of the dynamic routes, and the use of this information for the improvement of the set of rules used for the allocation of routes.

This solution incorporates elements whose initial maturity levels range from V1 to V2. As it is not possible to capture this range in one unique solution datapack, the proposed approach is to structure the delivery into two datapacks: one (“Digital synchronization of arrivals and departures”) shall cover the V3 delivery of those features that are mature enough for transitioning to industrialization at the end of Wave 2 (i.e. TS-0302, TS-0307) while the other (“Dynamic E-TMA for Advanced Continuous Climb and Descent Operations”) will capture other aspects that may only reach V2 at the end of the project’s activities (i.e. AOM-0702-B, AOM-0705-B, AOM-0806).

Digital synchronization of arrivals and departures	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent Operations	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

This solution is closely linked to solution 57, “RBT revision supported by datalink and increased automation”, solution 56 ‘Improved vertical profiles through enhanced vertical clearances’, as well as to solution 53, ‘Improved ground trajectory prediction enabling future automation tools’ and solution 1 “Next-generation AMAN for 4D environment”. The solution shall also coordinate with solutions 60 “and A-PNT enabler” and 77 “FCI services” and 107 “Future Satellite Communications Data link”.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solutions #01-02 and #01-03B in Wave 1 and covers the following OI steps:

- *AOM-0702-B — Advanced Continuous Descent Operations.*
- *AOM-0705-B — Advanced Continuous Climb Operations.*
- *AOM-0806 — Dynamic Management of Terminal Airspace Routes and Transition.*
- *TS-0302 - Departure Management from Multiple Airports.*
- *TS-0307 - Integrated Arrival Departure Management for traffic optimisation within the TMA and Extended TMA Airspace.*

These OI steps may need to be updated (or new ones may need to be added) in future datasets to cover the enlarged scope with regards to Wave 1 e.g. in order to cover digital components, ‘descend via’, tools to support reduced impact on fuel of separation aspects, air-to-ground sharing of descent planning information. In addition, the descriptions of the OIs listed above need to be cleaned to remove references to ‘implementation’ or to ‘airborne side mitigations’.

3.1.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.1.4.1 Solution PJ.01-W2-01 Next generation AMAN for 4D environment

This solution represents a significant step forward regarding AMAN and will provide enhancements to the arrival management systems and procedures in the context of digitalization in ATM. The following aspects are addressed:

- Uplink of AMAN constraints from the ground to the aircraft (e.g. speed constraints), potentially automatic (no ATCO validation), covering also the cross-border case;
- Uplink of a STAR or custom arrival route to the aircraft via ATN B2 from the ATSU currently controlling the aircraft, whether the arrival airport is at the same ATSU or in a different ATSU. There may be cases when the uplink has to be done from the HMI of the controller currently controlling the aircraft, whereas in other cases it may be possible that the uplink is done directly from the ground system to the aircraft without ATCO intervention, e.g. for routine STAR confirmation (including information of runway to expect) or even in case of an alternative STAR to what would be the default being allocated for early balancing of arrival traffic between different entry points, but when the uplink can take place sufficiently in advance. This aspect is also in scope of solution 8 "Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations" (there is an overlap); the objective is that solution 1 would cover the simpler use cases (uplink of STARs for one airport with one AMAN – no consideration of multiple arrival or departure flows-, or even uplink of a STAR where there is no AMAN or the existing AMAN is not being used for sequencing due to low traffic demand). The cross-border case (ground-ground coordination via SWIM) should at a minimum be considered for the uplink of routine STAR/expected runway information;
- Potential use of maximum descent speeds in order to promote overall fuel savings and provide a more homogeneous presentation of traffic to the TMA, and potentially resulting in more meaningful EPPs;
- Investigation of strategies to increase the use of managed/automatic mode for flights handled by TTL/TTG during sequencing, which need to be flown by the flight crew with the FMS in non-managed mode e.g. speed constraints, path stretching, etc. Potential mitigations include the improvement of flight management means to better apply ATC orders (link to candidate solution 57 "RBT revision uplink supported by data link and increased automation"). The increased of managed mode will allow to increase flight optimization opportunities and the relevance of downlinked data e.g. EPP;
- Improved consideration of downlinked aircraft data by AMAN algorithms, for example through the ADS-C RTA min-max for the speed range, or consideration of AUs preferences and priorities (as reflected by the EPP ETA for the preferred arrival time of an aircraft);
- Use of automatic descend when ready clearances (researched by solution #18-02a during Wave 1) and their impact on sequencing processes;
- Use of machine learning for the refinement of AMAN algorithms: use of artificial intelligence to monitor the difference between the AMAN-calculated sequence and its actual implementation and use machine learning techniques to improve the sequencing algorithms;

- Increase of automation in handling in-horizon departures via TTOT (which allow in-horizon departures to absorb delay on the ground);

- Management by en-route controllers of sequencing for multiple airports with overlapping AMAN horizons, e.g. improved HMI, including prioritization of AMAN constraints that the controller should apply in case workload is high, etc.;

This solution must assume ATN B2 equipage and is expected to contribute to the identification of future datalink requirements by identifying in their research cases where ATN B2's is not enough.

Note that the OI step DCB-0213 (Consolidation and facilitation of Target Times between local DCB, Airport CDM and Extended Arrival Management) is not covered by this solution (it is covered by solution 39 "Collaborative framework managing delay constraints on arrivals"). This must be recognised as a dependency between the two solutions that shall need to coordinate to ensure consistency. The solution is also linked to candidate solution #08 "dynamic E-TMA for Advanced Continuous Climb and Descent Operations", solution #57 'RBT revision uplink supported by increased automation' and solution #53 "Improved CD&R tools en-route and TMA".

This solution continues the work performed in wave 1 under solution #01-01. Because new elements have been integrated, the initial maturity at the start of wave 2 will be V2 on-going, so there is a need to perform additional feasibility analysis on part of the new features. The target maturity level is maintained as V3, to allow the solution to deliver those features that at that stage are considered as mature enough for transitioning towards industrialization. The solution should plan the delivery of V2 data packs (or even V1 if justified) to document those elements that are not V3 at the end of Wave 2.

Next generation AMAN for 4D environment	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #01-01 in Wave 1 and covers the following OI steps:

- *TS-0109 — Controlled Time of Arrival (CTA) in high density/complexity environment.*
- *TS-0305-B — Arrival Management Extended to En-Route Airspace - overlapping AMAN operations.*
- *TS-0315 — Arrival Management Systems integrated with DCB.*

These OI steps may need to be updated in future datasets (or added new ones) to cover the enlarged scope with regards to Wave 1 in terms of: digital components and the link to TBO.

3.1.4.2 Solution PJ.01-W2-06 Advanced rotorcraft operations in the TMA

The SESAR solution "advanced rotorcraft operations in the TMA" aims at the improvement of the integration of rotorcraft operations within TMAs. The solution may address the development of a number of advanced procedures and technologies for rotorcraft, beyond those already researched in SESAR 1 (solution #113) and in Wave 1 (solutions #01-06 and #02-05) e.g. Head up Display (HUD) or similar system e.g Helmet Mounted Display (HMD) to assist rotorcraft pilots by extending landing to degraded visual conditions, such as:

- Enhanced vision system (EVS) and combined vision system capabilities (CVS). One of the biggest limitations on rotorcraft is their inability to fly in degraded visibility conditions in the critical phases of approach and landing. This limitation could be overcome thanks to additional EVS and CVS capabilities for rotorcraft flight operations in those environments;
- Flight management and guidance for improved lateral navigation in approach via RNP 0.1;
- Use of SBAS/EGNOS technology to support low RNP (e.g. RNP 0.1) flight procedures;
- Alternative technologies for rotorcraft to meet PBN specifications e.g. on board integration of advanced inertial reference system for RNP AR, use of low drift rate AHRS in place of IRS/INS for RNP AR operations, use of military inertials, etc.;

The solution shall also address the specific needs of military/state operations.

The solution may also address the following activities:

- The effective and efficient integration of rotorcraft in the ATM environment by providing pilots with new cost efficient traffic surveillance systems enhancing their situation awareness as well as interoperability with GA, drones and RPAS;
- The development of operational concepts based on new technologies to support integrated rotorcraft and drones/RPAS flight operations in selected scenarios e.g.:
  - inside TMA where all aircraft are equipped with a transponder;
  - where there is electronic conspicuity based on alternative technologies e.g. TSAA, FLARM and drone-specific systems;
  - where there is no electronic conspicuity.
- The integration of operational validation concepts based on traffic situation awareness systems for rotorcraft supporting cooperative behaviour during mixed equipped encounters with ACAS (TCAS II/ACAS X) equipped aircraft. Such systems bring relevant safety benefits for rotorcraft operations in several airspace classes where rotorcraft and Drones/RPAS could fly.

This solution shall also cover the ATC procedures (and support tools if needed, e.g. TWR or approach controller HMI for improved awareness, markers on the approach radar screen to support separation provision, etc.) for handling a mix of rotorcraft and fixed-wing traffic at busy airports in high complexity/high density environments.

The reliability of GNSS (and legacy CNS) is critical for rotorcraft using GNSS procedures in the TMA. The solution shall develop the interface for the TMA to maintain awareness of CNS status in real time and the presentation of relevant information to ATC and the development of any required ATC procedures to safely manage GNSS unavailability. This aspect links this solution to solution 49 “Network Collaborative Performance Management”, with which the solution must interface regarding the presentation of CNS status to ATC, and with solution 4 “Advanced geometric GNSS procedures in the TMA”, who is in charge of the CNS degradation management for fixed-wing aircraft.

In terms of performance benefits the solution targets improvements in:

- Access and equity: thanks to a better integration between rotorcraft and fixed-wing aircraft there will not be any need of penalization of rotorcraft operations to facilitate fixed wing aircraft and vice versa;
- Capacity, resilience (under degraded visibility conditions) and efficiency;
- Safety and Human performance: the specific rotorcraft advanced approach procedures will help reducing ATCO and pilots' workload;
- Enhanced traffic situational awareness to the rotorcraft pilot to improve safety.

Advanced RC operations in the TMA	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

Relevant links to the ATM Master Plan Level 2 (DS18a):

This solution follows-up on certain elements of the work performed by SESAR Solution #11-A4 in Wave 1 on ACAS-Xp and relates to the following OI step:

- CM-0808-p — Collision Avoidance for General Aviation and Rotorcraft (ACAS Xp)

Note that the solution covers additional aspects that that may require the creation of additional Operational Improvements steps (OIs) for future datasets,

3.2 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ02 W2 Airport airside and runway throughput"

3.2.1 Problem statement and R&D needs

At capacity constrained airports, traffic demand for runway operations can exceed the runway capacity. With the expected rapid growth in air traffic, there will be an increasing number of capacity-constrained airports for significant periods of each day, and this situation will become even more critical under adverse weather conditions. Airport will have to improve the efficiency of runway operations and their resilience in visually and/or meteorological challenging conditions. This would be achieved in fully integrating surface management tools with other systems including runway occupancy time prediction, wake separation and arrival and departure management (AMAN/DMAN) systems. In turn it will further reduce the number of incidents / accidents at the airport e.g. collisions on the apron and taxiway with traffic and/or fixed obstacles.

Airports and airlines need to enhance their capability to deliver, plan and improve the use of airport resources so that costs, emissions and fuel consumption can be reduced, whilst improving passenger satisfaction.

3.2.2 Performance expectations

The delivered solutions are expected to have a positive impact on:

- Airport and Airspace TMA Capacity - Increase runway and airspace throughput (e.g. reducing runway occupancy time, or arrivals and departures wake turbulence separation) and resilience;
- Safety: maintain or increase runway, taxiway and apron safety levels, increase situational awareness, ATC Workload maintained or reduced;
- Improved access to secondary airports, with expected benefits in resilience, cost-efficiency and increased flexibility under non-nominal conditions at the airport;
- Predictability - increased predictability and airport efficiency (e.g. runway occupancy time, runway exit and departure rotation);
- Environmental Sustainability - reduced fuel consumption and noise near the airports.

3.2.3 List 1 SESAR Solutions

The proposals shall address at least one of the solutions included in List 1:

3.2.3.1 Solution PJ.02-W2-14 Evolution of separation minima for increased runway throughput

This solution builds on the work performed in Wave 1 by solutions #02-01 and #02-08.

The work may address:

- The potential refinement and consolidation of static pairwise separation matrixes and weather dependent separation minima for successive arrivals, and the development of static pairwise separation matrixes for successive departures and between arrivals and departures. The scope includes the development of suitable separation markers and decision support for controllers in delivering a more precise spacing beyond what has been done by PJ.02 in wave 1. The work may include further development (i.e. regulation and associated safety cases) of separation minima using categories (with more categories or different categories for more optimised use depending on the traffic mix), as well as the inclusion of new aircraft types in pairwise matrixes or separation minima defined as a function of the enhanced approach procedures flown, etc. The scope includes single runways, CSPR or runways more than 760m apart.
- The development and validation of ATCO tools to support controllers in the implementation of the complex separation rules, building on the tools developed in Wave 1. This should support the air traffic controller exploiting the multitude of concepts and separation minima plus different levels of aircraft equipage in complex, capacity constrained airport environments. For the tools supporting compression management, the research may develop monitoring systems that detect emergent evolutions of aircraft mix or even patterns of aircraft behaviour, with the objective of supporting the continuous adaptation of the target indicators in order to replicate human adaptive behaviour. It is expected that such a monitoring system will require the use of big data and machine-learning and more advanced wind knowcasting algorithm. The scope of this solution focuses on the ground based system allowing to manage traffic using a mix of approach procedures but explicitly excludes the evolution of aircraft

equipment allowing approach to different runways that is made possible by GNSS. This is covered by solution 4 “Advanced geometric GNSS based procedures in the TMA”.

- The evolution of the runway lighting system for supporting development of enhanced approach procedures.
- The evolution of the weather dependent reduction of separation between arrivals, departures and between departures and arrivals as well as the definition/refinement of the criteria for suspension of the use of reduced minima.
- For departures, the concept of wake avoidance of wake generated by the lead aircraft by the follower aircraft employing an earlier differentiated rotation position and a steeper climb profile than the lead aircraft, as typically occurs between A380 and Heavy wake category lead aircraft and Medium and Light wake category follower aircraft.
- For departures, the concept of wake avoidance based on weather-dependent early lateral displacement between leader and follower.
- The development and initial validations of the concept of operations for a dynamic Pairwise Separation minima based on flight-specific aircraft characteristics taken from the eFPL, downlinked from the aircraft, or from an evolution of the eFPL (e.g. aircraft weight), potentially WX-dependent.
- Use of flight specific information (e.g. vertical climb profile for departure or speed schedule in approach) in order to support reduced separations between arrivals, departures or between arrivals and departures. This can be obtained via:
    - New information to be added to the future evolution of the flight plan e.g. final approach speed planning;
    - Downlinking information from the aircraft. For the downlink of flight specific parameters from the aircraft, the EPP should be considered. Should needs beyond what the EPP can provide be identified, the research may propose a new ADS-C contract (yet to be defined depending on the needs).
- Note that the eFPL does not include the planned speed schedule for final approach. The solution may explore the usability of the final approach speed schedule planned before departure, and if benefits are proved propose that the addition of this element is considered in the FF-ICE evolution.
- The development of (potentially new) operational procedures required for the coordination between tower and approach controllers in order to be able to safely manage the increased runway throughput enabled by the new concepts e.g. advanced mix-mode operations, and development of new TWR-APP coordination tools if needed. This may include e.g. tools for mutual situation awareness between TWR and APP ATCO for example highlighting flights that have been already transferred to TWR, awareness of APP of TWR having issued landing clearance or speed advice to an aircraft, go-around pre-warning, etc.
- This development of TWR ATCO support tools for issuing landing clearances in an increased runway throughput environment, e.g. predicting the likely distance between two arrivals at the point the leader is exiting the runway to inform the ATCO that a landing clearance can be

issued in sufficient time when separation is reducing or adapted to land behind separation criteria.

- The development and validation of an ATCO support tool to predict ROT and support ATCOs on the feasible runway exit point and on the likelihood that an aircraft will not exit as expected, spending more time on the runway and potentially compromising a following landing or departing aircraft. The solution shall validate further benefits over the existing ATCO best-practices e.g. ATCO predicting the runway exit without tool support. In a first step the ground-based ROT prediction will be based only on static aircraft characteristics such as aircraft type, weight and equipage (EBS/non-EBS). The use of machine learning and data driven predictions should be assessed to improve post-operations offline analysis quality and continuous monitoring and improvement of the quality of the predictions during operations as a runway occupancy system support tool for the ATCO. This research builds on the Wave 1 research conducted within solution #02-08 but goes beyond that solution that may achieve at the end of V3 in wave 1.

- The development and initial validation of a concept that uses A/G exchange in order to better predict ROT and in order to support flight crews expedite runway vacation. This may include, for example, the use of dynamic information broadcast or downlinked from the aircraft for improving ground-based ROT prediction, or the uplink from the ground to the aircraft of relevant information in real time. This more advanced concept would require new data link services (ATN B3), and, if addressed at all during Wave 2, it is expected to reach V1 or even partial V1 maturity. This research must consider the issues identified during the SESAR 1 activities in this area.

This solution may consider potential constraints during LVP operations e.g. OFZ (Obstacle Free Zone) and ILS CSA (Critical Sensitive Area).

The development of new radar separation minima – minimum radar separation (MRS) – is out of the scope of this solution. The reduction of MRS between aircraft in parallel GBAS, SBAS or RNP approaches is also out of scope even if the management of the related separations will be covered by the developed ATCO support tool.

All improvements and/or solutions shall be documented to provide specifications and guidance material as direct inputs to regulatory enablers at European or ICAO level. The solution must consider wake risk analysis methodologies that are suitable for a safety case which can be used for regulatory approval.

The solution may explore the application of developments in new or enhanced aeronautical (AIM) information in order to improve the quality, consistency and usability of the information. The solution may also explore the application of known MET data or the introduction of new MET data and capabilities for improving the performance benefits delivered by the SESAR solution.

Runway throughput enhancement obtained by the various envisaged operational improvements will largely benefit from close collaboration with validation of Airport land side (AO-0808), DMAN (TS-0302, TS-0307), AMAN (TS-0109, TS-0305-B, TS-0315) and network traffic synchronisation (AO-0801-B, AO-0813).

The solution includes elements at a different level of maturity that should be documented in different data packs as proposed below. Note that this is an initial proposal to structure the work and delivery within a SESAR solution with a very wide scope; the bid can propose alternatives and, in any case, these data packs can always be adapted during the wave 2 timeframe depending on the progress of the project activities.

Static/Weather dependent wake separation for departures	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Static/Weather dependent wake separation for arrivals	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Static/Weather dependent wake separation between arrivals and departures	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

Dynamic Pairwise Separation minima	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

Enhanced wake separation between arrivals based on new flight specific data	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V0	V1

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required Operational Improvements steps (OIs) for a future Integrated Roadmap dataset.

The SESAR Solution could cover the following existing OI step in DS18a:

- *AO-0324: Wake Turbulence separations (for departures) based on Dynamic Aircraft Characteristics as a successor to AO-0323 improving Wave 1 performance using advanced techniaues such as big data / machine learning but also more digital information from MET providers or directly downloaded from the aircraft.*
- *TS-0316: More efficient mix-mode runway management allowing efficient grouping/gapping, optimising departure seauence also using big data / machine learning techniques that will not be fully validated in the Wave 1 timeframe.*
- *AO-0307: Wake Turbulence separations (for arrivals) based on Dynamic Aircraft Characteristics as a successor to AO-0306 improving Wave 1 performance using advanced techniaues such as big data / machine learning but also more digital information from MET providers or directly downloaded from the aircraft.*
- *It may include aspects of solution #02-01 not fully validated in the Wave 1 timeframe e.g. AO-0304 and the work on optional enablers such as A/C-47 "On-board management of meteorological data from on-board sensors for sharing and integration by ATM and ATM-MET systems" or AERODROME-ATC-60 "Airport ATC system to monitor wake turbulence risk using ground-based LIDAR/Radar" to support OI steps matured up to V3 in the scope of wave 1 solution #02-01.*
- *AUO-0505: Improved air safety using data exchange via e.g. ADS-B for Wake Turbulence prediction.*

Or the following ones that could be proposed as potential candidates for future datasets:

- *AO-0315 - (to be refined) : More efficient departure separation delivery between departing aircraft using better prediction of rolling distance and departure speed profile and trajectory also using big data / machine learning techniques as a successor to AO-0323.*
- *TS-0312 - Increased runway capacity through allowance of simultaneous runway occupancy (only for departures).*
- *New proposed AO-XXXX - (to be further refined): More efficient arrival separation delivery between arriving aircraft using better prediction of runway occupancy time and final speed profile also using big data / machine learning techniques as a successor to AO-0328 and AO-0310 and considering the effect of separation delegation (AUO-0507) on separation delivery tool and the effect of traffic mix using Increased glide slope or displaced thresholds.*
- *New proposed AO-XXXX - (to be further refined): Improved runway safety by predicting runway exit overshoot and developing advance lighting system also supporting safe use of increased glide slope or displaced threshold.*

Note: OI steps (or parts of OI steps) that are under the scope of solutions in wave 1e.g. #02-01 that will not achieve end of V3, shall be captured in relevant successors OI steps (to be created).

3.2.3.2 Solution PJ.02-W2-21 Digital evolution of integrated surface management

This SESAR solution high level objective is to increase pilots' and vehicle drivers' situational awareness by providing them with supplementary guidance means in all weather conditions and completes/complements the work done in Wave 1 under #03a-01. The SESAR Solution includes:

- The extension of the A-SMGCS routing functions to support tactical conflict management in the taxi phase. Routing and planning are optimised to deliver more accurate taxi times, and minimize delays and controllers' workload. The SESAR Solution integrates the input from airport DCB processes (that takes into consideration information provided by airport sequencing tools e.g. AMAN / DMAN) in order to determine potential conflicting situations when planning taxi routes;

- Guidance assistance to both pilots and vehicle drivers using Airfield Ground Lighting (AGL) and the consolidation of the "Follow-The-Greens" procedures. The use of AGL as speed control will ensure the minimization of waiting time for mobiles at intersections and the exchange of virtual stop bar (VSB) identifier and status between ATCOs and flight crews will also improve safety in low visibility conditions. Research shall be focused on improving the efficiency of operations through automation and the interoperability between ground and airside regarding the use of VSB with routing and AGL;

- The provision of accurate and available mobiles navigation information with high integrity to increase safety and optimise turn-around processes;

- The exchange of information between ATC and vehicles/aircraft using airport data link and other guidance means and the contribution to achieve their standardization (the SESAR Solution shall contribute to the identification of future air-ground data link requirements):

    - D-TAXI: to consolidate the set of instructions that produces relevant benefits when exchanged via data link between ATC and aircraft. The maximum latency value which is considered acceptable for operational use will be part of the study as well;

    - Data link service to ensure the exchange of VSB positions and statuses;

    - Data link service to ensure the exchange of clearances / instructions between vehicle drivers and controllers.

- The use of Advanced Controller Working Position increasing controllers' productivity such as those developed under SESAR Solution 97 "New HMI Interaction modes for Airport Tower";

- The use of new algorithms, artificial intelligence / expert systems to increase automation for ATC in tower ground positions. The interaction between controllers and AI/machine learning shall be addressed, in particular the interaction, interplay, division, etc. of labour and responsibility between humans and algorithms as well as the uncertainty in the situation. The solution should also address the means for explaining and justifying the deviations from the suggested decisions by the automated means e.g. AI;

- The integration into the A-SMGCS of inputs from the Airport DCB processes (developed by the solution 29 "Enhanced Collaborative Airport Performance Management").

The solution may consider the potential applicability to the airport surface of the autonomous automotive technologies to increase safety in a cost efficient way.

Note that this SESAR solution requires air ground datalink. CPDLC has been validated for use only in en-route (the data link mandate is restricted to airspace above FL285). It is expected that this solution will research the use of CPDLC on the airport surface, which explored the potential use of datalink. It is expected that this will require considerable research in the airborne domain, both in terms of procedures and in terms of development of improved on board HMI (e.g. to solve the issue of head-down time) and auto-load capabilities.

As the advanced use of datalink and the extension of datalink below FL285 (including the airport surface) will open new communication possibilities, it is expected that the use of datalink between controllers and pilots will increase and the use of voice decrease. For this reason, the development of the concept of operations for the advanced use of datalink is inextricably linked to the overall evolution of the controller-pilot communication and the evolution of the voice concept of operations. The following open questions on the future of controller-pilot voice communications have been identified:

- Would the future voice communications need to be point-to-point or multi-point (with a channel with party-line like current VHF frequencies)?
- Would a hybrid system be useful, i.e. point-to-point with no party-line but with a free/occupied indicator to prevent simultaneous incoming transmissions for the same ATCO?
- What would be the acceptable latency?
- Which would be the encryption and security needs?
- What are the wide-area communications needs?
- Which are the future automation needs connected to voice communications (e.g. remotely tune the system on another channel, handover, priority call…) and which operational requirements would be required to support them?

The future of controller-pilot communications requires a new concept of operations that includes voice and datalink. It is expected that this new “Controller-pilot communications CONOPS” will be developed by a separate SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The research in this solution has been identified as highly relevant for this CONOPS; consequently, this solution should plan effort to support the development of the “Controller-pilot Communications CONOPS”, e.g. by participating in the CONOPS development expert groups.

The SESAR solution shall as well address the extension (to cover the entire airport surface) and improvement of conflicting ATC Clearances (CATC) / Conformance Monitoring Alerts for Controllers (CMAC) alerting functions. These types of alerts are targeting the main airports and build on top of SESAR Solutions #02 and #22 already delivered in SESAR 1, and continue the work performed by SESAR solution #03b-01 on AO-0104-B. They may rely on the provision of SWIM services.

	MATURITY LEVELS	
Digital evolution of integrated surface management	**Maturity Level at the start of Wave 2**	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

The scope of the solution is large and includes a wide range of OI steps applicable in different operating environments and for various stakeholders. The work in wave 2 shall pay particular attention to the integration of the different elements under the solution scope, and the potential impacts and changes they may imply on solutions already under implementation as a result of SESAR 1 work e.g. “follow the greens”.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #03a-01 and #03b-01 in Wave 1 and covers the following OI steps:

- *AO-0206 — Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing.*
- *AO-0215 — Airport ATC provision of ground-related clearances and information to vehicle drivers via datalink.*
- *AO-0222-B — Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways).*
- *AO-0223-B — Enhanced Safety in LVP through use of Dynamic Virtual Block Control.*
- *AO-0224 — Advanced Automated Assistance to Controller for Surface Movement Planning and Routing.*
- *AUO-0308-B — Datalink Services used for Provision of Ground-related Clearances and Information for Step 2.*
- *AUO-0603-B — Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing in Step 2.*
- *AO-0104-B — Airport Safety Nets for Controllers at the Main Airports.*

3.2.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.2.4.1 Solution PJ.02-W2-04 Advanced geometric GNSS based procedures in the TMA

In SESAR 1, the transition from RNP to xLS was validated, including the transition from barometric to geometric guidance and the containment of the lateral path using RF turns in the case the transition required a curved path. SESAR 2020 Wave 1 solution #02-02 validated the use of the wider variety of glide paths made possible by GBAS/SBAS to support reduced wake separations and increase safety. This SESAR solution builds on the new possibilities offered by the use of GNSS as navigational guidance, continuing the work performed in wave 1 under solution #02-11.

This solution will validate the use of GNSS geometric guidance from the initial approach fix or earlier, in order to make the transition easier in certain MET conditions (e.g. high temperatures), especially when the alignment to final happens very close to the runway threshold. Thanks to the use of GNSS geometric guidance earlier in the approach and RNP containment (potentially stricter than 0.3, e.g. 0.1), a wider variety of curved approaches to a single runway will be possible (with different alignment points, some of them potentially very close to the runway). This may allow easier segregation of traffic flows, for example according to wake category or preferred approach speed.

The research may also address curved departures, potentially combined with precise geometric altimetry, in order to further develop curved departure routes that turn shortly after take-off, e.g. in order to avoid noise-sensitive areas or approach or missed approach routes. Geometric altimetry, potentially combined with lateral displacement, may also be considered in order to de-conflict by design departure routes from missed approach routes, thereby allowing for an increase in capacity for airports where there is a dependency between departure and arrival runways.

The solution must also study how to make it possible for controllers to ensure separation between aircraft flying the newly available approach and departure procedures, including the provision of safe vertical separation between aircraft that are flying using geometric altitudes and those that are flying using barometric altitudes, potentially including the definition of new vertical separation minima to be applied between aircraft when one or both aircraft are navigating to geometric altitudes. This may be achieved by the development of new airspace design concepts that use tight RNP containment in order to ensure de-confliction by design, but it may also require the development of ground tools and controller procedures, e.g. in order to support controllers in monitoring that separation is maintained (NTZ like concepts), or for handling the merge of traffic performing a curved approach with traffic performing a straight-in approach or simply having aligned earlier, or for ensuring vertical separation where appropriate regardless of whether vertical navigation is geometric or barometric.

The research will address the potential impact of MET conditions on the safe conduct of advanced curved operations and the required separation minima. The concept may require the establishment of MET parameters (e.g. maximum wind, absence of convection) for advanced curved operations to be safe from both the airborne and the ground point of view. Furthermore, wind may enhance the dissipation of wake vortex supporting application of optimised separation minima. A minimum performance of on-board automatic MET sensing system may be required.

The solution may also research the use of curved approaches and geometric altitudes for parallel runways, addressing, for example:

- Reduction of the MRS between pairs of aircraft flying PBN approaches (Baro V-NAV, SBAS (EGNOS) or GBAS approaches) to parallel runways; this may include not only the reduction of the MRS when both aircraft are already established on the final approach course (similar to the reduction between aircraft on parallel ILS approaches), but also for aircraft that are on an RF turn to final, thereby allowing a full descent clearance to be delivered before both aircraft are aligned. The reduction of MRS between aircraft when one of them is on an RF turn is expected to require tight RNP containments (e.g. 0.1NM), whereas less tight RNP containments (e.g. 0.3NM) may allow the reduction of separation for aircraft already established on the final approach course. This research must take into account previous research done outside SESAR, the status of the proposals for the amendment of PANS-ATM (Doc 4444), PANS-OPS (Doc 8168), and SOIR (Doc 9643) that, concerning this type of operations, are envisaged for applicability on 8 November 2018 and their applicability / relevance in Europe. This research must include NTZ management.

- Closely connected to the previous point, development and validation of the concept of independent parallel runways for PBN approaches. This requires the validation of a minimum distance between runway centrelines and with NTZ for the two runways to be considered independent, which may not be the same for all the PBN approach types (e.g. tighter containment may allow a lower distance for runways to be considered independent).

- Validation of the reduction of the divergence angle between independent departures in order to increase the flexibility in SID design, potentially including the consideration of curved departures where aircraft turn shortly after take-off. Even though the baseline specification that will be considered is RNP1, the solution may consider if tighter RNP specifications may allow lower angles in order to provide increased flexibility in specific environments. Parallel departures research must consider the impact on cross-wind conditions;

- Further validation of GBAS/SBAS-based enhanced separation concepts not fully validated in wave 1 (e.g. double slope), and new ones building on those already validated to V3 by PJ.02-02 e.g. lateral displacement to mitigate wake turbulence on departures as an alternatve to SRAP, etc.). This may include the consideration of the impact of go-around / missed approach, use of displaced thresholds for arrival/departure and use of different glide slope angles for wake avoidance purposes. This research may need to aspects related to runway lighting and marking schemes to support the new concepts.

This solution is specifically focused on parallel runways, and the development and validation of PBN structures in the TMA (e.g. merge to point, merge to axis) is out of scope. The follow-up of the work conducted by wave 1 solution #01-03a in this area has been included in the scope of candidate solution 8, Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations. Nevertheless, it is acknowledged that the validation of the advanced parallel operations concepts will require RTS and flight trials, and the development of PBN structures, even though it is not the main focus of this solution, may be required to support these validations. The reliability of GNSS (and legacy CNS) is critical for aircraft using GNSS procedures in the TMA. The solution shall develop the interface for the TMA to maintain awareness of CNS status in real time and the presentation of relevant information to ATC and the development of any required ATC procedures to safely manage GNSS unavailability.

The research will fully consider the mixed equipage environment (mix of aircraft able to perform advanced curved operations and aircraft that are not able, mix of aircraft using geometric and barometric vertical navigation, aircraft using different RNP specifications…).

The solution shall continuously liaise with the relevant standardisation and regulatory bodies e.g. safety aspects related to RNP specifications with EASA.

The solution may explore the application of known MET data or the introduction of new MET data and capabilities for improving the performance benefits delivered by the SESAR solution.

This solution must consider the output of solutions #02.01 in the domain of wake separation, #02-03 in the reduction of separation minima between successive arrivals to 2NM, #02-11 for efficient curved operations and use of geometric altitude, and #02-02 for GBAS approaches. There is a link with solution 49 “Collaborative Network Performance Management” for the CNS status monitoring aspects.

This solution addresses only fixed-wing aircraft; rotorcraft are addressed in candidate solution 6.

	MATURITY LEVELS	
Advanced geometric GNSS based procedures in the TMA	**Maturity Level at the start of Wave 2**	**Target Maturity Level at the end of Wave 2**
	V1 on-going	**V2**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #02-11 in Wave 1 and covers the following OI steps:

- *AOM-0607 — Enhanced Terminal Area for Efficient Curved Operation.*

It may also include aspects of solution #02-02 not fully validated in the Wave 1 timeframe:

- *AO-0322 - Enhanced Arrival procedures using double slope approach.*

In case parallel arrivals are addressed, this SESAR Solution would cover the following OI steps that were initially under the scope of SESAR Solution #01-03A in Wave 1:

- *AOM-0606 — Enhanced Parallel Approach Operations using RNP.*
- *AOM-0608 — Enhanced Parallel Approach Operations using PBN/RNP transitions to RNP (for at least one runway)*

In addition, the following OIs are potential candidates for inclusion in future integrated roadmap datasets that may be addressed by this SESAR solution:

- *AO-0312- Increased Runway Throughput by reducing separation distance defining CSPR*
- *AO-0313 - More flexible SID design by reducing divergence angle between independent departures*

3.2.4.2 Solution PJ.02-W2-17 Improved access to secondary airports

This SESAR solution builds on Wave 1 research (solutions #02-06 and #03a-04) to provide a comprehensive solution to increase access to secondary airports in all conditions, including in particular low visibility conditions. The improvements may be used by all airspace users, and the validation may be focused on Business Aviation, GA, rotorcraft and military aircraft. Performance benefits are related to percentage of equipped aircraft that needs to be taken into consideration for performance assessment and CBA.

The solution intends to develop systems and operational procedures that allow operational credits as considered by the Performance Based Aerodrome Operational Minima (PBAOM), for example:

- CAT II based DFMC SBAS;
- CAT II based on GAST-C (improved with SBAS to get GAST-D capabilities like);
- Use of advanced sensors for EFVS/SVS/EVS operations with ops credit, including the definition of generic guidelines for procedure design and the harmonisation of requirements;
- Definition of markings and lightings for secondary airports to support CAT II using CVS (or alternative systems);
- Low visibility procedures (LVP) for towered secondary airports with support from a low-cost surveillance system (LCS) that covers the airport surface and is based on ADS-B and/or MULTILAT in combination with cameras and vehicle tracking systems (VTS);
- Potential applicability of LCS-elements in a FIS-serviced airport for automatic broadcasting of runway status (runway free / runway occupied) in LVC for information purposes;

- Use of CVS (or alternative systems) for take-off ops credit and taxiing in low visibility conditions;
- Mixed equipage (GBAS and SBAS equipped aircraft on the same runway);
- Use of environmentally friendly approaches with IGS of up to 4.5 degrees based on SBAS in order to reduce the noise impact, in a similar way to the GBAS-based IGS solution developed by solution #02-02 in Wave 1 for airliners. This may be combined with curved approaches with RF legs.

The solution may explore the application of developments in new or enhanced aeronautical (AIM) information in order to improve the quality, consistency and usability of the information.

This solution may need to coordinate with candidate solution 25 "Safety support tools for avoiding runway excursions" that addresses the enhancement of runway status information on secondary airports.

The solution will take into consideration as necessary developments in multiconstellation under candidate solution 79 "Dual Frequency / Multi Constellation DFMC GNSS/SBAS and GBAS", which considers Galileo.

	MATURITY LEVELS	
Improved access to secondary airports	**Maturity Level at the start of Wave 2**	**Target Maturity Level at the end of Wave 2**
	V2	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #02-06 in Wave 1 and covers the following OI steps:

- *SDM-0301 — Improved Capacity and Safety of Runway Operations at Secondary Airports in Low Visibility Conditions.*
- *AO-0333 — Improved Approach procedures into Secondary Airports in Low Visibility Conditions.*

However, due to the enlarged scope, the SESAR Solution may require additional OI step in future integrated roadmap datasets.

3.2.4.3 Solution PJ.02-W2-25 Safety support tools for avoiding runway excursions

A runway excursion is defined as "an event in which an aircraft veers off or overruns the runway surface during either take-off or landing". The risk of a runway excursion is increased by wet and contaminated runways, in combination with gusts or strong cross or tail winds. The SESAR solution "safety support tools for avoiding runway excursions" aims at improving runway condition awareness to increase safety in order to prevent runway excursions (take-off and landing), following the work done in Wave 1 by Solution #03b-06. This solution also includes the enhancement of runway status information on secondary airports to increase safety (e.g. airport with short runways): on board runway friction coefficient elaboration and airport runway status model update. This solution may need to coordinate with candidate 17 that addresses improved access to secondary airports.

The objective is to provide the flight crews with objective and synthetic elements for them to make the right decisions in the preparation and execution of take-off, approach, and landing phases. In future operations, additional information will be provided by the aircraft, which can be potentially used for improving both the current and predicted Runway Condition Code (RWYCC) e.g. braking action, measured by a just landed equipped aircraft. The flight crew may also communicate the braking action through a pilot report (PIREP), spontaneously or upon request. Air Traffic Controllers will relay the current and predicted RWYCC to the flight crew via any suitable means and it will be disseminated towards the other interested stakeholders i.e. APOC and AOC to enhance their situational awareness.

The current and predicted RWYCC are to be used by the flight crew in the following phases:

- When preparing take-off data during the pre-flight preparation and just before take-off;
- Before the Top Of Descent (in the in-flight landing planning phase), when assessing the aircraft performances for landing;
- During the approach, to confirm landing can be performed safely, evaluating necessary landing distance (taking into account the current RWYCC, trajectory parameters and aircraft data) against the landing distance available;
- After touchdown, once braking devices are engaged, to adapt the deceleration method to the remaining distance available.

An on-board Runway Overrun Awareness and Alerting System (ROAAS) may alert the flight crew if a risk of runway overrun occurs during the final approach and landing run.

In order to foster digitalization and further automation on-board, the solution may use computer vision to detect objects, aircraft and incorrect trajectory as for auto land Cat I below 200 ft. supervision.

This SESAR solution requires air ground datalink. Therefore it shall contribute to the identification of future data link requirements. The SESAR solution outcome shall contribute to the relevant standardization activities related to this field e.g. EUROCAE.

Safety support tools for avoiding runway excursions	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #03b-06 in Wave 1 and covers the following OI steps:

- *AO-0107 — Improved Airport Safety with Better Prevention of Runway Excursions for Tower Controllers.*
- *AO-0216 — Enhanced Runway Condition Awareness.*
- *AUO-0606 — Improved Awareness of Runway Friction Evolution.*
- *AUO-0616 — Improved Safety with Better Prevention of Runway Excursions for Pilots.*

3.3 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ04 W2 Total airport management"

3.3.1 Problem statement and R&D needs

The full integration between Airport and Network Operations has still to be achieved. In particular, the management of predicted airport performance deterioration needs to be aligned with the Network. Collaborative recovery procedures and support tools in coordination with all the relevant ATM stakeholders are required to facilitate the pro-active management of predicted performance deteriorations such as airport capacity reduction. Total airport demand and capacity balancing processes and tools require further integration with the execution tools (arrivals and departure management systems and advanced surface movement guidance & control systems) and resource allocation planning tools (e.g. stand/gate allocation) with the objective of optimising the airport capacity to better comply with the traffic demand. Airport landside/airside performance monitoring and management processes need to be further integrated while the turnaround monitoring within the Airport Operations Centre (APOC) requires refinement in coordination with the Airspace Users. Impact assessment tools available to the APOC need to better integrate information about MET forecast uncertainty. Post-operations analysis processes, support tools and reporting capabilities need to be as well developed.

3.3.2 Performance expectations

The delivered solutions are expected to have a positive impact on:

- Better use of existing airport capacity and its optimisation to comply with traffic demand;
- A better situational awareness through SWIM information sharing, enabling provision and reception of Airport CDM data including MET and AIM;
- A significant increase in the predictability, efficiency, environmental sustainability and flexibility of airport operations thanks to a performance-driven airport through KPIs monitoring and early detection of deviations, collaborative decision making using support tools and what-if functions, post-operations analysis used as learning process, etc.;
- Proactive management of predicted impacts to normal operations, quicker reactions on deviations;
- Increased resilience through shorter and effective recovery to normal operations and collaboration with the Network, from predicted or unpredicted adverse operating conditions;

- Increased safety in the airport environment due to reduced uncertainty of operations and reduced congestion through better planning.

3.3.3 List 1 SESAR Solutions

The proposal shall address, as a minimum, one solution from List 1:

3.3.3.1 Solution PJ.04-W2-28 Enhanced Collaborative Airport Performance Planning and Monitoring

The SESAR solution "Enhanced Collaborative Airport Performance Planning and Monitoring" aims at enhancing the collaborative airport performance planning and monitoring processes.

The cornerstone of this solution is the Airport Operations Plan (AOP) that holds all actual and future elements of the airport operations: the AOP is the central part of airport operations decision support tools and collaborative decision making processes. The SESAR solution includes four main (transversal) business services performed around the AOP:

- **Steer** airport performance service: develops the performance standard (i.e., goals, targets, rules, thresholds, trade-off criteria and priorities) for airport operations and sets an overall strategic direction;
- **Monitor** airport performance service: maintains surveillance over airport operations, airport performance and processes (against KPAs), and airport environment (e.g. weather monitoring), supervising airport related information and any information that can impact the airport performance; it provides observations, forecasts, alerts and warnings against predefined thresholds;
- **Manage** airport performance service: instantiates the AOP at the beginning of the medium-term planning phase. It uses the operational data provided by the airport stakeholders and the performance standard defined by the steer airport performance service;
- **Learn (perform post operations analysis)** service: records any planned and actual data used in the airport processes during the planning and execution phases. This information is then used to produce post-operations analysis reports in the post-operations phase. These reports allow the airport stakeholders to:
    - Understand the airport performance against the performance plan;
    - Identify the root causes of any deviation;
    - Assess the continued relevance of the performance plan;
    - Justify the need for improving the way the airport operations are run;
    - Investigate of any disruption in the operations;
    - Analyse actions and decisions made during the planning and execution phases.

These services may be provided by the airport or delegated by the airport to other actors.

The SESAR solution shall address the option of a decentralised / virtualised AOP that could be particularly relevant for smaller airports or networks of airports. Cybersecurity and the definition of non-functional performance requirements are key aspects to be addressed for this virtualised AOP.

The SESAR solution includes the following operational improvements:

- Enhancement of the airside processes with the inclusion of landside (passenger and baggage flow) process outputs (shared in the AOP via the TOBT update) that can affect ATM performance. The landside aspects shall also address aspects beyond the airport and consider connectivity and multi-modality aspects;
- Ensure a full and seamless interoperability with the AU operational systems;
- Extended turn-round monitoring within the APOC: by monitoring key aspects of the turnaround process, the APOC shall get an early warning indicator of process and infrastructure inefficiencies / issues / failures, resulting in possible delays;
- Network connected regional airports: to improve the connectivity between regional airports and the NMOC through the provision of DPI messages based on target times and a reduced set of turnaround milestones compared to the full A-CDM implementation;
- Finalization of AOP-NOP information sharing that would ultimately lead the European standardization, procedures to support AOP-NOP collaborative process, including AOP-NOP information quality requirements and exchange of AOP-NOP information through SWIM (AOP milestones are used to calculate a revised TOBT and this is shared with the NOP).

The SESAR Solution shall determine the applicability of the functionalities and requirements to the different categories of airports considering deployment and cost/benefit dimensions. The SESAR Solution needs to ensure that the need for harmonization and standardization is addressed to avoid specific local solutions.

Note that this solution is closely linked to candidate solutions 39 “Prioritization strategies for arrivals including UDPP” and 49 “Collaborative Network Performance Management “.

The .solution may take into consideration the more relevant and mature results from the ER project PNOWWA “Probabilistic nowcasting of winter weather for airports”.

Enhanced Collaborative Airport Performance Planning and Monitoring	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V3 on-going	V3

Approved

Founding Members

EUROPEAN UNION EUROCONTROL

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #04-01 in Wave 1 and covers the following OI steps:

- *AO-0801-B — Collaborative Airport Planning Interface (AOP fully integrated with NOP).*
- *AO-0802-B — A-CDM process enhanced through integration of landside (passenger and baggage) process outputs.*
- *AO-0818 — Extended Turn-round monitoring within the APOC.*
- *AO-0821 — Post-Operations Analysis support solutions and reporting capabilities.*
- *AO-0824 — Network-connected Regional Airports (Note that this OI step may achieve end of V3 in wave 1 timeframe following the feedback from the Project review in March/April 2018)*

3.3.3.2 Solution PJ.04-W2-29 Digital Collaborative Airport Performance Management

The SESAR Solution "Digital Collaborative Airport Performance Management" continues the work done in SESAR Solution #04-02 "Enhanced Collaborative Airport Performance Management" in wave 1 that had initiated the research on the initial application of data analytics and big data mining for the collaborative pro-active management of airport performance between airport stakeholders moving towards a total airport DCB management process.

The "digital" Airport Operations Plan (AOP) holds all actual and future elements of the airport operations. The AOP is the central part of airport operations decision support tools and collaborative decision making processes covering the four main (transversal) airport business services: steer, monitor, manage & learn.

The solution refers to the digital data management of airport performance thanks to the development and validation of rationalised predictive data driven dash boards fed with all landside and airside leading key performance airport indicators covering the TAM processes e.g. data dashboards for monitoring the status of the AOP by supervisors and managers in both normal and special/crisis situations. This requires the improvement of airport data quality for compliance with the data chain supporting operational needs. The data management may consider the use of the block chain concept.

Business intelligence/machine learning should help stakeholders to share the same vision and collaborate in root cause analyses incorporating real-time information presenting both "what has happened" and also "what is predicted to happen" through forecast or predicted future airport performance and what-if capabilities enabling the proactive management of situations. Meteorological impacts on the AOP are pro-actively managed by decision support functionalities that can assess the impact of key meteorological conditions on airport performance and that can propose pre-defined solution scenarios. Environmental parameters (performance and restrictions) are integrated into the Airport Operations Plan in planning, monitoring, execution and post-operations phases.

The solution may develop a computer-based collaborative decision-making and "what-if" decision support tools enabling the proactive management of situations including functionalities such as: the dynamic identification of airport related performance issues, facilitate the involvement of the right stakeholders and the decision making process at the APOC, 'trade-off' analysis by different stakeholders including user defined prioritisation processes (relating to numerous performance indicators, including relevant EU Performance Reference Period metrics), the documentation of the decision making processes, “what if” probing capabilities, etc.

The total Airport Demand-Capacity Balancing (A-DCB) is achieved through the pro-active assessment of the available total airport capacity and the most up to date demand information, considering prevailing and forecast weather and other relevant operational conditions.

In order to ensure global optimisation of the airport / TMA operations, this SESAR solution (in coordination with TMA and Network DCB processes) shall:

- Assess the current and future limiting factors and conditions by integrating information from A-SMGCS, AMAN/ORD, DMAN, AOP information/procedures, etc.;
- Determine the relationships between the different types of demand and the availability of resources and how they influence each other and;
- Trigger local optimisation / sequencing processes such as the A-SMGCS planning and routing function, AMAN / DMAN, etc. based on the overall airport operational strategy;
- Address the UDPP airport processes. Note that this should take into consideration any work performed in wave 1 and the lessons learnt from SESAR 1 UDPP airport step 2 validation activities.

The SESAR Solution will enable stakeholders to pro-actively identify demand and capacity imbalances, their timeframe, location and impacted trajectories. The resolution of these imbalances is supported by what-if capabilities. Collaborative recovery procedures and associated predictive and decision support tools to support Airport, AUs, NM and ANSP stakeholders to anticipate, understand and collaboratively manage disruptive adverse events to reduce impact and knock-on effect, optimising solutions whilst ensuring that users' end-to-end processes are managed.

In addition, since the airport is often at the centre of a multi-modal transport network, the SESAR solution shall address inter-modality aspects ensuring that the performance monitoring and management processes incorporate interacting transport modes (AO-0812) e.g. train and bus companies, taxis, road and air vehicle traffic managers, etc. The objective is to consider how airports can make use of data available from other transport modes and how to integrate them in order to provide a full picture to the passengers for their end-to-end journey and optimise their door-to-door time (Flightpath 2050 Europe’s Vision for Aviation 4 hours goal).

The SESAR Solution shall determine the applicability of different functionalities and requirements to different categories of airports considering deployment and cost/benefit dimensions. Specific needs of smaller airports are considered by ensuring that the concept is scalable as a function of the traffic and potential network impact, notably through the identification of which technological enablers should be implemented so as to yield the most performance benefit in a cost-efficient manner.

Regional airports often form part of a group or network to benefit from economies of scale and better managing their available capacity and use of resources. Wave 2 will assess how performance target-setting could be applicable to such a group of airports (AO-0808, AO-0809, AO-0810). The research will also address the development of the TAM concept to both individual groups of airports (for example where there is a strong performance interaction) and to develop simplified and low-cost solutions to the APOC, for example through automated decision support (AO-0815) in order to reinforce deployment potential at smaller, regional airports. The SESAR Solution needs to ensure that the need for harmonization and standardization is addressed to avoid specific local solutions.

Solution #04-02 in wave 1 has already initiated the research on the application of data analytics and big data mining for the collaborative pro-active management of airport performance between airport stakeholders. The objective in wave 2 is to further explore data and video analytics, big data and machine learning techniques in order to improve the management of airport performance and support what-if decision support capabilities and using the power of data to understand how to incorporate historical operational knowledge. The purpose is to improve the management of airport performance and to anticipate special/crisis situations by correlation with historical data to mitigate as much as possible any airport performance decrease, better allocation of airport resources and thus improve resilience, predictability and cost efficiency.

The SESAR solution shall also explore the use of Internet of things (IoT) technology to help monitoring the progress of processes including turn-around, anticipating potential delays and issues (refuelling, catering, boarding, etc.) that impact the overall performance of the airport. The solution shall consider the internet network infrastructure e.g. 4G and 5G networks and the required bandwidth needed to support this solution and the associated security requirements (cyber security is essential).

The solution shall coordinate with solution 21 “Digital evolution of integrated surface management”, solution 1 “Next generation AMAN for 4D environment” and solution 49 “Collaborative Network Performance Management”.

Enhanced Collaborative Airport Performance Management	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #04-02 in Wave 1 and covers the following OI steps:

- *AO-0813 — Enhanced Collaborative Airport Performance Management.*
- *AO-0819 — Pro-active management of meteorological impacts on the AOP.*
- *AO-0820 — Pro-active Collaborative Management of Predicted Performance Deterioration via UDPP.*
- *AO-0822 — Environmental Performance and Restrictions Accommodated in the Airport Operations Plan.*
- *AO-0823 — Airport Learning Environment based on Post-Operations Analysis.*
- *DCB-0311 — Total Airport Demand-Capacity Balancing (A-DCB).*

The OI steps may need further updates for future integrated roadmap datasets to reflect inter-modality aspects, further integration with the network processes beyond UDPP, use of new technologies following the digital evolution, etc. The following OI steps are proposed (or will be proposed) for future datasets.

- *AO-0825: Pro-active Collaboration Hub Airport / Network Management of Predicted Performance Deterioration*
- *AO-0826: Pro-active Collaborative Regional Airport / Network Management of Predicted Performance Deterioration*
- *AO-0805 —Improved airport collaboration in "Service to Schedule principle"*
- *AO-0807 —Dynamic target profiles for airport performance*
- *AO-0811 —Digital smart airport*
- *AO-0812 —Airport Integrated in a multi-modal transport network*
- *New OI step —What-if analysis*
- *New OI step —Airport Performance Prediction Techniques*
- *New OI step —Airport KPIs of the Performance Scheme*
- *New OI step —APOC dashboard integrated in NM*
- *AO-0808 —AOP for a group of airports*
- *AO-0809 —Setting performance targets for a group of airports*
- *AO-0810 —Monitoring Performance for a group of airports*
- *AO-0816 —Connecting regional APOC*
- *AO-0815 —(Lite) APOC for regional airports*
- *New OI step —APOC Business re-engineering*

3.4 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ05 W2 Digital technologies for Tower"

3.4.1 Problem statement and R&D needs

Some small and remote European cities are highly dependent of local and regional airports for connection purposes, maintaining local business and cargo. Remote Tower Services (RTS) provide an opportunity for continued operation of airports and rural development. The costs for performing Air Traffic Service (ATS) are high and could be reduced, particularly at low to medium density airports, by provision of Air Traffic Services (ATS) from a remote tower specifically through a highly efficient multi remote tower solution. The focus on maintaining situation awareness becomes an increasingly important factor with multiple remote tower operations, therefore additional automation functionalities e.g. voice recognition, conflict detection, and conflict resolution advisories should be developed in order to gradually increase the operating range of the concept. There is a need for effective planning tools in both short term and long term all managed by a supervisor role.

The efficiency of using the CWP HMIs for the airport tower requires improvements by exploiting the latest mature technologies and new interaction modes e.g. touch, gesture, voice, etc.

3.4.2 Performance expectations

The solutions to be developed under this topic are expected to provide:

- Improved cost-efficiency with the optimisation of the use of available resources;
- Increased safety with an increased awareness of the traffic situation thanks to the use of digital display information available to the tower controller;
- Increased ATCO efficiency with the use of technologies allowing ATCOs to focus on key tasks.

3.4.3 List 1 SESAR Solutions

The proposals shall address, as a minimum, one solutions from List 1:

3.4.3.1 Solution PJ.05-W2-35 Multiple Remote Tower and Remote Tower Centre

The SESAR solution "Multiple Remote Tower and Remote Tower centre" addresses the remotely provision of Air Traffic Services (ATS) from a Remote Tower Centre (RTC) to a large number of airports (including the service provision to two or more airports from a remote tower position) thanks to a flexible and dynamic allocation of airports connected to different Remote Tower Modules (RTM) over time. The solution continues and completes the work performed in wave 1 by SESAR solution #05-03.

The related airport categories include several small to medium airports connected to a site with several modules for remote air traffic service. The solution shall address VFR/IFR operations and all types of airspace users including RPAS, GA, Business aviation and Rotorcraft.

In particular, the SESAR Solution addresses:

- The RTC supervisor role and required support systems. This includes the development of tools and features for a flexible planning of all aerodromes connected to remote tower services, including effective planning tools in both short term and long term all managed by the supervisor;
- The integration of approach services for airports connected to the RTC;
- The connection between RTC and flow management;
- Transition aspects e.g. how to handle a handover (planned and urgent) and what are the operational / system support needs e.g. debriefing tool, RTC to RTC coupling transferring responsibility of an airport, etc.;
- Contingency situations e.g. close of a RTC, etc.
- Advanced automation functions to maintain ATCO situational awareness in operations involving multiple remote towers e.g. voice recognition, alerting and warnings for conflict detection and conflict resolution advisories, etc.;

- SWIM infrastructure and related technical aspects such as the network quality and resilience/redundancy aspects, improved surveillance needs (e.g. seamless integration of air/ground multi-sensor tracking);

- Further development of the CWP (Controller Working Position) is required for a module more suitable for a centre with several CWPs;

- Training and licensing aspects, in particular in RTCs covering cross-border operations are elements that will have to be considered;

- Interoperability aspects regarding cross border operations are to be addressed for the possibility to develop systems working beyond borders.

It is expected that the solution will have a major impact on the cost reduction e.g. through flexible use of human resources while maintaining capacity and safety/security levels.

Multiple Remote Tower and Remote Tower centre	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #05-03 in Wave 1 and covers the following OI steps:

- *SDM-0210 — Highly Flexible Allocation of Aerodromes to Remote Tower Modules.*

3.4.3.2 Solution PJ.05-W2-97 HMI Interaction modes for Airport Tower

The SESAR solution “HMI Interaction modes for Airport Tower” addresses 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.). These improvements may be applicable in current operations and/or in future operational concepts still in development under the scope of other SESAR solutions.

The SESAR solution shall consider modern design and development approaches and methodologies such as modularity, SoA, adaptive automation, etc. as a mean to improve cost efficiency, maintenance and evolution of the CWP.

The objective is to improve ATCO productivity supporting the ATCO to get the benefits of a more automation level, while maintaining / increasing the level of safety. The SESAR solutions shall take into consideration the impact on human performance as well as the cost efficiency aspects of the proposed features.

The SESAR Solution may include (the list is not exhaustive), the development of the following features (some of them have been already addressed by solution #16-04 in Wave 1, but for the ATC centre):

- Multi-touch input devices: is a technology that enables a surface e.g. touchscreen to recognize the presence of several points of contact with the surface. The results indicate that multi-touch systems are in general suitable to overcome mental bottlenecks in the human-system interaction.

- Use of in-air gestures for user interaction;

- Automatic speech recognition (ASR): enables the recognition and translation of spoken language e.g. ATCOs commands into the system reducing their workload and improving safety e.g. reduce head down times of the controller.

- Attention control: attention control enables to guide the attention of the controller, especially in a highly automated environment to important events to support the future monitoring task of the controller. For example, gaze detection can assess and guarantee the quality of the controllers attention by capturing ATCOs' eye movements and therefore measure and monitor, in real-time, their level of vigilance.

- User Profile Management Systems (UPMS): to identify/authenticate the controller wherever he sits in the ATC centres e.g. speech, finger print, iris or face recognition etc.

- Tracking labels, including not only the potential to deliver benefits for the ATCO, but also potential side effects on the ATCO's situational awareness in particular in the context of abnormal situations e.g. ATCO may not notice events that are not tracked automatically if he/she becomes too reliant on the tracking labels;

- Virtual and augmented reality in different means e.g. smart screens, head-on display, and enhanced technology to allow tower ATCOs to conduct safe operations under any meteorological conditions while maintaining a high runway throughput.

The SESAR solution shall propose solutions for the different categories of airports i.e. a given feature may be required for a major airport but not for a smaller one.

The solution addresses as well the integration of artificial intelligence (AI) and machine learning algorithms for the intelligent data provision to the controllers on the HMI: data should be only available and presented to ATCOs if needed in order to avoid information overflow. The presentation of the information to ATCOs should be intelligent, providing not only "raw data" but also why it is shown and what should be done based on the information. The interaction between controllers and AI/machine learning shall be addressed, in particular the interaction, interplay, division, etc. of labour and responsibility between humans and algorithms as well as the uncertainty in the situation. The solution should also address the means for explaining and justifying the deviations from the suggested decisions by the automated means e.g. AI.

This requires operational validation, which may be undertaken independently of other SESAR solutions if a given new HMI feature is applicable and can provide benefits in SESAR KPAs (e.g. reduced workload, increase safety, etc.) in current operations, in which case the feature should become an independent SESAR Solution.

The SESAR solution shall consider the integration of the different HMI features developed for the Airport Tower, not only from a technology perspective but also taking the HP, safety and other operational performance aspects into account.

The solution shall take into consideration the inputs from exploratory projects such as MALORCA and RETINA.

HMI Interaction modes for for Airport Tower	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #16-04 and in ER project RETINA (but it may include additional features). Relevant OI steps and enabler(s) need to be created in the ATM MP Level 2 to cover the scope of the solution, on toop of those already available:

- *AO-0212 — Equivalent Visual Operations for Tower Control in Low Visibility*

3.5 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ07 W2 Optimised airspace users operations"

3.5.1 Problem statement and R&D needs

The current ATM environment based on static flight plans is evolving towards a trajectory based environment in order to improve airports and ATM network performance. Airspace users' (AU) decision processes and resulting business priorities differ from AU to AU and from flight to flight within one AU. The trajectory development and management processes in ATM currently do not allow each individual user to incorporate specific aircraft/flight priorities into the requested trajectory, and respect any constraint in a way that best meets the business priorities. Similarly, OAT flight plans are not harmonised at European level and information is not disseminated into the network, this induces a lack of awareness about military traffic intentions that can impact ATM network performance (including safety), a lack of flexibility in the definition of cross-borders exercises and limitations in terms of interoperability. Irregular operations impose unplanned/additional cost on airlines and have a huge impact on airlines' annual costs and revenue. Today the ATM system allows little flexibility to airspace users (e.g. ATFM slot swapping process). Airspace users' full participation through their flight operations centres (FOC/WOC) into ATM collaborative processes, including flights' prioritisation with the full user driven prioritisation process (UDPP), is essential to minimise impacts of deteriorated operations for all stakeholders including airspace users. A better recovery process that should offer more flexibility to accommodate AUs' changing business priorities and equity in the ATM system. The collaborative planning and flight execution processes shall be performed at 'level playing field', i.e. performance of all actors is taken into consideration. Rules must be implemented in case no collaborative planning is possible.

3.5.2 Performance expectations

This topic will develop solutions that are expected to have a positive impact on the Network improving:

- Increased capacity based on a better integration of the AUs trajectory definition and the network demand and capacity function;
- Increased flexibility by allowing the airspace users to recommend to the network management function a priority order for flights;
- Environmental sustainability - fuel efficiency thanks to the use of the preferred trajectory taking into consideration the Airspace users' needs;
- Increased punctuality and predictability of individual flights thanks to the collaborative framework of the trajectory management.

3.5.3 List 1 SESAR Solutions

The proposal shall address, as a minimum, one solution from List 1:

3.5.3.1 Solution PJ.07-W2-38 Enhanced integration of AU trajectory definition and network management processes

The objective of this solution is to reduce the impact of ATM planning on Airspace Users' costs of operations, by providing them a better access to ATM resource management and allowing them to better cope with ATM constraints. Enhancing the CDM planning between the providers and the users ensures a better adherence to the agreed trajectory during execution, hence a better predictability on the traffic demand.

The solution shall improve Airspace Users flight planning and network management through improved FOC participation into the ATM network collaborative processes in the context of FF-ICE and its potential evolutions. The research builds on Wave 1 PJ.07-01 and PJ.09-03 work, and shall also consider the results of the Wave 1 Network Collaborative Management (NCM) VLD. The following aspects may be included:

- Provision of enriched DCB information e.g. ATFCM regulations, hotspots, Congestion Indicator (CI) to support AU decision-making by raising awareness of network activated constraints, potential constraints and opportunities;

- Automation of AU flight planning/network management interactions and impact on network stability and performances;

- Anticipated trajectory planning and negotiation to support pre-tactical phase processes and reach agreements closer to optimum trajectories;

- Provision by the AU of preliminary flight plans as early as possible to support efficient collaborative network planning enabled through early view on the planned flights

- Involvement of AUs in the application of STAMs through extended collaborative advanced planning made possible by an NM-centralized and standardised connection to the FOC similar to what is available locally through some ANSPs (e.g. CAP in France). Note that this is specifically aimed at level capping measures, but extension to other measures or trajectory opportunity proposals may also be considered;

- Assess the interactions with the NOP (impacted process, time horizon, required information that goes to the NOP and/or which is expected from the NOP, constraints, etc.;

- Inclusion of AU priorities (relative importance of the flights in the fleet) and preferences (in case ATM measures are affecting the flights) in the flight-plan to be considered by NM or by LTMs in ATFM processes (for some specific use-cases).

- Development of working methods associated to the collaborative and incremental process (supported by automation) for AUs trajectory definition/negotiation together with DCB;

- Consideration of business aviation specificities (business aviation operators do not always have a FOC (or a full-equipped FOC)): last minute flight planning and flight modification, etc. The solution provides to these airspace users the means to coordinate with the Network Manager so the flight crew can prepare and negotiate the flight plan .The solution shall address the NM necessary service to these airspace users and the end-to-end validation involving on-board (cockpit)/ground and ground/ground segments in a representative environment.

The solution will focus on the planning phase and SBT management but will also consider the execution phase limited to NMf/FOC trajectory negotiation/information exchanges taking into account inputs from Wave 1 solution #18-02a and ICAO FF-ICE execution.

The solution requires coordination with solution 49 “Collaborative Network Performance Management”, solution 45 “Enhanced Network Traffic Prediction and shared complexity representation” and solution 57 “RBT revision supported by datalink and increased automation”.

Enhanced integration of AU trajectory definition and network management processes	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #07-01 in Wave 1 and covers the following OI steps, but they may require updates following the updates in the SESAR Solution scope:

- *AUO-0207 — SBT management supported by FF-ICE services.*
- *AUO-0208 — Inclusion of preferences in SBT for DCB processes.*
- *AUO-0219 — Use of enriched DCB information to improve AU flight planning.*
- *DCB-0217 — DCB Support to FF-ICE.*
- *AUO-0206 — FOC Management of the Reference Business Trajectory*

3.5.3.2 Solution PJ.07-W2-40 Mission trajectories management with integrated Dynamic Mobile Areas Type 1 and Type 2

The objective of the solution is to improve the use of airspace capacity for both civil and military users and the efficiency of airspace management by introducing more automation and increased flexibility in the civil-military coordination, as well as by enhancing the harmonisation between civil and military processes across Europe and facilitate cross-border operations. The increased flexibility will result in better Network and Local performances.

This SESAR solution builds on the SESAR 1 solution #31 (Variable profile military reserved areas and enhanced (further automated) civil-military collaboration), P7.6.2 (Business and Mission Trajectory), P7.5.4 (Advanced Flexible Use of Airspace), and on the work carried out in Wave 1 by PJ.07-03, PJ.08-01 and PJ.18-01a.

The solution delivers improvements to the planning phase of the mission trajectory, from the first time the MT is shared with the network until mission completion. The improvements brought by this solution include the connection of MT management with the booking of ARES (in the context of this solution DMA Type 1 and Type 2), for which the WOC will be the key actor. The solution completes the work performed by solution #07-03 on the flight planning for the MT where relevant elements of the iOAT flight plan may be shared with the network manager e.g. transit flights, refuelling, test flights, etc.

The SESAR concept includes improvements to the whole lifecycle of the MT, but only improvements to the planning phase are covered by this Wave 2 solution. The increase in the level of flexibility for making changes after the mission has started and the involvement of ATC and flight crews in the revision of MT are out of scope for this solution (but this solution is an important building block towards making this possible in the future).

The coordination between WOC and regional NM is a key element for this solution, and there is a dependency between this solution and the Dynamic Airspace Configurations (DAC) solution (Solution

44), the integration solution looking at introducing flexibility in the sectorization in order to better adapt capacity to demand in support of DCB processes.

DMAs express the exact AUs' and mission needs. They constitute a volume of airspace designed to satisfy specific AU operational requirements, encompassing civil, state and military flights engaged in activities such as training, survey, and/or aerial photography ensuring safety for the rest of AUs. DMAs are expressed in the trajectory 4D profile description, linked or not (in the case where the entire MT is inside the DMA) to the Mission Trajectory and they become an input to the NM system to facilitate both DCB and DAC processes. The position of this volume over specific geographic location is variable and negotiated through CDM process and the outcome may require from the AU complete modification of the relevant MT.

DMA Type 1 is a volume of airspace of defined dimensions described as an integral part of a MT at flexible geographical locations agreed upon in a CDM process satisfying Airspace Users requirements in terms of a time and/or distance constraint parameters from a reference point as specified by AU (e.g. Aerodrome of Departure).

DMA Type2 is a volume of airspace of defined dimensions that can be planned and used at any geographical location along the trajectory.

DMAs types 1 and 2 will be “positioned” with minimum impact on other trajectories (both BT and MT) and best fitting to DAC, while keeping the other parameters on MT within the required limits defined by the military/state airspace user. In this way DCB is complete and allows for dynamic management of the Airspace configurations and AU trajectories.

The SESAR solution shall address the required system developments and further automation to support the AUs to define DMAs and develop their trajectories. This includes “What-if” tool functionality nd automated tool functionalities for the Airspace Management process, as well as the potential use of AI, machine learning techniques to improve this process.

It is acknowledged that the whole scope of the solution will not be able to reach V3 maturity at the end of Wave 2. However, the target maturity level has been set to V3 because it is expected that some elements of the solution will reach V3, and these must be documented in a V3 datapack. The solution should therefore plan on delivering both a V3 datapack for the elements that are ready to progress to implementation and a V2 datapack for those that are not.

Mission trajectories management with integrated Dynamic Mobile Areas Type 1 and Type 2	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #07-03 (and activities in #18-01a) and elements in #18-01b in Wave 1 and covers the following OI steps:

- *AOM-0303 — Pan-European OAT Transit Service.*
- *AOM-0304-A — Mission Trajectories in Step 1*
- *AUO-0210 — Participation in CDM through iSMT and Target Time (TTO) negotiation.*
- *AUO-0211 — WOC Management of iRMT via improved OAT FPL.*
- *AUO-0213 — SMT including military user preferences associated to meteo.*
- *AUO-0214 — SMT including user preferences and mission trajectory information for DCB processes.*
- *AUO-0215 — Sharing iSMT through improved OAT flight plan.*
- *AUO-0228 — Agreed iRMT.*
- *AOM-0208-B — Dynamic Mobile Areas (DMA) of types 1 and 2*

3.5.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.5.4.1 Solution PJ.07-W2-39 Collaborative framework managing delay constraints on arrivals

The Collaborative framework enables the integration and necessary coordination of 4D constraints from various stakeholders (airports, ANSPs, AUs and NM) in order to ensure the continued stability and performance of the network and to give the opportunity to the Airspace Users to prioritize their most important flights hence reducing the impact of ATM planning constraints on the costs of their operations.

The integration of these 4D constraints issued from multiple sources will be managed via the NOP through new rules and mechanisms (including AU priorities, 4D Targets and Tolerance Windows (note that this refers to pre-departure), synchronization and reconciliation of multiple flow measures affecting the same flights or flows) that will replace current slot allocation (based on first planned/first served principle).

The solution shall apply the Collaborative framework to the coordinated management of delay constraints resulting from capacity issues on arrivals (as they are considered the most important capacity issues), and to streamline all prioritisation processes occurring in the planning phase from all stakeholders concerned on arrivals: airports APOC, LTM/ATC at airport and in TMA, extended arrival management, en-route FMP and Network. In response to a DCB imbalance detected on arrivals, the APOC/Extended Arrival Manager/local LTM may propose to resolve the imbalance by allocating target times to specific flights instead of using a classical regulation. In addition to the arrival constraint, the priority that AU assign to every flight involved in the imbalance is key to the process of selecting flights for target time allocation. In particular, Solution 39 shall bring an improved integration of the AU priorities in the Target Time management process. The solution shall consider the results and recommendations related to Target Time management stemming from projects and solutions in SESAR 1 and wave 1, in particular the lack of proven benefits of target time adherence (removed from the scope of solution #18 CTOT and TTA).

The User Driven Prioritisation Process UDPP is intended as a service to AUs usable for any type of delay constraint resulting from capacity issues in the network, to help reduce the impact of delays on AUs. It has been defined with AUs dispatchers and OCC OPS supervisors to be equitable by design: no prioritisation made by one AU on his flights has a detrimental impact on the flights of another AU; AUs can also protect some flights and this may have a slight positive impact on other AUs. The UDPP prioritisation process takes into account the network impact through a What-If and produces a reordered list of flights (not a priority number). Each AU works independently from the others and reorders its flights in its own slots aiming to reduce the impact of delay on its own operations and business.

The Solution 39 builds on the research conducted in SESAR 2020 wave1 solution #07-02, #09-03, #09-02, #04-01 and #04-02. The solution requires coordination with solution 28 “Enhanced Collaborative Airport Performance Planning and Monitoring”and solution 29 “Digital Collaborative Airport Performance Management”.

It is proposed in the solution 39 to focus on arrivals, which are considered the most important constraints, and to streamline all prioritisation processes from all stakeholders concerned on arrivals: airports APOC, LTM/ATC at airport and in TMA, en-route FMP and Network. Pre-departure regulation of arrival time is linked to departure regulation (solution #18 from SESAR 1).

Expected benefits include an improved coherency between the different processes, enhanced predictability from common usage of the most up-to-date flight data by all users, including impact of already applied constraints, and minimised impact on Airspace Users operations.

Collaborative framework managing delay constraints on arrivals	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #07-01 and #07-02 in Wave 1 and covers the following OI steps. There may be others to cover additional aspects e.g. iAMAN:

- *AUO-0109 - UDPP for Airport constraint*
- *AUO-0110 - UDPP for network constraint*
- *DCB-0213 - Consolidation and facilitation of Target Times between local DCB, Airport CDM and Extended Arrival Management.*

3.6 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ09 W2 Digital Network Management Services”

3.6.1 Problem statement and R&D needs

Today, air traffic flow and capacity management (ATFCM), airspace management (ASM) and air traffic control (ATC) are still separated processes and the interfaces between ATFCM, ASM and ATC processes and systems require further integration, as well as full collaboration between ATM actors and airspace users. Also, the sharing of airspace information is not optimally adapted to Aircraft Operators (AO) and other Airspace User (AU) processes, which is leading to limited usage of available dynamic configurable airspace. Similarly, the current ATM environment provides neither an accurate prediction of traffic and relevant measurements of its uncertainty nor the sector predicted workload with a confidence index, with which to determine efficient airspace organisation.

The organisation of resources across Area Control Centres need to be improved as well as the scoping of measures from local level to full network impact assessment, and the promotion of opportunity measures over those with implication on airspace users costs. The operational data shared in the network operations plan (NOP) has to be expanded in scope and time horizon to integrate more tactical (real-time) dynamic airspace configuration and Airports data. The relevant information should be accessible to everyone and distributed in a transparent but cohesive way with the aim of ensuring sufficient flexibility in the short term DCB phase and the efficient ATC involvement in the DCB process execution. Accurate traffic prediction has to be made available to all actors concerned (e.g. NM, AUs, ATC) from medium-term planning till execution of the trajectories for managing traffic complexity, solving traffic constraint issues and optimising the performance of the network. Relevant indicators to assess DCB measures and monitor execution against the predicted impact on network performance need to be defined and provided through automated tools enabling what-if and what-else analysis.

3.6.2 Performance expectations

Under this topic, solutions will be developed that are expected to have a positive impact on the Network improving:

- Capacity through a dynamic airspace management responding with flexibility to the Airspace users' flight trajectory needs;
- Safety: Improved safety in better anticipating and managing potential overloads;
- Efficiency thanks to the monitoring of the DCB measures and network performance and the implementation of corrective actions;
- Cost-efficiency: DCB allows improved ATM resource planning and better use of existing capacities leading to reduced ATC and Airport Capacity costs;
- Predictability: the NOP will provide the planned network situation considering all known constraints and time deviation will be managed by anticipating demand/capacity imbalance detection and improving the implementation of DCB solutions;
- Flexibility: common awareness to all stakeholders through the NOP and access to opportunities in case of late changes in capacity or demand.

3.6.3 List 1 SESAR Solutions

The proposal shall address, as a minimum, three solutions from List 1:

3.6.3.1 Solution PJ.09-W2-44 Dynamic Airspace Configurations (DAC)

The objective of the solution is to improve the use of airspace capacity for both civil and military users by increasing the granularity and the flexibility in the Airspace Configuration and Management within and across ANSPs' areas of responsibilities, resulting in better Network and Local performances. This Solution will continue the work performed by PJ08-01 in Wave 1 (except for DMA type 1 and 2 topics under the scope of solution candidate 40) regarding the integration of concepts and procedures to allow flexible sectorisation boundaries to be dynamically modified based on demand (Free Routing trajectories and AFUA needs - VPAs and Type 1 and 2 DMAs) so that the ATM environment matches resources to daily-changing hot-spots. It addresses the full assessment of the operational CDM process for the application of the DAC concept, the required DAC/DCB coordination to determine optimum/possibly combined DAC/DCB solutions to cope with hotspots. This includes potential implications for ATCO licences, international boundaries and potentially IOP and A/G multi-datalink communication capabilities.

The above mentioned CDM process will cover the full sharing of DAC information via the NOP, between ANSPs, Network manager and AUs beyond the current notification processes (CDR route, AUP/UUP), as well as the developments of capabilities to allow AUs to contribute to the DAC process before its completion.

Finally it covers the management of RBT in execution phase according to DAC evolution e.g. consideration of TTO/TTA management, ATC interface, etc.).

The research shall address any relevant transition issues. Additionally, building on what has been done in PJ.08-01, there is a need to research into how dynamic sectors are created and shaped (laterally and/or vertically), using available DCB information (e.g. demand prediction, complexity and workload) as well as novel artificial intelligence techniques. To this regard, innovative solutions will be assessed to maximise the effectiveness of the capacity management processes taking full advantage of the available trajectory information in a Trajectory-Based Operations environment.

The solution shall consider the impact on ATC team operations.

The SESAR solution shall address:

- The application of more advanced types of airspace use coordination processes (if any) than those under the scope of solution #08-01 is wave 1 e.g. processes that require the integration with DCB, etc.;
- The user acceptability and feasibility of the proposed Dynamic Airspace Configurations (DAC) solutions;
- Potential means for the visualization of airspace configuration changes for different actors;
- The required system developments and further automation to support the AUs to define DMAs and develop their trajectories;
- The solution covers the developments of "What-if" and automated tool functionalities for airspace management process, the potential use of AI, machine learning techniques to improve this process, and virtual reality to increase the relevant actors' understanding of the airspace configurations, etc.

The SESAR solution requires coordination with solution 40 "Mission trajectories management with integrated Dynamic Mobile Areas Type 1 and Type 2", solution 45 "Enhanced Network Traffic Prediction and shared complexity representation" and solution 48 "digital INAP".

Dynamic Airspace Configurations (DAC)	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2	**V3 on-going**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #08-01 and covers the following OI steps:

- *AOM-0805 — Collaborative Airspace Configuration.*
- *AOM-0809- A— Initial Sector Design and Configurations Unconstrained by Predetermined Boundaries..*
- *AOM-0809-B —Advanced Sector Design and Configurations Unconstrained by Predetermined Boundaries.*
- *CM-0102-B — Dynamic Airspace Management based on complexity.*
- *DCB-0210 — Full integration of Dynamic Airspace Configurations into DCB*

The scope of the solution includes as well the integration with other SESAR solutions e.g. DCB, sector team operations, and therefore the Solution may need updates in terms of the OI steps.

3.6.3.2 Solution PJ.09-W2-49 Collaborative Network Performance Management

The aim of this SESAR Solution is to provide a common framework and toolbox to the other solutions and actors, allowing them to assess the Network Performance in the pre-tactical and tactical phases of the Network Management. The solution shall advance the work started in Wave 1 in Solution #09.01 to further establish a performance driven network management culture.

Transparent and shareable network performance indicators (PI) - The solution will complement the current network performance management process focused on delay reduction by a shared situational awareness and an agreed set of performance indicators to be used for real time performance monitoring in support of network operations including trade-off indication and “what-if” impact assessments. The aim of these indicators shareable via the NOP is to encourage every individual actor to contribute actively to the overall objective of optimizing the network performance and thus to achieve mutual benefits for all stakeholders. The performance indicators measured at individual actor level shall take into consideration whenever a given actor has endorsed penalizing measures for the actors’ interests for the benefit of the network performance.

In order to adapt to the diversity of network operations, the Network PIs need to be dynamically selected according to network geographic interest scales and specific time horizons. Common local and regional impact /status indicators will be used including their relation considering a selected set of network congestion mitigation strategies. Therefore, performance driven network management presumes an integrated transparent collaboration culture to share constraints and enable joined coordination to find agreed solutions among all stakeholders. Thus, it shall also take into account the outcome and lessons learned from the Collaborative DCB Framework elaborated in Wave 1 Solution #09.03.

NMOC supervision and awareness based on Network state monitoring and prediction - Solution shall further develop the concept of Network resilience and network states, with a clear focus on more data driven prediction of network state evolutions (advanced data science techniques to be applied). This includes the development of advanced performance monitoring tool to improve awareness of network performances. Depending on specific network states (elaborated in Wave 1) and different intended network scales, the individual set of effective indicators may vary. Based on an identified common pool of indicators and a pre-defined collaboration policy, these indicators are going to be selected and weighted/prioritized according to individual interests and needs.

The network awareness functions may include the awareness of CNS status across the network e.g. RFI interference (link to solution 79 “DF/MC GNSS/SBAS and GBAS”), as well as the interface to make CNS status available to ANPs in real time (link to Solution 76 “Integrated CNS and spectrum”).

Network performance What-If and What-else capabilities - It is the aim of the consolidation and performance trade-off analysis to regularly balance stakeholder needs by an arbitration process among all stakeholders and thereby to identify most pressuring performance needs, whether on the regional or on the local network scale. The fair spread of advantageous and disadvantageous decisions for individual stakeholders shall be one of the major criteria of the envisaged collaboration concept.

It is therefore important to not only negotiate decisions on a peer-to-peer basis, but to consolidate all relevant information, which will conduct the trade-off between stakeholder interests and performance needs on the basis of an air traffic flow oriented cost formulation. The Wave 1 research covers only a "manual" trade-off, whereas the Wave 2 shall explore more advanced tool assisted trade-off mechanisms. The outcome of several ATM performance related SESAR ER projects, e.g. INTUIT, APACHE and AURORA shall be taken into consideration.

This SESAR solution includes the use of data analytics and may include the use of AI, deep-learning techniques, etc. for continuously improve the underlying algorithms related to the what-if and what-else functionalities, dynamically identify trends and patterns, digital means to collect and share information and needs from the various stakeholders, at local/sub-regional levels (as an intermediate layer with the NOP), etc.

The R&D topics to be covered:

- Transparent and shareable network performance PIs and needs/constraints of each stakeholder (impact/status indicators);
- NMOC supervision and awareness based on Network state monitoring and prediction;
- Network resilience concept;
- Network performance What-If capabilities (focus on Tactical phase - in support of operations).

The solution may take into consideration the more relevant and mature results from the ER project COCTA “Coordinated capacity ordering and trajectory pricing for better-performing ATM”.

Collaborative Network Performance Management	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3 on-going**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #09-03 and covers the following OI steps:

- *DCB-0214 — DCB What-if Network Impact Assessment*
- *DCB-0212 — Network Performance Assessment for Distributed Network Operation*

3.6.3.3 Solution PJ.09-W2-47 Network optimisation of multiple ATFCM time based measures

This SESAR Solution aims at improving the efficiency and reducing the adverse impact of multiple regulations affecting the same flight or flows. It explores the relationships between the DCB regulations and their interactions trough the flights to quantify the network effect of those interactions. The solution will build up on the results from Wave 1, which demonstrated that due to the network effect, interactions between multiple regulations may have positive or negative side effects.

Key to this solution is to identify and avoid regulations with negative impact on network performance either in form of overprotection leading to unexploited capacities or in form of overloads created in other areas. On the other side, cleverly placed regulations minimize the adverse impact on the traffic flows and airspace capacities. Due to synergy effects, a number of regulations could be avoided or down tuned into a set of "cooperative regulations" leading to a "smart regulation scheme" which has the potential to solve multiple constraints at the same time with minimum interference to the rest of the air traffic and ATC capacities.

The research may include the use of big data and machine learning to identify best practice regulation strategies for particular traffic load patterns based on historic data. The archive regulation strategies will be complimented by the results from multiple network simulations to develop optimized strategies for the most frequent traffic load situations in the European ATFCM network.

This is a follow up work from Wave 1 in #09.03 and PJ24 that aims at achieving a pre-industrial phase of maturity (V3). The intention is not to propose full CASA integration, but rather to build a dedicated regulation optimization support tool for a human operator. It shall include not only visualization of the flights and airspace volumes impacted by multiple regulations, but also to explore the possibility to optimize the use of regulations. The aim is to achieve a pre-industrial phase of maturity (V3). The intention is not to propose full CASA integration, but rather to build a dedicated regulation optimization support tool for a human operator.

The solution requires coordination with candidate solution 39 "Collaborative framework managing delay constraints on arrivals".

Network optimisation of multiple ATFCM time based measures	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #09-02 and #09-03 and covers the following OI steps:

- *AUO-0108 — Most Penalizing Delay based on reconciliation between DCB and Airport CDM.*
- *DCB-0215 — Consolidation of imbalances and arbitration of Trajectory Management solutions.*

3.6.3.4 Solution PJ.09-W2-45 Enhanced Network Traffic Prediction and shared complexity representation

This SESAR Solution aims at improving the accuracy of the network manager traffic prediction from medium-term planning phase (D-2) to execution (included), relying in particular on new trajectory management features such as the preliminary FPL (see solution 38). It shall adapt existing methodologies and algorithms for demand prediction and regional complexity assessment. The solution continues and completes the work done in Wave 1 by solutions #09-01 and #09-03. It shall also consider the outcome of the relevant ER projects such as COPTRA and DART.

In the time horizon of D-2 and D-1, this solution explores improvements originating from latest slots updates provided by slot coordinated airports and the calculation of more accurate network predicted flight data. The solution aims to integrate the latest slots updates with the predicted flight data (PFD) to be able to confirm or not the predicted flight and to update to latest changes.

Predicted flight data are built from historical data and schedule data from airlines and airport slots. The solution will improve the algorithm for the PFD route assignment based on AI (follow-up of Wave 1), and will explore improvements for the IATA/ICAO call sign mapping a must for matching schedule and flight plan data. These elements support the concept of the dynamic/ rolling predicted flights that represents a step ahead from the more static today's approach.

In early D day, preliminary FPL from FF-ICE would be integrated (dependency with Solution 38 "Enhanced integration of AU processes for trajectory definition in planning phase and network management processes").

During the D day, imbalances from locals and possibly complexity shall be integrated by a common and sharable representation of the complexity (dependency with solution 48 – Digital INAP, for local complexity assessment). The solution will provide relevant actors, e.g. NMf, Extended ATC planning roles, with an accurate and timely prediction of imbalance. In addition, the improved traffic prediction is a necessary input for the tolls used to manage hotspots and complexity resolution.

During execution, the solution shall explore the integration of the download trajectory EPP.

The main performance objective is to reduce capacity buffers through improved trajectory prediction and the resulting impact on traffic demand forecast.

This solution shall be in line with the agreed NOP principles & requirements. The solution may explore the integration of new capabilities provided by FO/IOP, both in planning and execution.

Enhanced Network Traffic Prediction and shared complexity representation	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

The SESAR solution requires coordination with solution 40 "Mission trajectories management with integrated Dynamic Mobile Areas Type 1 and Type 2", solution 48 "digital INAP", solution 49 "Collaborative Network Performance Management" and solution 44 "Dynamic Airspace Configurations (DAC)". The solution shall take into consideration the activities undertaken by VLD project PJ24 in wave 1.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #09-01 and covers the following OI steps (that may be adapted, or require new OI steps e.g. use of EPP):

- *CM-0103-B — Automated Support for Traffic Complexity Assessment (the part related to complexity assessment at network level)*
- *DCB-0211 — Traffic & Demand forecast in 4D trajectory management context.*
- *DCB-0103-B — Collaborative NOP Step 2*

3.6.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.6.4.1 Solution PJ.09-W2-48 Digital Integrated Network Management and ATC Planning (INAP)

Today there is still a gap between the management of traffic flows at network level (dDCB) and the control of flights in individual sectors. The SESAR solution "digital INAP" aims at filling in that gap, developing and integrating local functions and associated tools, roles and responsibilities that address demand & capacity balancing issues with the network management function. The solution provides an automated interface between Local NM and ATC Planning to assist controllers in alleviating traffic complexity, traffic density, and traffic flow problems. The solution continues and completes the work performed in Wave 1 under solution #09-02. In particular, the SESAR solution intends to:

- Enhance network performance through the coordination between DCB and DAC, based on the implementation of established CDM process and on the improvement of ATM resource management efficiency;

- Provide support to the planning control service (e.g. Multi Sector / Extended ATC Planner) to better manage traffic e.g. smoothing flows of traffic and de-conflicting flights, interaction with trajectories in terms of level/ speed, etc. in a multi-sector/multi-unit and dynamic airspace management environment;

- Provide support to INAP actors for the identification and resolution of local hotspots in a fully integrated way while evaluating the impact of these actions from the performance point of view, both at local level and at Network level. DCB solver (HORA, Cop-Organizer...) should represent a step beyond with the introduction of Automated Aid Tool for the Hotspot/Optispot resolution (use of AI to identify the best potential set of solutions: capacity and demand type measures, airborne and ground, flow and cherry picking, etc.);

- Integrate FMP and Extended ATC Planning activities into a single working environment, and share the ATFCM situation awareness on both DCB and ATC sides. Local solutions proposed by the ANSPs are integrated with the Network Manager and other relevant stakeholders e.g. airports, AUs and neighbouring ANSPs. Interface between the local ATC system and the NM is also under the scope of the solution;
- Enhance the coordination between all the actors involved, including AUs, with CDM;
- Taking into account additional information from CDM, provide the best trade-off between optimizing individual trajectories and ATM resources through the coordination of the most adequate complexity and workload resolutions measures in line with both DCB and ATC operations;
- Develop a shareable congestion level indicator: the outcome of the local complexity assessment shall be common and shareable via the NOP.

The solution implies the integration of local tools with the network management function, the integration of various information sources e.g. MET, local trajectory prediction, NM B2B/SWIM data, MTCD, complexity, additional parameters coming from AUs, etc.), and the development of automated notification systems that allow the smooth collaboration of all actors.

Digital INAP applies to a timeframe approximately up to 15 minutes before the sector entry, facilitating a seamless transition from long-medium term planning to short-term planning – execution phases. In terms of performance benefits, the solution aims at improving cost-efficiency.

The solution also covers the development of the required automated tools and the use of best available information to continuously monitor and evaluate traffic workload and complexity in defined airspace volumes according to predefined parameters. These advanced complexity assessment tools will provide accurate and timely prediction on upcoming congestions and appropriate input for the extended ATC planner to monitor and assess ATC workload/complexity and to provide input to complexity resolution.

The work in wave 2 shall carefully investigate the change in Roles and Responsibilities, within the scope of the solution, and especially the interactions/responsibilities between INAP and the control team (EC/PC).

It is acknowledged that the whole scope of the solution will not be able to reach V3 maturity at the end of Wave 2. However, the target maturity level has been set to V3 because it is expected that some elements of the solution will reach V3, and these must be documented in a V3 datapack. The solution should therefore plan on delivering both a V3 datapack for the elements that are ready to progress to implementation and a V2 datapack for those that are not.

Digital Integrated Network Management and ATC Planning (INAP)	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2 on-going	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #09-02 and covers the following OI steps:

- *CM-0104-B — Automated support to INAP (Integrated Network Management and Extended ATC Planning) function.*
- *CM-0302 — Ground based Automated Support for Managing Traffic Complexity Across Several Sectors.*
- *CM-0103-B - Automated Support for Traffic Complexity Assessment (but the scope should be limited to the local tools, since network aspects are covered in candidate solution 45).*

3.7 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ10 W2 Separation Management and Controller Tools"

3.7.1 Problem statement and R&D needs

Current operations within continental En-route and TMA airspace are based on sectorisation structures that intend to handle the traffic demand according to the capacity of the controllers to handle it. It results in the tactical use of multiple radar vectors and stepped climbs and descents to maintain separation between aircraft in high traffic situations. This leads to less efficient flight profiles and high levels of workload for both ATC and the flight crews. It makes it also very difficult to balance the operators' requirements in terms of flight efficiency (notably user-preferred trajectories) with the need for overall capacity, safety of the operations and ATC workload. Occasionally, where no further splitting of sectors is possible due to limited controller resources, the sector demand exceeds the available controller capacity resulting in flow restrictions, level-capping and other measures that ensure safety at the expense of flight efficiency and timeliness. Future En-Route and TMA environment is anticipated to be even more loaded and complex than today's.

New system functionalities and further steps of automation provide the chance to achieve significant operational benefits. New ATC tools and the development of new concepts will allow for sectorless environment (where appropriate) to suit various airspace structures like free route, various traffic levels and complexities. Controller productivity needs to be addressed with new team organisations to cope with the collaborative planning and control based on the unplanned boundaries concept.

In today's situation Air Navigation Service Providers (ANSPs) usually host a monolithic ATM system in each Air Traffic System Unit (ATSU) with very few information services and infrastructure elements being shared between the different centres. In the virtual centre approach, the controller working positions are decoupled and may even be geographically separated from the ATM information services that they consume, and these ATM information services may be shared between different ATSUs or even between ANSPs. The main benefits expected from the virtual centre approach are cost reduction and more flexibility to support load-balancing between the participating ATSUs, delegation of airspace or manage contingency situations. The development of technical services and common interfaces resulting from new technologies, working methods, service oriented architectures (SOA) and procedures would also need to address human factors considerations.

There is a need to increase the efficiency of using the CWP HMIs for the En-Route and APP ATC centre by exploiting the latest mature technologies and new interaction modes e.g. touch, gesture, voice, etc.

3.7.2 Performance expectations

The solutions under the scope of this topic are expected to have a positive impact on the Network improving:

- Safety by being flight centric focused in particular in Free route environment and a reduction of the potential conflict that are laterally far better distributed over the airspace;
- Capacity thanks to the reduction of the partitioning of the airspace (sectors), the airspace capacity is no longer restricted by sector capacity and thanks to the reduction of the controller workload (reduction of sectors handovers) that would lead to increase the amount of flights per ATCO;
- Efficiency with a reduction of coordination and handover the pilot has to comply with and the set up;
- Flexibility thanks to the load-balancing or the management of the contingency situations between ACCs and controllers when applying virtual centre concept;
- Cost-efficiency thanks to the interoperability between system and the decoupling of the ATM data provision from the ATC service provision enabling data to be shared between different ATSUs.

3.7.3 List 1 SESAR Solutions

The proposals shall address the three solutions from List 1, taking into considerations the expectation in terms of maturity:

3.7.3.1 Solution PJ.10-W2-73 Flight-centric ATC and Improved Distribution of Separation Responsibility in ATC

The solution covers a concept that consists of assigning aircraft to ATCOs without references to geographical sectors, and have the aircraft controlled by that same ATCO across two or more geographical sectors. The pure flight-centric criterion for allocation is based on distributing workload as evenly as possible, with the objective of increasing controller productivity (by avoiding lost productivity in under-loaded sectors). An alternative non-geographical allocation criterion has been defined in Wave 1 for the TMA environment, and is based on assigning arrivals to one team of controllers, departures to another team of controllers. In both cases, the conflicts between two aircraft assigned to different controllers happen more often than when traditional geographical sectors are used, and usually only at sector boundaries will conflicts involve two controllers.

The solution requires flight-centric specific allocation, visualization (traffic filtering) and coordination tools (e.g. in the event of a conflict, establish which controller is responsible for its resolution). For high traffic densities, the concept also requires advanced CD&R tools that are not flight-centric specific, but may have specific functions to support flight-centric ATC (e.g. allocation of conflict to a controller, consideration of potential conflicts with a long look-ahead time to allocate when possible aircraft that may be in conflict to the same controller, etc.). In order to validate the benefits of flight-centric ATC, all CD&R support tools that may be used in sectored ATC shall be considered in both the reference and the solution scenarios, even if they have been developed specifically for this solution because they are considered to be a pre-requisite for flight-centric ATC.

The research may address the potential benefits of operating flight-centric ATC only at certain times e.g. night; in this case the concept element should address the transition between flight-centric ATC and normal sectored ATC. If the concept considers that flight-centric should be operated H24, then only the transition between neighbouring sectored ATC and the flight-centric area must be addressed.

The concept of collaborative control with planned boundaries, which was researched in wave 1 by #10-01c, is also included in the scope of this solution. In this concept, sectors are retained as they are today, with aircraft being assigned to a sector according to its geographic location, and with boundaries between sectors having planned coordination conditions like in current operations. By default, controllers are also assigned to a geographic sector and are responsible for aircraft in their sector, but some flexibility is added by allowing controllers to issue clearances without prior coordination to aircraft in a different sector without pre-coordination, e.g. via datalink, a downstream sector could clear an aircraft for descent while it is still in R/T contact with the upstream sector. In addition, controllers could issue clearances that infringe the default planned conditions without prior coordination.

Under the collaborative control with planned boundaries concept, all controllers in the collaborative control area are responsible for their own geographical sector as they are today, but they are also to a certain extent co-responsible for all the flights in the area; this is expected to allow for a more flexible use of airspace. The concept is expected to be applicable in high density airspace, allowing for planned boundary coordination levels to be waived with less coordination effort than what is required today, which should support improved vertical profiles.

The collaborative control with planned boundaries concept may also research a more flexible use of R/T; for example, the concept may include the skip-sector concept, which would allow aircraft staying in R/T contact with a single sector in the collaborative control area when flying across two or more sectors, in order to better balance the workload associated to R/T communications between sectors and limit the number of frequency changes for a single aircraft (skip-sector). Furthermore, the research may address the shared R/T frequency concept, which would allow two or more executive controllers that are assigned to different sectors to share a single R/T frequency. This may allow for further sector splitting in order to increase capacity where additional frequencies are not available. This concept is expected to be especially applicable for sectors where workload is high but not necessarily linked to R/T e.g. because of use of data link.

The collaborative control with planned boundaries concept may explore its applicability in different team set-ups, e.g. MSP, SPO. In the SPO set-up, controllers would work collaboratively in the area taking up both planner and executive controller responsibilities, allowing for the introduction of more sectors in order to increase capacity without necessarily increasing the number of ATCOs, the number of frequencies or the number of frequency changes required for a single aircraft.

This solution must address the challenges related to the legal responsibility for traffic separation in the collaborative control environment or flight-centric environment, which may include shared responsibility between controllers in the area and may also be linked to the performance of the support tools that support the concepts. In addition, the training needs and their impact on the controller validation scheme and training needs must also be considered for both concepts. In particular, the research should consider whether in a flight-centric environment it may be possible for controllers to be validated to provide service in a wider area than it is possible today with sector-based flight-to-controller allocation.

The flight-centric solution will usually require aircraft to remain in communication with the same controller during a longer period than in current operations, potentially beyond the coverage of a single VHF frequency. The concept allowing this is referred to as the wide area communication concept. In Wave 1, the research of the wide area communication concept has been conducted under the same solution as the flight-centric concept research (#10-01b).

The SESAR solution shall address the required enablers to support:

- Wide Area Communications to operate using the current analogue VHF system over a wide geographical area (i.e. beyond the coverage of a single VHF antenna) via multiple analogue VHF antennas or future digital voice system (e.g. using VoIP).

- In case digital voice is considered, the research should consider digital point-to-point vs. broadcast communication in different environments (from low density like in current oceanic operations to high-density European airspace).

- Wide Area Communications must consider an ECAC-wide deployment scenario, regardless of whether the chosen technology is digital voice or analogue VHF with extended coverage.

- For the case of analogue VHF system, the feasibility of migrating to a VHF frequency assignment plan supporting the new voice coverage will need to be assessed.

The future of controller-pilot communications requires a new concept of operations that includes voice and datalink. It is expected that this new "Controller-pilot communications CONOPS" will be developed by a separate SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The Wide Area Communications concept has been identified as highly relevant for this CONOPS; consequently, this solution should plan effort to support the development of the "Controller-pilot Communications CONOPS", e.g. by participating in the CONOPS development expert groups.

The SESAR solution shall address as well how network management is impacted, in particular ATFM processes.

Note that based on the feedback received during the project review in 2018, solution #10-01b may not achieve V2 at the end of Wave 1). If this is confirmed, the initial maturity level in Wave 2 will be adapted accordingly.

It is acknowledged that the whole scope of the solution may not be able to reach V3 maturity at the end of Wave 2. However, the target maturity level has been set to V3 because it is expected that some elements of the solution will reach V3, and these must be documented in a V3 datapack. The solution should therefore plan on delivering both a V3 datapack for the elements that are ready to progress to further industrialization and deployment e.g. Flight-centric ATC in Non-Geographically-Constrained, Low and Medium complexity environments and a V2 datapack for those that are not (covering for example Flight-centric ATC in Non-Geographically-Constrained High and very High Complexity environment).

The SESAR solution requires coordination with solution 77 "FCI services".

Flight-centric ATC and Improved Distribution of Separation Responsibility in ATC	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #10-02a in Wave 1 and covers the following OI steps:

- *CM-0200-B — Flight-centric ATC in Non-Geographically-Constrained, Low complexity En-Route environment.*
- *CM-0200-C — Flight-centric ATC in Non-Geographically-Constrained Medium and High Complexity En-Route environment.*

This SESAR Solution follows-up the work performed by SESAR Solution #10-01c in Wave 1 related to collaborative control with planned boundaries.

- *CM-0306 — Sector Team Operations Adapted to New Responsibilities and Operating Procedures involving reduced Coordination in En-route.*
- *CM-0309 — Sector Team Operations Adapted to Collaborative Operating Procedures involving reduced tactical co-ordination in the TMA.CM-0310 — Sector Team Operations Adapted to Collaborative Operating Procedures involving reduced tactical co-ordination in En-Route.*

Only the elements of these OI steps corresponding to the collaborative Control with planned boundaries concept will be relevant for this SESAR solution.

3.7.3.2 Solution PJ.10-W2-93 Delegation of airspace amongst ATSUs

The objective of this solution is to explore the different possible delegation of airspace amongst ATSUs based on traffic / organisation needs (either static on fix-time transfer schedule (Day/Night) or dynamic e.g. when the traffic density is below/over certain level) or on contingency needs.

The work in Wave 2 covers two threads:

- An operational thread, which aims at defining and validating the different types of delegation of airspace as described above.
- A technical thread, which aims at specifying the impacts of the operational thread on the services defined in the Virtual centre concept.

Operational thread:

The operational thread covers the Use Cases that are relevant for En-Route, TMA and ATFCM domains: Delegation of airspace amongst ATSUs for Traffic, Organisation or Contingency needs.

The operational thread shall:

- Describe the required operational services and environment description, including the conditions under which the delegation of airspace would be activated;
- Describe the operational transition from nominal control to delegation of airspace, and vice versa;
- Perform the required validation activities;
- Cost – benefit analysis;
- Assess safety and Human Performance impacts (especially the impact on roles and responsibilities between the ATSUs);
- Address business / legal issues.

The solution will provide a means for ATSUs to be able to answer the different needs:

- The delegation plan could be based on fix-time transfer (Day/Night) or dynamic transfer based on Traffic with the purpose of load balancing between ATSUs. Civil/ Military ATSUs will have the possibility to delegate the airspace to another ATSU while there is guarantee of the seamless ATS service provision in the delegated airspace. The combination of individual delegation plans will constitute a European Delegation of Airspace Plan. Relevant use cases and operational procedures have to be defined to support these different types of delegation.
- To rely on each other in case of contingency, each ATSU's contingency plan (part of an integrated a European Contingency Plan) is supported by this SESAR solution so in case of failure a given ATSU can transfer the responsibility to other ATSUs. Use cases, operational procedures have to be defined to support this European approach. Based on EU Regulations (IR 1035/2011), ANSPs must establish contingency plans for their provided services in the case something happens that leads to a degradation of these services. New possibilities for on-site / remote contingency solutions exist to make the system more resilient and remedy the impact of events such as terrorist attacks, infrastructure critical failures, weather catastrophes, etc.
- The solution shall consider the issue of controller validations for contingency as well as for routine operations. Note that the validation for contingency may consider reduced capacity for solving the contingency situation.

Delegation of airspace amongst ATSUs	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V1	**V3**

Note: the initial maturity level V1 at the beginning of wave 2 assumes that initial work on the operational use cases and controllers validations has been addressed by #16-03 in wave 1 (an action is on-going between SJU and #16-03 to cover this gap).

The validation exercises of this operational thread could be conducted with Virtual Centre based platforms or Ad-hoc platforms or combination of the 2 types. The validation scenarios may include:

- The full transfer of responsibility of one of more sectors from one ATSU to another ATSU in case of contingency;
- ATSU consolidation at times of low-demand;
- A single contingency ATSU to be used to cover the contingencies of two different ATSUs;
- Consolidation of the radar approach service with the tower service in a conventional/remote tower, so that both services can be delivered by a single controller at periods of low demand, e.g. during the night.

Technical thread:

The technical thread will focus on the impacts of the Use Case Delegation of airspace on the services defined in the Virtual Centre concept.

Virtual Centre definition: a virtual centre is a single Air Traffic Service Unit (ATSU) or a grouping of collaborative ATSUs using data services provided by ATM Data Service Provider (ADSP). The concept provides, at least, geographical decoupling between ADSP(s) and some ATSU(s), through service interfaces defined in Service Level Agreements. One ATSU may use data services from multiple ADSPs, just as an ADSP may serve multiple ATSUs. The ADSPs provide ATM data services, such as flight data management & distribution, voice communication, surveillance, etc.

The objective of a virtual centre is to allow decoupling that could deliver the flexibility and performance aspects of the services to ensure the ability of the virtual centre solution to at least support or to improve the operational performance. Performance benefits are related to improving cost efficiency of service provision, capacity, interoperability and flexibility.

The technical thread follows-up the work performed in Wave 1 by solution #16-03 that may reach TRL-6 maturity for the use case related to rationalisation of Infrastructure and some deployment options. In particular, the effort in Wave 1 focused on:

- En-Route and approach domains;
- Virtual Centre ATSU is provided with all other ATC and Voice services consumed at the CWP (from one or several specialised ADSPs);
- Implementation options involving 1 ADSP (Data Services) and 2 ADSPs (Voice services).
- Technical validation of an initial list of services as Flight plan management and distribution, correlation, coordination & transfer and voice.

The technical thread shall address in wave 2:

- Virtual Centre support to the use cases of static and dynamic contingency and delegation of airspace, that require additional R&D and technical validation activities in the En-route and approach domains;
- Definition and validation of the required SDDs;

- More complex architectures and implementation options beyond those addressed by #16-03 involving multiple ADSPs;
- Safety and security considerations.

The activities shall cover: definition of functional and service architecture for the advanced virtual centre, definition of functional and non-functional requirements. Core part of the work shall be devoted to service definition and modelling. Technical validation work shall comprise as well developments of prototypes and validation platforms and the execution of verification activities (both for the service interfaces and safety and performance requirements).

The solution may explore the application of developments in new or enhanced aeronautical (AIM) information in order to improve the quality, consistency and usability of the information.

Relevant links to the ATM Master Plan Level 2 (DS18a):
This is a new SESAR Solution that needs to be created together with the required Operational Improvements steps (OIs) for future datasets.

3.7.3.3 Solution PJ.10-W2-96 HMI Interaction modes for ATC centre

The SESAR solution "HMI Interaction modes for ATC centre" addresses the development of new human machine interface (HMI) interaction modes and technologies in order to minimise the load and mental strain on the controllers in the ATC centre (especially under high traffic density/complexity situations). These improvements may be applicable in current operations and/or in future operational concepts still in development under the scope of other SESAR solutions.

The SESAR solution shall consider modern design and development approaches and methodologies such as modularity, SoA, adaptive automation, etc. as a mean to improve cost efficiency, maintenance and evolution of the CWP.

The objective is to improve ATCO productivity supporting the ATCO to get the benefits of a more automation level, while maintaining / increasing the level of safety. The SESAR solutions shall take into consideration the impact on human performance as well as the cost efficiency aspects of the proposed features.

The SESAR Solution includes, but not exclusively, the development of the following features that have been already addressed by solution #16-04 in Wave 1:

- Multi-touch input devices (matured in #16-04 up to TRL-4): is a technology that enables a surface e.g. touchscreen to recognize the presence of several points of contact with the surface. The results indicate that multi-touch systems are in general suitable to overcome mental bottlenecks in the human-system interaction.
- Automatic speech recognition (ASR): matured in #16-04 up to TRL-4, enables the recognition and translation of spoken language e.g. ATCOs commands into the system reducing their workload and improving safety e.g. reduce head down times of the controller.
- Attention control: attention control enables to guide the attention of the controller, especially in a highly automated environment to important events to support the future monitoring task

of the controller. For example, gaze detection (matured in #16-04 up to TRL-4) can assess and guarantee the quality of the controllers attention by capturing ATCOs' eye movements and therefore measure and monitor, in real-time, their level of vigilance.

- User Profile Management Systems (UPMS): to identify/authenticate the controller wherever he sits in the ATC centre e.g. speech, finger print, iris or face recognition etc. This feature has been also addressed by #16-04 up to TRL-4.

The solution addresses as well other elements not addressed in wave 1 under industrial research activities i.e. #16-04 such as: the integration of artificial intelligence (AI) and machine learning algorithms for the intelligent data provision to the controllers on the HMI (data should be only available and presented to ATCOs if needed in order to avoid information overflow), the application of machine learning to speech recognition for controller assistance (building on results from exploratory research project MALORCA). The presentation of the information to ATCOs should be intelligent, providing not only "raw data" but also why it is shown and what should be done based on the information. The interaction between controllers and AI/machine learning shall be addressed, in particular the interaction, interplay, division, etc. of labour and responsibility between humans and algorithms as well as the uncertainty in the situation. The solution should also address the means for explaining and justifying the deviations from the suggested decisions by the automated means e.g. AI.

The SESAR solution shall take into consideration the promising results of exploratory research project RETINA that addressed the application of Synthetic Vision (SV) and Augmented Reality (AR) technologies in the definition and design of new tools for controllers.

This requires operational validation, which may be undertaken independently of other SESAR solutions if a given new HMI feature is applicable and can provide benefits in SESAR KPAs (e.g. reduced workload, increase safety, etc.) in current operations, in which case the feature should become an independent SESAR Solution.

The SESAR solution shall consider the integration of the different HMI features developed for the ATC centre, not only from a technology perspective but also taking the HP, safety and other operational performance aspects into account.

HMI Interaction modes for for ATC centre	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #16-04 (but it may include additional features). The relevant enabler/enablers need to be created in the ATM MP Level 2.

3.7.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.7.4.1 Solution PJ.10-W2-70 Collaborative control and Multi sector planner (MSP) in en-route

SESAR solution #10-01c addresses in wave 1 the evolution towards a concept where the coordination between ATC sectors is by exception rather than by procedure. The work in wave 1 has covered two possible operating methods, collaborative control with unplanned boundaries and collaborative control with planner boundaries. This Wave 2 solution covers only the unplanned boundaries option; the planned boundaries concept is covered in Wave 2 under the solution 73 "Flight-centric ATC and Improved Distribution of Separation Responsibility in ATC".

In the collaborative Control with unplanned boundaries concept, the traditional requirement to coordinate traffic at all sector boundaries is waived for an area covering two or more sectors, and constraints are only applied when it is necessary to fulfil a specific ATM function, e.g. separation, or traffic synchronization. Controllers of the unplanned boundaries area work in a collaborative way, and are able to issue clearances into or operate traffic within all of the sectors in the area without the requirement to pre-coordinate. This concept is envisioned at being particularly well suited for groups of sectors for which there is a single MSP and traffic is not very high, but the research may explore additional team set-ups, e.g. groups of sectors with SPO at times of low traffic demand.

The collaborative control with unplanned boundaries concept may require the development of advanced controller tools that support reduced coordination, which must be developed within this solution. It is acknowledged that the support of advanced CD&R may also be required, but the development of such tools is out of the scope of this solution (development of CD&R tools should take place in other SESAR solutions e.g. solution 53 "Improved ground trajectory prediction enabling future automation tools" and solution 57 "RBT revision uplink supported by increased automation"). However, there may be a need to perform an adaptation of the use of the CD&R tools to the collaborative control environment, e.g. to determine which conflicts should be displayed to which controllers, or to support the pre-filing of coordination proposals.

This solution must address the challenges related to the legal responsibility for traffic separation in a collaborative control environment, which may include shared responsibility between controllers in the area and may also be linked to the performance of the coordination support tools.

In terms of performance benefits, the SESAR solution supports:

- Improved use of ATCO resources; and
- Improved fuel efficiency (improved aircraft profiles) thanks to less co-ordination constraints at sector and/or centre boundaries, better use of airspace and increase flexibility to airspace users.

The operational environment is both en-route and TMA. The SESAR solution covers scheduled, non-scheduled, general aviation and training flights (military flights will be supported as long as they are treated as GAT traffic).

The application of co-ordination-free transfer of control is likely to be deployed within a Centre. It may be possible at a later juncture to consider broadening the concept to encompass what are currently OLDI boundaries and enhancing the flight object to allow a similar option of co-ordination-free transfer at an Inter-Centre (network) level. Relevant SWIM services are Interoperability (IOP) and enhanced co-ordination messages across unit boundaries.

The SESAR solution continues the work performed in Wave 1 under #10-01c under the 'unplanned boundaries' thread.

At the date of the elaboration of this DOW, and based on the feedback received during the project review in 2018, it is expected that solution #10-01a will complete the validation of the solution "Multi Sector Planner (MSP) in en-route" during wave 1 (except Single Person Operations (SPO) that have been captured in a different OI step). In case this assumption is finally not confirmed, the SESAR Solution 70 shall complete the remaining work to complete V3 for the OI step CM-0303. The solution develops, for the en-route environment, the concept of operation and the required system support e.g. coordination tools for operating in a team structure where a Planner has responsibility for the airspace under the executive control of two or more independent Executive Controllers. The MSP is able to adjust the internal (executive) sector boundaries so that workload is balanced between the Executive controllers. The concept is primarily intended to be applied within a Unit and is based upon the capabilities of the local FDPS and/or Centre architecture to allow the allocation of a single Planner role to several Executive ones.

In terms of performance benefits, the SESAR solution is expected to significantly improve cost efficiency (less air traffic controller staff compared to traditional (current) one Planner – one Executive team organisation) and human performance.

Safety levels shall be maintained or increased. For that, the required system support shall be enabled by the development of new trajectory prediction, conflict detection, conflict and intent monitoring tools and flight conformance monitoring. However, these developments i.e. CD&R tools are not under the scope of this SESAR Solution that shall focus on coordination support tools.

Harmonization and integration aspects with local ATFCM processes need to be taken into account.

Collaborative control and Multi sector planner (MSP) in en-route	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #10-01a in Wave 1 and covers the following OI steps:

- *CM-0303 — Sector Team Operations Adapted to New Responsibilities in En-route, 1 Planning to several Tactical Controllers team structure.*
- *CM-0307 — Sector Team Operations Adapted to New Responsibilities in En-route, Single Person Operation.*

This SESAR Solution follows-up the work performed by SESAR Solution #10-01c in Wave 1 related to collaborative control with unplanned boundaries.

- *CM-0306 — Sector Team Operations Adapted to New Responsibilities and Operating Procedures involving reduced Coordination in En-route.*
- *CM-0309 — Sector Team Operations Adapted to Collaborative Operating Procedures involving reduced tactical co-ordination in the TMA.CM-0310 — Sector Team Operations Adapted to Collaborative Operating Procedures involving reduced tactical co-ordination in En-Route.*

Only the elements of these OI steps corresponding to the collaborative Control with unplanned boundaries concept will be relevant for this SESAR Solution.

3.8 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “PJ13 W2 IFR RPAS”

3.8.1 Problem statement and R&D needs

The number of remotely piloted aircraft systems (RPAS) is continuously increasing and this will imply higher interactions with the wider ATM system. IFR RPAS operation characteristics e.g. speed, manoeuvrability, etc., together with their avionic system equipage may differ substantially from conventional aircraft.

One basic principle underpinning the integration of IFR RPAS in ATM, in alignment with ICAO principles, is that RPAS have to be treated in a similar manner to manned aircraft while duly considering the specific character of remotely-manned operations. IFR RPAS must be transparent (alike) to ATC and other airspace users.

3.8.2 Performance expectations

This topic will develop solutions that are expected to have a positive impact on the Network improving:

- Safety thanks to the development of detect and avoid system for preventing collision with other traffic;
- Efficiency with the definition of adequate procedure and systems enabling the introduction of IFR RPAS in a controlled environment;
- Access and equity in enabling airspace access to new users.

3.8.3 List 1 SESAR Solutions

The proposals shall address, as a minimum, two solutions from List 1:

3.8.3.1 Solution PJ.13-W2-111 "Collision avoidance for IFR RPAS"

The solution will develop and operationally validate a Detect and Avoid (DAA) system for IFR RPAS.

In airspace classes A-C, ATC is responsible for separation provision for IFR aircraft. According to the Rules of the Air, and in common with manned aviation, the remote pilot is required to comply with ATC instructions at all times unless an emergency situation arises. It is important, therefore, to ensure that any capability provided by the DAA system does not interfere or counteract the normal execution of ATC, including responsibility for separation provision.

The purpose of a DAA system is to allow the remote pilot to contribute to safety by preventing collisions, should normal separation provision fail. According to ICAO SARPS currently under development, a DAA system has two functions:

- Collision Avoidance (CA); and
- Remain Well Clear (RWC).

The CA function that will be developed by this solution is intended as a safety net that will provide an additional safety layer in a similar way to the function performed by TCAS and ACAS X for manned aviation. CA manoeuvres will be executed by IFR RPAS without prior ATC clearance (equivalent to current TCAS resolution advisories - RA) which, in some cases, will cause the IFR RPAS to deviate from its ATC clearance. Once an IFR RPAS has deviated from its ATC clearance in compliance with an RA, or a pilot reports an RA, the controller will cease to be responsible for providing separation between that aircraft and any other aircraft affected as a direct consequence of the manoeuvre induced by the RA.

The validation will bring the solution to full V3. This requires that the integration of the CA and RWC systems with the rest of the avionics are fully addressed. The remote pilot's human performance must be assessed in human-in-the-loop simulations covering a comprehensive sample of conflict events. The project must also consider the potential impact on controllers' human performance of this solution, e.g. differences with respect to TCAS/ACAS X in the CA time threshold and of the RA being reported to ATC, impact of differences between the remote pilots' behaviour in conflict events from the behaviour expected from a pilot of a manned aircraft, etc.

The RWC function that will be developed by this solution is designed to provide the remote pilot with greater situational awareness, allowing him to comply with the ICAO Annex II section 3.2 requirement for taking responsibility for the safety of the aircraft and maintaining vigilance, without the use of an out-the-window view. It should be noted that the RWC function in airspace classes A-C does not provide an alternative means of providing separation, which is the job of ATC, and nor does it exist to compensate for systematic weaknesses in the RPAS system design, such as data-link latency or frequent lost-link events. In order to fly IFR in airspaces A-C, the RPAS must be able to perform to a sufficient degree so as to enable ATC to be the separator, and the DAA system must perform its role in that context. The development of the RPAS performance requirements that will be needed for operating in airspace classes A-C is out of the scope of this solution (it is in the scope of solution 115 'IFR RPAS accommodation in airspace A-C' and solution 117 'IFR RPAS integration in airspace A-C').

In the cases where, based on information from the RWC function, the remote pilot's assessment is that the current ATC clearance will not ensure that the RPAS will remain well clear from another (manned or unmanned) aircraft, the pilot will be expected to contact ATC and request a new clearance, unless an RA is initiated by the CA function. The execution of a manoeuvre to avoid a nominal loss of well clear without an ATC clearance by IFR RPAS will not normally be allowed in airspaces A-C, just as it is not allowed for manned aviation, except in situations where some other failure may make communication with ATC problematic.

It is clear, therefore, that Solution 111 must coordinate closely with Solutions 115 ‘IFR RPAS accommodation in Airspace Class A to C’ and 117 ‘IFR RPAS Integration in Airspace Class A to C’ in order to ensure that the specification for the CA and RWC functions match the operational requirements defined by those solutions, especially regarding the complex subtleties of the execution of RWC manoeuvres in airspace classes A-C. For the RWC function, appropriate time thresholds and airspace volumes for alerts and, where appropriate, advisories must be defined. For the CA function, the research must determine the time thresholds and volumes that will apply for RAs, and validate whether the implementation of the RAs should be automatic or manual, taking into account RPAS-specific issues such as data link performance. The research must also address how the operation will return to normal after the conflict has passed, taking into consideration the specificities of RPAS, and whether the implementation of the RA was automatic or manual. The work requires RPAS performance analysis and logic runs with the development of models and metrics, and may cover lateral avoidance guidance and manoeuvres.

Like for TCAS and ACAS X, it is expected that RAs for RPAS can be generated before ATC separation minima are violated and sometimes even when ATC separation minima will never be violated if the aircraft complies with its clearance. The research must consider this aspect in their definition of the time thresholds and volumes that will apply for RAs in the safety assessment. As specific separation minima for RPAS are currently not defined (currently the same as for manned aircraft), the project will need to use as inputs assumptions based on the activities being undertaken for the definition of separation minima by solution 115 ‘IFR RPAS accommodation in Airspace Class A to C’ and solution 117 ‘IFR RPAS Integration in Airspace Class A to C’.

The solution must be interoperable with TCAS and ACAS X, and consider interoperability with potential future CA solutions currently under development (e.g. work on CA for GA and rotorcraft by PJ.11 in Wave 1) and should assess its performance in the current and future (foreseen) ACAS regulatory environment in Europe, and/or propose an evolution.

Both cooperative and non-cooperative targets must be considered, but the development of sensors for detection of non-cooperative traffic is out of the scope of this solution, i.e. detection of non-cooperative targets for this solution must be done by radar or other enablers that are already mature, and what the research must establish is how the DAA system will process the non-cooperative targets. In airspace A-C all targets should be cooperative and the inclusion of non-cooperative targets in this DAA system covers the event of a malfunctioning transponder or a non-cooperative unauthorised intruder.

This solution must consider the work conducted in Wave 1 by PJ.11-A2 on ACAS Xu and PJ.10-05, as well as the relevant work conducted outside of SESAR (e.g. EDA research projects TRAWA and MIDCAS). Coordination with both EUROCAE WG-75 and WG-105 is required.

Both civilian and military airspace users should be considered by this solution. For the military airspace users, the research project must coordinate with EDA. The research must as a minimum define the set of RPAS platforms and typical flights/missions, so as to be representative of the initial demand that can be anticipated in the 2021-2025 timeframe. The task of identifying the initial demand must be conducted at the start of the project in cooperation with solution 115 “IFR RPAS accommodation in Airspace Class A-C”. It is anticipated that RPAS will be able to be accommodated in the shorter time frame through the definition of rules, procedures and requirements that, whilst still somewhat constraining RPAS operations, will allow them to start flying. It is not yet clear how much a DAA system will be required to support such accommodated operations, or which functions will be required. Consequently, this Solution must work closely with Solution 115 to ensure that the accommodation solution has a technical solution for DAA that is commensurate with the rules and procedures required to accommodate initial IFR RPAS operations.

Collision avoidance for IFR RPAS	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

CM-0808-u — Collision Avoidance for Remotely Piloted Aircraft

The solution will require additional Operational Improvements steps (OIs) for DS18b.

3.8.3.2 Solution PJ.13-W2-115 IFR RPAS accommodation in Airspace Class A to C

This SESAR solution is aimed at accommodating IFR RPAS in non-segregated airspace in the short-term, in accordance with the drone roadmap in the ATM Masterplan. The objective is to enable IFR RPAS operating from dedicated airfields to routinely operate in airspace classes A-C as GAT without a chase plane escort. The research shall consider a limited set of military or civilian RPAS platforms and missions/flights, so as to be representative of the initial demand that can be anticipated in the 2021-2025 timeframe

It is expected that a Detect and Avoid (DAA) system will be required for routine integration of RPAS, and may be required to enable IFR RPAS accommodation. However, development of the DAA system itself is not in the scope of this solution since there is a dedicated solution for this, which is solution 111 "Collision avoidance for RPAS". However, the R&D activities for the development of the collision avoidance (CA) and Remain Well Clear (RWC) functions need to consider the separation minima applicable to RPAS that will be developed by this solution, along with the operational requirements for RWC, which creates a dependency between this solution and solution 111 "Collision avoidance for IFR RPAS".

The following considerations should be taken into account in order to ensure focus is on the short-term accommodation:

- The solution must develop and validate the concept of operations and corresponding operational requirements for initial accommodation, with a view on developing a solution that is V3 mature at the end of Wave 2;
- The identification of the initial accommodation needs for the 2021-2025 timeframe is an important scoping activity for the research. A task needs to be planned at the start of the

project with the objective of producing a well-defined characterization of the accommodation needs both in terms of platforms and in terms of flights/missions that they will want to conduct in European airspace. This task needs to be performed in cooperation with solution 111 "Collision avoidance for IFR RPAS". It is anticipated that initial demand will include long-endurance flights. The initial scoping activity must research and clearly define what the specific demands related to the long-endurance of the flights are expected to be (e.g. re-plan during flight, en-route holding during re-plan, etc.), so that the research on accommodation can consider them;

- The research must take as a starting point the lessons learned from isolated non-segregated IFR RPAS operations that have already been conducted in European airspace and focus on overcoming the issues that have been identified to allow their scalability. The objective is to allow routine operations to be conducted in a safe and standardized way across Europe, including cross-border operations;

- In order to allow the accommodation to be possible in the short term, the accommodation solution shall consider that the communications between the remote pilot and ATC will be via the same voice radio frequency used by ATC to communicate with manned aircraft in the same sector (directly or through a relay). Alternative means of communication may be considered in the IFR RPAS integration solutions;

- Real time simulations must be the primary basis for the validation of this solution. The simulations must consider all relevant stakeholders (RPAS operator, communications service provider, ANSP and manned aviation) and be of a high-fidelity. The simulations must focus on the qualitative assessment of the impact that the proposed accommodation solution has on human performance and safety, as well as on quantifying the impact on traffic complexity metrics of the IFR RPAS flights and their potential impact on capacity and on DCB processes;

- It is expected that European ANSPs will handle an increasing number of demands for non-segregated IFR RPAS operations, which will continue to increase the knowledge on this field; the research in this solution can't be conducted in isolation of these ongoing developments. The solution must plan an activity to monitor relevant ongoing activities all along the conduct of the project in order to identify synergies and opportunities, and to modify the project execution in light of these developments;

- Dedicated flight-trials are not required; instead, the solution should plan a validation thread that can take advantage of the opportunities that are identified in the monitoring activity described in the previous bullet (e.g. participate actively or as observers in ad-hoc workshops where procedures to handle real demand are designed, collection and analysis of data from real operations, etc.). RTS exercises must take place in a fully-representative ATM environment, including en-route and terminal ATC, in order to test the full scope of unmanned operations;

- The solution must develop ATC procedures to allow accommodation. The research may also develop or adapt existing ATC tools. However, the constraint of this solution targeting V3 for the accommodation at the end of Wave 2 requires that developments to the ground systems be minimized (those should be considered by solution 117 'IFR RPAS integration in Airspace Class A to C'). The accommodation solution should answer the question 'How much and how can we safely accommodate with the systems we have today?', whereas the integration solution should look further ahead and develop whatever is necessary to allow full accommodation;

- The research must establish the potential impact on ATC capacity and efficiency of accommodating IFR RPAS, and produce guidance material for managing this impact (e.g. guidance for quantifying impact on sector capacity, guidance for quantifying the impact on SES flight-efficiency indicators);

- The solution must produce a Required Link Performance (RLP) to allow those functions that need to be conducted remotely to meet appropriate operational requirements as defined in the concept of operations (e.g. PBN alert, latency of voice communications, C2 link continuity and availability, etc.). Cybersecurity requirements for the RLP link must be established. The requirements may be linked to the operational environment (e.g. lower latency may be a requirement to fly in busier/more complex airspace);

- IFR RPAS operations conducted to date have shown that the specificities of RPAS contingencies require special consideration. Scalable lost C2 link procedures that allow routine accommodation shall be developed. The solution shall also establish guidelines and standard procedures for the handling of any other contingencies that are deemed necessary to support the accommodation safety case;

- The solution shall define the navigation performance requirements that are required in the accommodation phase, which may be dependent on the airspace in which the operations take place;

- IFR RPAS operations conducted to date have shown that separation minima applied between manned aircraft may not be enough for IFR RPAS. The solution shall validate a separation minima scheme (between IFR RPAS and between IFR RPAS and manned aircraft) that ensures that the operations are safe. For this accommodation phase, it is expected that the separation minima may be larger than they will need to be in the integration phase. The separation minima may include different minima depending on the navigation performance, the C2 Link performance or the applicable contingency procedures. It is expected that the IFR RPAS integration solutions may conduct research to refine the initial (more stringent) set of minima applicable for accommodation;

- Flight planning processes should be adapted on both the NM and the FOC/WOC side with the minimum changes required to allow the successful conduct of the type of flights foreseen for this type of operations (e.g. unmanned cargo aircraft, long-endurance flight operated by national security agencies). The research shall investigate which options may be available in the short term (i.e. implementable by 2025) for allowing changes to the flight plan during flight for long-endurance missions (e.g. partial flight-plan refiling for changes to the plan beyond a specific look-ahead time to be coordinated between FOC/WOC and the ATM system without involving the remote pilot and the ATCO). The process for recording flight-specific contingency planning in the flight plan will also be considered;

- Impact of vehicles with significantly different performance to manned aircraft on traffic complexity will need to be assessed, and in order to allow routine accommodation, ATC procedures and ATFM processes shall need to be updated accordingly;

- The development of a system performing the RWC function is being carried out by Solution 111 "Collision avoidance for IFR RPAS", and this solution must cooperate closely with them. The RWC function is designed to provide the remote pilot with greater situational awareness, allowing him to comply with the ICAO Annex II section 3.2 requirement for taking responsibility for the safety of the aircraft and maintaining vigilance, without the use of an out-the-window view. It should be noted that the RWC function in airspace classes A-C does not provide an alternative means of providing separation, which is the job of ATC, and nor does it exist to compensate for systematic weaknesses in the RPAS system design, such as data-link latency or frequent lost-link; in order to be able to operate IFR, the RPAS must be able to perform to a sufficient degree so as to enable ATC to be the separator. This solution must develop the operational requirements and procedures to cover RWC to support accommodation, especially regarding the complex subtleties of the execution of RWC manoeuvres in airspace classes A-C.

- The research should consider as inputs the following work:
  - Solution PJ.10-05 data pack: this accommodation solution must build on the most mature results that are implementable in the short term to allow accommodation, while the less mature results (or those requiring more changes) should be further researched by the IFR RPAS integration solutions;
  - EDA accommodation study;
  - EDA project ERA, in particular for contingency and emergency recovery; and
  - DESIRE project output.

The KPA for this solution is access and equity.

For military airspace users, the research project must coordinate with EDA both in the initial task of identifying the platforms that are foreseen to constitute the demand in the 2021-2025 time period and all along the conduct of the project.

In accordance with the ATM Master Plan, research into accommodation is expected to develop a short-term accommodation solution (solution 115), but the ultimate goal is to achieve full integration (solution 117). Both will be researched in parallel; solution 115 will be looking at accommodation of limited numbers of RPAS (initial demand) with minimum change to operations and systems, while solution 117 will be researching full integration, and may propose significant changes where needed in order to reach the integration goal. There is a strong dependency between these two solutions.

IFR RPAS accommodation in Airspace Class A to C	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2	**V3**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required Operational Improvements steps (OIs) for future Integrated Roadmap datasets. Note that solution #10-05 has addressed OI step AUO-0618 in wave 1, and this OI step may need split between candidate solutions 115 and 117.

3.8.3.3 Solution PJ.13-W2-117 IFR RPAS integration in Airspace Class A to C

This SESAR solution aims at providing the technical capabilities and procedural means to allow IFR RPAS to comply with ATC instructions and the development of new procedures and tools to allow ATC to handle IFR RPAS in a cooperative environment in full integration with manned aviation. Integrated surface operations are out of the scope of this solution.

The research will take into account the impact on ATC of different automation levels of IFR RPAS. It is expected that a Detect and Avoid (DAA) system will be required for accommodation, but its development is not in the scope of this solution; there is a dedicated solution for this, which is solution 111 'Collision avoidance for RPAS'. However, the R&D activities for the development of the Collision Avoidance (CA) and Remain Well Clear (RWC) functions need to consider the separation minima applicable to RPAS that will be developed by this solution, which creates a dependency between this solution and solution 111.

The SESAR solution includes the development and validation of the operational concept and technical enablers for the integration of IFR RPAS in European airspace in airspace classes A-C:

- Development of operational requirements and technological solutions for communication between ATC and IFR RPAS (R/T and CPDLC, both direct from ground-stations and via satellite communications relay, and/or ground-ground link between controller and RPAS pilot), with the consideration of the performance of each of the options;

- Research for characterizing, quantifying and assessing the impact of the communications performance of satellite-based relays when complying with ATC instructions (this includes the combination of the latency of the communication from ATC to the RPAS pilot, the time for the RPAS pilot to introduce the command in the RPS and the communication from the RPS to the RPAS for implementation);

- Development of IFR RPAS RLP for operating airspace classes A to C. The concept may consider the creation of airspace sub-classes with different performance requirements (e.g. less stringent latency requirements in low density airspace, but potentially with higher separation minima between IFR RPAS, and between manned aircraft and IFR RPAS);

- Investigation of the potential need for modified separation minima between IFR RPAS and between manned aircraft and IFR RPAS, including both wake and radar separation minima. Where necessary, new criteria should be developed and validated by this solution. The research on the definition of new separation minima must be coordinated with solution 54 "Digital evolution of separation minima in en-route and TMA";

- Assessment of navigation performance requirements for RPAS, including assessment of the ability of an RPAS to execute existing published procedures, and development of new procedures if necessary;

- Development of contingency procedures and supporting technology, considering in particular the lost-link contingency, including in particular determination of the time milestones after a failure to communicate in which the link is to be considered lost, and addressing in particular the intermittent lost-link contingency;

- Development or adaptation of ATCO procedures and support tools for handling IFR RPAS. This may require the adaptation of current CD&R tools in order to account for the specificities of IFR RPAS (e.g. different performance models, adaptation of the TP, etc.);

- Assessment of the impact on ATC of the increased variety of performance envelopes and RPAS characteristics, and assessment of the impact on the complexity metrics used to support demand and capacity balancing;

- Adaptation of the network manager function (procedures and systems) to integrate IFR RPAS traffic. This should take into account IFR RPAS specificities such e.g. long persistence of IFR RPAS flights in the same area, etc.;

- Development of Flight Operation Centre procedures and systems (FOC/WOC) for IFR RPAS including flight planning, consideration of contingency procedures in the flight planning phase and coordination with the network. For long-endurance missions, the solution shall allow making modifications to flight plans after the mission has started, with processes that may be different depending on the look-ahead time. In particular, the solution shall investigate the possibility that changes to the flight plan during the flight execution that are submitted sufficiently in advance are processed between NM and the FOC/WOC without the involvement of ATC;

- The development of a system performing the RWC function is being carried out by Solution 111, and this solution must cooperate closely with them. The RWC function is designed to provide the remote pilot with greater situational awareness, allowing him to comply with the ICAO Annex II section 3.2 requirement for taking responsibility for the safety of the aircraft and maintaining vigilance, without the use of an out-the-window view. It should be noted that the RWC function in airspace classes A-C does not provide an alternative means of providing separation, which is the job of ATC, and nor does it exist to compensate for systematic weaknesses in the RPAS system design, such as data-link latency or frequent lost-link; in order to be able to operate IFR, the RPAS must be able to perform to a sufficient degree so as to enable ATC to be the separator This solution must develop the operational requirements and procedures to cover RWC to support integration, especially regarding the complex subtleties of the execution of RWC manoeuvres in airspace classes A-C.

The solution should address IFR rotary wing RPAS as well as fixed wing.

HALE IFR RPAS may operate long portions of their flights in uncontrolled airspace (above class A airspace). It is expected that as the density of IFR RPAS operating in this area increases, may become necessary for ATC to provide separation between IFR RPAS operating above manned aircraft. Even though this SESAR solution only concerns airspace classes A-C, it must also develop criteria to determine when a separation provision service between HALE RPAS flying at high altitude is necessary (e.g. above a certain density of HALE flights), and provide recommendations for either extending class A airspace above its current limits or propose the creation of a new class of airspace to cover this specific service provision. The potential involvement of ATC and NM in the control of access of HALE IFR RPAS to uncontrolled airspace (which takes place through class A airspace) is also in the scope of this solution.

In accordance with the ATM Master Plan, research into accommodation is expected to develop a short-term accommodation solution (solution 115), but the ultimate goal is to achieve full integration (solution 117). Both will be researched in parallel; solution 115 will be looking at accommodation of limited numbers of RPAS (initial demand) with minimum change to operations and systems, while solution 117 will be researching full integration, and may propose significant changes where needed in order to reach the integration goal. There is a strong dependency between these two solutions.

There is also a dependency between this solution and solution 54 "Digital evolution of separation minima in en-route and TMA".

References:

- DESIRE II (EDA);
- ERA (Enhanced RPAS Automation);
- Solution #10-05 data pack;
- EDA in general;
- ICAO RPAS Panel;
- JARUS;
- GSA Projects;
- EUROCONTROL RPAS Operational Concept; and
- EUROCAE RPAS Standardisation (WG75 and WG 105).

IFR RPAS integration in Airspace Class A to C	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #10-05 in Wave 1 but with an enlarged scope that may need additional OI steps beyond the following one:

- *AUO-0618 — Enabling integrated RPAS IFR operations.*

3.9 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ14 W2 Integrated CNSS"

3.9.1 Problem statement and R&D needs

Communication, Navigation and Surveillance, except for few cases, are actually significantly relying on national infrastructure deployed and operated by Air Navigation Services Providers. This leads to a deployment of technologies based on local/national choices and priorities resulting in un-synchronised, un-homogeneous and fragmented deployments. Some of these technologies have been in operation since decades and are not capable to support the automation of the ATM and the future need of airspace users including new entrants (e.g. RPAS). New technologies are being introduced. However, optimisation of the infrastructure has not largely been undertaken resulting in accumulation of legacy and new technologies having negative impacts of cost of operation and maintenance, spectrum usage, number of embarked systems.

Performance requirements for Communication, Navigation and Surveillance (CNS) systems are becoming increasingly complex and demanding considering convergence towards a common infrastructure, and a unified concept of operations (CONOPS) across the different (COM, NAV and SUR) domains. The new technical capabilities must be developed to fully meet the requirements derived from operational needs, taking into account the new emerging CNS technologies.

3.9.2 Performance expectations

While the technological solutions developed under this topic do not have direct impact on operational key performance areas, they are in the critical path to deliver the ATM Master Plan performance ambition in areas as efficiency, capacity, safety, security and cost-efficiency.

3.9.3 List 1 SESAR Solutions

The proposal shall address, as a minimum, four solutions from List 1:

3.9.3.1 Solution PJ.14-W2-76 Integrated CNS and Spectrum

The solution "Integrated CNS and spectrum" addresses the CNS cross-domains consistency in terms of robustness, spectrum use and interoperability including the civil-military aspects through the provision of a global view of the future Communications, Navigation and Surveillance services and the definition of the future integrated CNS architecture and of the CNS spectrum strategy. The solution follows up the work done in Wave 1 under #14-01-01. The Solution will consider the different users (including GA, unmanned vehicle and RPAS, military, etc.

In terms of performance expectations, a holistic analysis of the technical and safety requirements of the current and future integrated CNS infrastructures and systems will highlight opportunities to improve the efficiency, safety, resilience and interoperability of the CNS infrastructure.

In Wave 2 the solution shall:

- Develop the Service Driven CNS Approach describing how the services will be delivered for navigation, communication, and surveillance and information (e.g. traffic, flight information) including the cross domain services (e.g. contingencies). Different business models will be considered which may depend on the service to be delivered. Clarify the necessary mechanisms to be set-up to operate under a service-based framework (e.g. how costs will be controlled, how long term availability will be ensured, which governance has to be implemented to protect stakeholders' interest while avoiding blocking decision making, liability). The development of the Service Driven CNS approach will be performed in cooperation with Solution 77 (FCI Services), Solution 81 (Long-term alternative Position, Navigation and Timing) and Solution 83 (Surveillance Performance Monitoring;;

- Develop the performance based approach to fulfil operational needs including the definition of the relevant performance indicators related to each service as well as the way to measure them. The development of the performance based approach will be performed in cooperation with Solution 49 (Collaborative Network Performance Management), Solution 77 (FCI Services), Solution 81 (Long-term alternative Position, Navigation and Timing) and Solution 83 (Surveillance Performance Monitoring);
- Develop requirements for integration of C, N and S identifying synergies and technology transfer opportunities between the 3 C, N, S pillars and pass these requirements to Solution 77 (FCI Services), Solution 81 (Long-term alternative Position, Navigation and Timing);
- Develop the performance monitoring framework to verify that the delivered services match the service specifications, based on performance indicators in cooperation with Solution 77 (FCI Services), Solution 81 (Long-term alternative Position, Navigation and Timing) and Solution 83 (Surveillance Performance Monitoring);
- Update and maintain the CNS and spectrum evolution Roadmap and Strategy addressing:
  - The service driven CNS approach;
  - The performance based framework;
  - The integrated and rationalised CNS infrastructure to move from the current fragmented infrastructure towards a cost efficient and service driven approach, supporting all users including RPAS, being cyber secure and resilient. The integrated and rationalised CNS infrastructure shall include any type of rationalisation.
  - The civil-Military CNS interoperability for current and future CNS infrastructure services and performance equivalence;
  - The spectrum requirements and the effective use of available spectrum;
- Ensure the link/dependency between Technological and ATM solutions;
- Contribute to the operational and technical validations for aspects related to integration of CNS elements in SESAR 2020 Wave 2;
- Support the harmonisation of the CNS technical requirements developed within SE-DMF across the CNS domain;
- Support to the development of the CNS architecture in EATMA ensuring that relevant links to other architectural elements are made, i.e. ATM / technological solutions, OI steps / enablers, etc.

- Coordinate and with the following standardisation bodies/working groups/relevant entities including:
  - EUROCONTROL Navigation, Communications and Surveillance Steering Groups;
  - EUROCONTROL Communications Navigation and Surveillance Infrastructure Team (CNS-Team);
  - CANSO;
  - EUROCAE;
  - RTCA;
  - Data Link Users Forum,
  - Other relevant stakeholder forums or working arrangements, including ICAO, FAA, etc.

Note that this is a transversal solution, and therefore the maturity levels (either V or TRL) do not actually apply to this solution. For this reason the table with the initial and target maturity level is not relevant here.

Relevant links to the ATM Master Plan Level 2 (DS18a):
This activity follows-up the work performed by SESAR Solution #14-01-01 but with a larger scope. This is not a SESAR Solution as such so it does not require OI steps or enablers.

3.9.3.2 Solution PJ.14-W2-77 FCI Services

Future ATS and AOC (Airline Operation Communication) services, even if they have different targets and different Quality of Service, will demand higher Air/Ground and Air/Air communication capacity and better performance than the current system can offer. It is known that AOC requires high bandwidth with increasing demand, and this must be taken into consideration to ensure that all services are optimised.

This Solution addresses the provision of “Communication Services” between mobile users and other users (mobile or non-mobile). A mobile user can be an aircraft, an airport vehicle or any new mobile entrant (such as unmanned aircraft and suborbital flight). Note: the Solution scope does not include provision of services between two or several ground Users. The Solution will allow the real-time sharing of 4D trajectories, timely access to ATM data and information services and the support to SWIM.

The “Communication Services” will support all ATN-B1, ATN-B2 ATS services, and be expandable to support advanced ATM applications such as ATN-B3 ATS services. It will support AOC services and digital voice (VoIP) services. The Communication Services will be delivered using ATN/IPS and will allow interoperability with ATN/OSI protocols.

It is expected that the operational requirements for the digital voice concept of operations will be developed by a SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The following Wave 2 solutions should plan effort to support its development: 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 73, "Flight-centric ATC and Improved Distribution of Separation Responsibility in ATC" and solution 56, "Improved vertical profiles through enhanced vertical clearances", solution 57, "RBT revision supported by datalink and increased automation". This solution should also plan effort to support the development of the "Controller-pilot communications CONOPS" by the exploratory research project, e.g. by participating in the expert groups (with the technical perspective), as well as for coordinating with all the above solutions regarding the future voice (and eventually datalink) concept of operations. The future "Controller-pilot communications CONOPS" includes both the future voice CONOPS and the extension of datalink below FL285, which this solution must also provide support to. For voice, the CONOPS is expected to provide insight into the following questions:

- Would the future voice communications need to be point-to-point or multi-point (with a channel with party-line like current VHF frequencies)?
- Would a hybrid system be useful, i.e. point-to-point with no party-line but with a free/occupied indicator to prevent simultaneous incoming transmissions for the same ATCO?
- What would be the acceptable latency?
- Which would be the encryption and security needs?
- What are the wide-area communications needs?
- Which are the future automation needs connected to voice communications (e.g. remotely tune the system on another channel, handover, priority call…) and which operational requirements would be required to support them?

The "FCI Communication Services" will rely on a set of components which all together will deliver the "FCI Communication Services".

Among the components, the Mobile Components will provide wireless access to mobile Users. They include:

- "ICAO technologies" (i.e. L-DACS, SatCom Class A, and AeroMACS) for supporting the safety related ATS services (as these technologies operate over protected spectrum, are secure and ensure interoperability), and
- "Open Network Services" (e.g. based on 5G) in the support of non-safety critical services.

Smooth transition with current sub-networks services (e.g. VDL Mode 2) will also be ensured.

Transversal Components: the Communication Services will also rely on "Transversal Components" which include (but are not limited to) those required to manage the Mobile Components, the management of the mobility of users between the different Mobile components, the routing of the messages, the Ground components of the FCI (e.g. A/G Routers, Ground stations, gateways to ATN/OSI), the interoperability with, including the transition from, ATN/OSI, the security, the end-to-end performance monitoring, the interface towards the military ground users. The FCI will rely on NewPENS to interconnect the Ground components of the FCI.

The Solution will also act as the "Architect" for the whole communication related Wave 2 Solutions; it will define the end-to-end functional architecture, ensuring no gaps and no overlaps among the different communication related Solutions.

Some or all components delivering all together the Communication Service, including the "ICAO technologies", could be operated under a service-based framework.

The bidder will provide in its proposal a gap analysis considering what has been achieved in SESAR 1 and wave 1 (PJ.14-02-04) and will describe the activities proposed to fill these gaps within Wave 2 Solution 77).

The work continues and completes the work performed by #14-02-04 in Wave 1 in the view to achieve TRL-6. In particular, the activities in Wave 2 shall include:

- Update, as required, the Communication requirements to consider the evolutions of the ATM concept and considering the requirements expressed by SESAR Solution 100 (SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing, by Solution 57 (RBT revision supported by datalink and increased automation) and by Solution 76 (Integrated CNS and spectrum) for the requirements addressing integration of CNS and for which Solution 77 will provide its support to Solution 76; the updated requirements should extrapolate ATN-B3, VoIP and new entrants such as unmanned aircraft and suborbital flight and to support further automation in ATM; AOC requirements will also be updated. The process to update the FCI requirements (including the AOC requirements) as well as the baseline(s) which is proposed to be used will have to be described in the bidder proposal. Note: a first version of the updated requirements based on ATN-B2 services should be delivered at T0+6 (rationale: dependency to apportion requirements to underneath solutions);

- Apportion the communication requirements to all the components supporting the Communication Service (including to the "ICAO technologies", "Open Network Services" and the "Transversal Components") and transfer them to the specific SESAR Solutions (60, 61, 107);

- Complete the specification and the development of the "Transversal Components";

- Be the owner of the FCI functional architecture;

- Execute the technical validations involving all 3 "ICAO technologies". To proceed to such validation, coordination will be established with solutions, 60 (FCI Terrestrial Data Link and A-PNT enabler (L-DACS)) and 107 (Future Satellite Communications Data link Class A). Coordination will also be established with Solution 61 (Hyper Connected ATM) to include into the validation any service/technology which would be mature enough to demonstrate feasibility and with Solution 76 (Integrated CNS and spectrum) for aspects related to integration of CNS;

  The objective is to achieve TRL-6 for FCI Services for ATN-B1, ATN-B2, AOC, ATN/IPS, L-DACS, SatCom (see further remark on SatCom), AeroMacs, and interoperability with ATN/OSI and TRL-4 for solutions resulting from Solution 61;

  For other services and functionalities, the bidder will describe which validation level he is expecting to achieve;

  Remark: For SatCom, depending on service availability/maturity, the validation may involve real service or prototypes and if not available, validation with Class B service could be envisaged. The proposed approach shall be documented in the bidder proposal;

- Cooperate with the other identified SESAR Solutions.

Wave 2 shall also address non-technical issues, which if not considered at the proper stage could jeopardise the implementation of the "Communication Service", and contribute to solve them including through coordination with the relevant standardisation and regulatory bodies e.g. EASA:

- In collaboration with Solution 76, contribute to the identification of the appropriate business model(s) to provide the "Communication Services" and the identification of actors which are part of the model(s) and their respective role. Note: it is anticipated that some Communication Service Providers could operate one or several "ICAO technologies" (e.g. SatCom);

- In collaboration with Solution 76, contribute to the clarification of the necessary mechanisms to be set-up to operate under a service-based framework (e.g. how costs will be controlled, how service long term availability will be ensured, which governance has to be implemented to protect stakeholders interest while avoiding blocking decision making, liability;

- In collaboration with solution 76, contribute to the definition of the performance monitoring framework;

- In collaboration with other communication related solutions, be responsible for the FCI functional architecture;

The SESAR solution shall coordinate with solution 57 "RBT revision supported by datalink and increased automation", Solution 60 (FCI Terrestrial Data Link and A-PNT enabler (L-DACS)), Solution 61 (Hyper Connected ATM), Solution 107 (Future Satellite Communications Data link Class A), Solution 100 (SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing),

The SESAR solution shall support the elaboration of required standards at global level in coordination with:

- FAA;

- EUROCAE/RTCA for MASPS and MOPS definition: WG-72, WG-78, WG-82;

- ICAO: Work Program of the ICAO Communications Panel (CP) and Navigation Systems Panel (NSP) for AMS(R)S SARPS;

- AEEC;

- ESA Iris programme.

FCI Network Technologies incl. voice solutions and military interfacing)	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	TRL-4	**TRL-6**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-02-04 and covers the following enabler:

- *CTE-C04 — Future Communication Infrastructure - ATN/IPS and Multilink.*

It covers as well the following enabler addressed in Wave 1 under #14-02-02:

- *CTE-C01b - New Digital Voice*

3.9.3.3 Solution PJ.14-W2-60 FCI Terrestrial Data Link and A-PNT enabler (L-DACS)

The SESAR Solution "FCI Terrestrial Data Link (L-DACS) and A-PNT enabler" constitutes one of the "ICAO technologies" as referred in solution 77 i.e. the future terrestrial A/G and A/A data link solution to support the increasing ATM performance requirements (due to the growth of air traffic and its complexity) and the air traffic services evolution according to the ICAO technology roadmaps and the ATM key improvement areas as defined in the ATM master plan. In particular, the 4D trajectory management operational concept needs to be supported by a reliable, scalable, modular and efficient data link technology. L-DACS also constitutes a potential component of the A-PNT to support positioning and navigation requirements in PBN/RNP operations in case of a GNSS degradation or outage.

L-DACS also constitutes a potential component of the A-PNT to support positioning and navigation requirements in PBN/RNP operations in case of a GNSS degradation or outage.

This solution will address both avionics and ground implementations for communication and navigation.

Communication:

In full alignment with the ICAO/GANP, the future terrestrial data link L-DACS (L-band digital aeronautical communications system) activities shall support the standardisation initiatives as required in ICAO, EUROCAE/RTCA and AEEC.

The SESAR solution will enable the widespread adoption of 4D trajectory management concepts for separation management by providing:

- Greater availability due to the support of multilink;
- Higher data capacity;
- Improved communications performances such as, low latencies and high continuity and availability and management of Quality of Service;
- Improved spectrum efficiency;
- Resilience to cyber treats.

Navigation:

The SESAR solution will support A-PTN requirements to:

- Improve the resilience of GNSS;
- Contribute to the rationalisation of the CNS infrastructure.

The activities shall include:

- Integration of the requirements apportioned to L-DACS by Solution 77 (on FCI Services) into the L-DACS specifications (including performance monitoring, security);
- Contribution to the functional FCI architecture developed by and under responsibility of Solution 77 (FCI Services);
- Finalization of the development and contribution to the standardization of the L-DACS communication technology;
- Finalization of the specifications and of the development to support A-PTN based on requirements issued by Solution 81 on Long-term alternative Position, Navigation and Timing (A-PNT);
- Provide an analysis of the synergies and limitation in combining Communication and Navigation services in the L-DACS system;
- Validation of a fully functional L-DACS prototype:
    - Capable of supporting the requirements expressed by Solution 77 (FCI Services) in the view to support A/G ATN-B1, ATN B2 and AOC applications and be expandable to support ATN-B3, Air/Air datalink applications and to VoIP over an L-band air/ground data link communications using the ATN/IPS protocol;
    - Capable of supporting A-PNT requirements.
- Achievement of TRL-6 maturity level (to support ATN-B1, ATN B2 applications, AOC) by involving during validation prototype avionics and prototype ground systems developed each by more than one manufacturer and involving flight trials. The approach will be provided by the bidder in its offer;
- Contribute to and support end-to-end validation as performed by Solution 77 (FCI Services);
- Achievement of TRL-4 maturity level for A-PNT and contribution to the feasibility assessment in cooperation with Solution 81 (Long-term alternative Position, Navigation and Timing (A-PNT);
- Assessment of impact on and from external systems (DME, interference to military systems e.g. JTIDS/MIDS, TACAN, GNSS) and implementation of measures to manage these impacts;
- Assessment of civil-military interoperability e.g. when military aircraft are equipped with L-DACS.

The solution shall consider military requirements during all stages of L-DACS specification and technical validation e.g. cockpit integration, co-existence with military avionics, etc.

The solution needs to coordinate with the candidate solution 77 on FCI services and solution 81 on Long-term A-PNT.

Note: SWIM and voice requirements will be coordinated with Solution 77 (FCI Services) which will coordinate with solution 100 "SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing" for SWIM services.

FCI Terrestrial Data Link and A-PNT enabler (L-DACS)	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6 for COM TRL-4 for A-PNT

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-02-01 and covers the following enabler:

- *CTE-C02e — New A/G datalink using ATN/IPS over L-band.*

The Solution will contribute to other enablers such as CTE-N13a — A-PNT (Alternative Positioning Navigation and Timing) that is under the scope of candidate solution 81, or to enablers CTE-C02g - A/A functionality and CTE-C01b - New Digital Voice that are under the scope of candidate solution 77.

3.9.3.4 Solution PJ.14-W2-107 Future Satellite Communications Data link

The SESAR solution "Future Satellite Communications Data link" addresses the development of the future satellite data link technologies Class A SatCom for both the continental and remote/oceanic regions needed for supporting the future concepts beyond 2020. The solution represents one of the "ICAO technologies" as referred within Solution 77 (FCI Services). It is an essential part of the seamless, resilient and integrated Future Communication Infrastructure to allow the real-time sharing of 4D trajectories and timely access to ATM data and information services.

In terms of performance benefits the solution will increase the datalink availability and capacity and will improve safety and security (resilience). The solution represents a technical enabler required for achieving the performance and safety objectives of the 4D trajectory management operational concept.

Solution #109 (Iris Precursor solution (Class B)) was already completed in SESAR 1, so this solution will continue and complete the work performed by #14-02-02 in Wave 1 on Long term Class A SatCom. In particular, the activities in Wave 2 shall include:

- Completion of Technical Specifications, including requirements apportioned to the SatCom sub-network by Solution 77 (FCI Services), regarding data and voice, for the Class A SatCom, including the required safety and security assessments to ensure robustness of the solution in front of internal/external interferences. The technical specifications shall be technology independent;

- Completion of the development and specification of a performance monitoring and control concept for the seamless integration of Long Term SatCom within an ATN/IPS network;
- Contribution to the functional FCI architecture developed by and under responsibility of Solution 77 (FCI Services);
- Develop SatCom voice, including as a full HF alternative in oceanic airspace including contribution to support the regulatory case required to allow full replacement of HF by SatCom;
- Proceed to the technical validation towards TRL-6 of satellite Air-Ground Datalink for Long Term SatCom integrated in the FCI, including flight trials for operational validation of critical functions in coordination with ESA and/or any other Class A SatCom specifications-compliant SatCom service. The bidder will explain its approach to proceed to validation in its proposal. Contribute to and support end-to-end validation as performed by Solution 77 (FCI Services);

The SESAR solution shall coordinate with Solution 77 (FCI Services).

The SESAR solution shall support the elaboration of required standards at global level in coordination with:

- FAA;
- EUROCAE/RTCA for MASPS and MOPS definition: WG-72, WG-78, WG-82;
- ICAO: Work Program of the ICAO Communications Panel (CP) and Navigation Systems Panel (NSP) for AMS(R)S SARPS;
- AEEC;
- ESA Iris programme.

Future Satellite Communications Data link	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	TRL-4	**TRL-5 (TRL-6 on-going)**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-02-02 and covers the following enablers (some are proposed to be included for DS18):

- *CTE-C02h — Future Satcom for ATM - Long term Satcom/IRIS (class A Satcom).*

3.9.3.5 Solution PJ.14-W2-61 Hyper Connected ATM

The SESAR solution aims at identifying and specifying the high level operational requirements for a fast and exponentially capable broadband air/ground and air/air datalink for supporting future ATM and U-space operations, air/ground data exchanges, etc.

The research will aim at finding a balance between open and safety critical applications, with the objective of maximising the use of open networks (e.g. cellular) for open applications.

The SESAR solution shall address the following aspects in wave 2:

- Explore the potential use of IP networks for Air/Ground and Air/Air communication considering the requirements expressed by Solution 77 (FCI Services) to support safety and non-safety services and in particular safety and security requirements as well as requirements to integrate new entrants, such as unmanned aircraft and suborbital flight;
- Demonstrate the feasibility of using open networks (open Satcom, cellular) to integrate all air vehicles (including drones) and to support safety and non-safety critical applications into the communication networks;
- Contribute to the functional FCI architecture as developed by and under responsibility of Solution 77 (FCI Services) to integrate open network services into the FCI;
- Contribute to the identification of business models and assess their feasibility (financial, long term availability, …) to deliver hyper connected services in cooperation with Solution 77 (FCI services);
- Define requirements for usage of non-safety A/G subnets for safety purposes. Explore its impact on the IPS router and other FCI components;
- Define the best balance between openness security (which may result in and safety critical issues);
- Deliver the concept of operations, use cases and high level requirements for the new service;
- Explore the requirements on radio spectrum;

This SESAR solution shall coordinate with the candidate SESAR solution 77 on FCI services.

Hyper Connected ATM	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-0	TRL-2

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required enablers for DS18b.

Initially, the solution could address the enabler *CTE-C02g - A/A functionality addressed by solution #14-02-01 in Wave 1.*

3.9.3.6 Solution PJ.14-W2-81 Long-term alternative Position, Navigation and Timing (A-PNT)

The SESAR Solution "Long-term alternative Position, Navigation and Timing (A-PNT)" aims at developing A-PNT systems capable to provide better performances in comparison to the short-term solution (based on DME-DME) and support PBN/RNP operations in case of a GNSS degradation or outage. Long term A-PNT airborne solution is expected to support: RNP 1 for the SID or STAR developed upon RNP 1 navigation specification, the airways defined with RNP 0.3 or RNP 1 constraints, and preferably RNP-APCH operations down to LNAV/VNAV minima supposing appropriate ground infrastructure. The solution continues the work performed in wave 1 under solution #14-03-04.

Alternative-Position, Navigation and Timing (A-PNT) will provide users with a reversionary backup with similar levels of performance in case of corruption, degradation or absence/loss of GNSS, maintaining capacity and operational safety in such circumstances. For air navigation service providers the solution will avoid the increase of ATCO workload and the potential impact on airspace capacity. For airspace users benefits will be related to the airspace accessibility and avoidance of additional costs and delays generated by flights re-routing or cancellation. In addition, the long-term A-PNT solution aims at enabling the optimization of the ground infrastructure, significantly improving the spectrum efficiency and be as economical as possible i.e. in terms of new infrastructure and avionics cost. However, since the Long-term A-PNT will be based on a new system/technology that has not yet been defined or standardized by ICAO, this solution may require new ground infrastructure and changes in some of the existing on-board systems.

The SESAR Solution shall complete the R&D phase considering Wave 1 results in terms of:

- The navigation performance level needed for future operations and the definition of the A-PNT system concept providing covering these future needs;
- The A-PNT requirements for all phases of flight including navigation reversion modes and increased autonomy aspects; The technologies selected from the candidates considered in Wave 1 (initial candidate technologies include Multi-DME solution and RAIM algorithm, Enhanced DME, L-DACS-NAV, Mode N, Inertial, including data fusion of these different sources) with regards to the required navigation performance and integrity. Long term A-PNT will be based on a new system/technology that has not yet been defined or standardized by ICAO, which may require major changes of the existing ground and on-board systems. For L-DACS, Solution 81 shall coordinate with Solution 60 (FCI Terrestrial Data Link and A-PNT enabler (L-DACS)) and provide A-PNT technical requirements to this Solution.
- The identification and detailed description of long-term selected candidate new technologies for rotorcraft, RPAS, GA, etc. (e.g. terrain or visual based navigation, Inertial) to provide on airborne side additional enabling capabilities which will allow for all phases of flight in degraded conditions in constrained environment, providing more efficient usage of airspace.
- Provide an analyse of the benefits and limitations associated to each solutions;
- Follow-up of the work performed on the potential use of military inertial systems for State aircraft operations in a PBN/RNP airspace environment.

CNS synergies should be taken advantage of to the maximum extent possible. Further work is also necessary on operational requirements in order to confirm the required navigation performance (i.e. accuracy, continuity, integrity), especially in light of multi-constellation GNSS capabilities and the ability to mitigate associated residual system vulnerabilities. The SESAR Solution shall closely coordinate with the standardisation bodies e.g. EUROCAE and EASA to define the MASPS and MOPS as well as the AMC.

Long-term alternative Position, Navigation and Timing (A-PNT)	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

The SESAR solution shall complete the standalone mid-term aircraft technological enhancement (researched in Wave 1) that supports RNP-based Operations in the TMA e.g. RNP1 SIDs and STARs (mid-term A-PNT). The Mid-term solution investigates the possibility to improve DME based localization algorithms in the airborne FMS to fully support the OBPMA integrity requirements defined for a RNP navigation specification in the PBN manual.

Medium-term alternative Position, Navigation and Timing (A-PNT)	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

The SESAR Solution shall take into consideration as well the work and results produced by Exploratory Research project NAVISAS.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-03-04 and covers the following enabler:

- *CTE-N13a — A-PNT (Alternative Positioning Navigation and Timing), for the Long-term A-PNT solution.*
- *A/C02d — Multi DME positioning with Autonomous Integrity Monitoring supporting RNP Navigation (proposed new enabler for the Mid-term A-PNT solution).*

3.9.3.7 Solution PJ.14-W2-79 Dual Frequency / Multi Constellation DFMC GNSS/SBAS and GBAS

The SESAR Solution "Dual Frequency / Multi Constellation DFMC GNSS/SBAS and GBAS" addresses:

- The progress in development of GBAS approach service type F (GAST-F) and its degraded modes, which is the final goal to achieve the target ambition of SESAR.

And also:

- DFMC GNSS/SBAS/GBAS receivers architectural considerations

- The completion of wave 1 activities related to:
  - ABAS / SBAS DFMC GNSS developments for multi-constellation GNSS receivers;
  - GBAS approach service type D (GAST-D) extended scope including: Expanded Service Volume (ESV), extreme latitudes, complex airports.

DFMC GNSS can bring significant technical benefits by improving robustness and performance of the navigation solution. The use of dual frequencies will help mitigate vulnerabilities in respect of ionospheric disturbance (important for high and lower latitude applications), and stabilizes the accuracy of the navigation solution over larger areas In addition, fall-back (degraded) modes using one of the two frequencies will improve the robustness and reliability of the system in environments of radio frequency interference affecting a single frequency. The availability of multiple constellations will contribute to mitigate ionospheric scintillation and the risk of having insufficient satellites within a single constellation for all phases of flight.

These technical improvements provided by DFMC will enable operational benefits in terms of safety and efficiency, such as improved operational reliability for CNS applications, increased deployment of 3D instrument approach operations worldwide including a robust CAT III service in all latitudes, introduction of innovative operational concepts and applications, and continued rationalisation of conventional navigation aids. Therefore, this SESAR solution will enable to improve performance and robustness to support the following applications: PBN, precision approaches, advanced approaches concepts (Second Runway Aiming Point (SRAP), Further Runway Aiming Point (FRAP), adaptive increased glide slope (AIGS)), precision approaches with lower minima, fuel-saving approaches including curved approaches, vertical geometric navigation to support navigation enhanced TMA operation, ADS-B and 4D concepts, navigation and operations on the airport surface. It will also allow ground infrastructure rationalization, etc.

Given the differences in scope and levels of maturity between the above threads, the work under solution 79 shall be documented in a number of independent solution data packs (threads) as proposed hereafter:

Thread 0: DFMC avionics/receiver architecture

Having a single solution merging #14-03-01 and #14-03-02 from Wave 1, brings the opportunity to better define and develop an overall navigation avionics architecture exploiting synergies and complementarities between DFMC ABAS (ARAIM), DFMC GBAS and DFMC SBAS augmentations. However it will require a significant effort from partners to harmonise key assumptions, technical parameters and degraded modes that were defined separately in wave 1. This thread 0 shall address the overarching avionics architectural aspects following up the initial work performed in Wave 1 (e.g. TS-IRS document from solution #14-03-02).

This thread would have to consider airborne architecture optimising transitions between augmentations considering different nominal and degraded modes in each augmentation. This thread shall address technical challenges common to all augmentations in terms of antenna front end design, out of band rejection characteristics and algorithms.

This overall architecture would contribute to the definition of requirements for each augmentation to be further considered in threads 1 and 2.2.

As many aircraft are operating globally, expandability to process all core constellations, computational complexity and interoperability for all phases of flight are considerations to be taken into account.

This thread should contribute to address the open points identified in the ICAO DFMC GNSS CONOPS on service provision, certification, regulatory and avionics aspects in coordination with relevant national authorities, GSA, EC and EASA.

The preliminary assessment of operational benefits identified in the DFMC CONOPS and the qualitative CBAs analysis that is being developed in wave 1 (solution #14-03-02 task 3), will have to be further elaborated in wave 2 within this solution.

Thread 1: ABAS / SBAS DFMC GNSS

This thread continues the work developed in in Wave 1 in solution #14-03-02 on the DFMC aircraft enabler that has been focused on the development of avionics incorporating GNSS receivers processing GPS and GALILEO signals in L1/E1 and L5/E5 augmented by DFMC SBAS and ABAS (A-RAIM) for all phases of flight.

The new constellations and signals together with these augmentations may also enable the LPV below 200ft decision height either by themselves of in combination with other means such as vision systems.

This tread also continues the work developed in Wave 1 with regard to the benefits of the introduction of DFMC GNSS receivers on State aircraft as well as undertakes standardisation work on the introduction of DFMC GNSS, based on the use of secure signals, for State aircraft operations in a General Air Traffic (GAT) environment. It takes into account security aspects (jamming, spoofing, etc.). Satellite navigation receivers are principally susceptible to interference e.g. intentional or not-intentional jamming and/or spoofing impacting the navigation services based on GNSS (or its augmented derivatives). This SESAR solution aims at improving security and enhancing resilience against these threats.

Based on outcome from the solution #14-03-02, RTCA and EUROCAE are assessing implementing an RFI detection capability in the DFMC avionics to be downlinked to the ground (e.g. via ADS-B data).

There is a need to further develop this work in wave 2, progressing with relevant standardisation bodies in coordination with related CNS activities (ADS-B ground stations and message impact). Additionally there is a need to establish a dependency with the SESAR solution 49 “Collaborative Network Performance Management”, which is in charge of receiving CNS status information for the purpose of maintaining an updated view of the current CNS status across the network and make it available to ANSPs. Cost efficiency shall be addressed to ensure that implemented techniques provide the required robustness to cover most of the threats scenarios with a sufficient degree of efficiency and at a reasonable cost (design, manufacture and certification).

This thread will contribute requirements to be considered in the thread 0.

This thread will contribute to the development of standards (e.g. SARPS and MOPS) and specific definition documents for DFMC SBAS and DFMC ABAS/A-RAIM under development by the ICAO NSP.

ABAS / SBAS Dual Frequency / Multi Constellation (DF/MC) GNSS	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4 on-going	TRL-5 (TRL-6 on-going)

Note: the effect of GALILEO not declaring FOC before late in Wave 2 and the GPS L5 standards and implementation timelines are a major risk factor for the achievement of TRL-6 (ICAO standardisation is a requirement for TRL-6 achievement and this will happen not earlier than 2 years after FOC declaration).

Note: The feasibility of having flight test in wave 2 depends on availability of funding, interest from partners, availability of aircraft and maturity of the avionics prototype.

Thread 2: GBAS

The GBAS operational benefits include a capacity increase in low visibility conditions, the capability to fly shorter routes and fuel-saving approaches, thus providing cost-savings, less emissions and noise and the provision of precision approaches on runways where ILS is not feasible. This part of the SESAR solution continues the work in Wave 1 in solution #14-03-01 GBAS.

The work on this thread shall contribute to update (if required) the existing standards on GBAS GAST-D and/or the development of required ones for GAST-F. It also covers the liaison with regulatory bodies (EASA).

The work on this thread is proposed to be structured as follows:

Thread 2.1: GBAS GAST-D Extended Scope

Although the basic scope and functionalities of GBAS GAST D already achieved V3/TRL-6 at the end of SESAR1 (solution #55), this thread aims at extending the scope of GBAS GAST-D beyond the outcome of SESAR 1. The objective of this thread is to:

- Cope with adverse ionospheric conditions and conditions outside the mid latitudes (high and low latitude issues);
- Efficiently operate in large and complex airport environments. This helps securing objectives related to the expected rationalization of some ILS CAT III in the selected airports e.g. Frankfurt, Paris, Madrid-Barajas, London-Heathrow where, given the timeframe for GAST-F development, CAT II/III operations will need to be based on the GAST-D solution;
- Include GBAS Expanded Service Volume (ESV) and increased Dmax requested by airspace users beyond 23 Nautical Miles also covering operational aspects.

The work in Wave 2 shall:

- Complete the technical specification and required validation for the GAST-D extended scope to achieve TRL-6 (note that GAST-D initial scope has already achieved TRL6 in SESAR 1). This work will be based on the outcome in Wave 1 by solution #14-03-01 and exploiting the high quality data measurements collected in wave 1 and wave 2;
- Complete security and safety assessments e.g. threat characterization and mitigations related to various threats such as Radio Frequency Interference (RFI), jamming, and conditions derived from ionospheric aspects outside mid-latitudes.
- Focus on improving GBAS GAST-D to meet the requirements of a globally deployable solution, providing the required inputs/changes for standardization e.g. ICAO GAST D SARPs (already

available) and coordinating with EASA in order to put regulation and AMC in place to enable system certification and operational use.

Note: This SESAR solution includes elements that are at a different maturity level: in particular, the scope related to GBAS "expanded service volume" (ESV) is on-going TRL-2 at the start of Wave 2. Nevertheless, the target is to complete the remaining GBAS GAST-D aspects in Wave 2.

GBAS GAST D Extended Scope	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

Thread 2.2: DFMC GBAS GAST-F

This thread aims at achieving the target ambition of SESAR.

The SESAR solution also addresses the development of GBAS approach service type (GAST-F) based on DFMC (following wave 1 work, based only on GPS and Galileo) to maximise the benefits of this technology down to CAT II/III to allow for more robust operations, especially at high and low latitudes with tougher ionospheric conditions and with regard to resilience to radio frequency interferences on a single band. The benefits and constraints of GBAS approach service (GAST-F) based on DFMC down to CAT II/III for State aircraft operations may be covered in this solution.

This thread will contribute requirements to be considered in the thread 0.

This thread will contribute to the development of standards (e.g. SARPS and MOPS) and specific definition documents for DFMC GBAS under development by the ICAO NSP.

The work includes liaison with ICAO to conclude on the concept, progressing the standardisation and the validation of the proposed solution, investigation about degraded modes of operation, etc.

DFMC GBAS GAST-F	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

Note: the target maturity level for GAST-F at the end of wave 2 depends on the availability of external inputs e.g. SARPS for Galileo, GPS L5, etc. Appropriate coordination shall be addressed in order to mitigate these risks for the solution.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-03-01 and #14-03-02 and covers the following enabler:

- *CTE-N07c — GBAS Cat II/III based on Multi-Constellation / Multi-Frequency (MCMF) GNSS (GPS + GALILEO / L1 + L5).*
- *A/C-56b — Flight management and guidance to support GBAS CATII/III using dual GNSS*
- *A/C-02b — Enhanced positioning using multi constellation GNSS dual frequency*
- *CTE-N07d — GBAS service volume extension*
- *CTE-N07e - GBAS Cat II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions.*
- *CTE-N07f- GBAS Cat II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to large and complex airport environments.*

Note that the creation of the last two enablers has been proposed but they are still under consideration for DS18:

3.9.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.9.4.1 Solution PJ.14-W2-110 Aircraft as an AIM/MET sensor and consumer

This SESAR solution addresses the application of information made available by the aircraft such as Aircraft Meteorological DAta Relay (AMDAR) or any other avionics source (information derived from ADS-C application can be used), and future evolutions, or CNS status information, in Air Traffic Management, and the representation and the improved usage of MET and AIM information to airspace users in order to enhance their situational awareness and to improve strategic trajectory management and collaborative decision making.

1) AMDAR utilises existing aircraft on-board sensors, computers and communications systems to collect, process, format and transmit meteorological data to ground stations via satellite or radio links. Aircraft are equipped with a specific module installed in the aircraft avionics that facilitates data acquisition and initial data quality checks. The measurements are compiled into a standard message format (AEEC, ARINC 620) and transmitted as near to real-time as possible, and they include:

    - High resolution vertical profiles of air temperature, wind speed, direction;
    - Regular real-time reports (e.g. every 5-10 minutes) of meteorological variables whilst en-route at cruise level;
    - Accurate measurement of coordinates (time, latitude, longitude and pressure altitude);
    - Measurement of turbulence (potentially linked to the ongoing IATA initiative to share turbulence information)
    - Derived Equivalent Vertical Gust (DEVG);
    - Eddy Dissipation Rate (EDR);

- Optionally: water vapour or humidity, if the aircraft is appropriately equipped.

The expected performance benefits are mainly related to safety (advanced and more accurate warning of severe weather phenomena will lead to reduced potential issues for the aircraft, passengers, and flight crew) and cost-efficiency (improved quality in meteorological information will have a positive impact on the accuracy of flight planning operations and less fuel consumption).

The objective in wave 2 to validate the following potential benefits in air traffic management:

- AMDAR data and information can be used by FOC/WOC for internal AUs forecasting activities, so an increased confidence and reliance on weather information would lead to improvements on the accuracy of flight planning operations:
    - Better flight planning, and optimised planning for fuel consumption and re-fuelling.
    - Improved route planning associated with severe weather to reduce unplanned flight deviations;
    - Enhanced flight level selection to optimize efficiency
- Avoidance of severe weather that could increase maintenance requirements and costs;
- Avoidance of severe turbulence;
- The direct use of AMDAR data, in addition to the traditional meteorological information, can support ATC on any aspect affected by weather-related phenomena, such as:
    - Improved trajectory prediction;
    - Horizontal and vertical separation management in en-route, trajectory revisions, altitude change procedures, etc.
    - Departure and arrival management, and improved vertical profiles;
    - Avoidance of holdings and re-routings for which accurate wind information is needed;
    - Runway management and changes to conditions affecting runway management e.g. wind strength and shear, fog conditions, etc.

Note that the work on this area requires a state of the art analysis to justify the R&D needs.

2) In terms of the representation and the improved usage of MET and AIM information to airspace users, the objectives in Wave 2 cover:

- Development of an integrated flight environment description concept allowing seamless integration of various AIM, meteorological and traffic information on board and on ground. Guidance for proper interpretation of integrated flight environment description. This includes the development of the required functions to take into consideration the further MET/AIM information available and the enhancement of communication means (air/ground and between avionics and EFB);

- The maturation and on-board operational validation of up to date AIM and MET information services by flight crew during flight execution; based on the user needs already specified and designed up to TRL-4 in wave 1.

3) The scope of the solution shall include as well the consideration of CNS status information provided by the aircraft e.g. downlink of information on GNSS interference that could also be highly useful and will be essential to make a comprehensive link to future COM link and SUR downlink needs especially in a performance based context.

The SESAR solution shall address CBA aspects, and in particular the comparison in terms of cost and benefits with other potential alternatives e.g. updated standards for ADS-B, use of Mode S parameters, etc.

The SESAR Solution shall comply with the applicable Regulation, Standards and Specifications for the provision of SWIM based 'information services' or when absent relevant SWIM developments conducted in SESAR1 or in SESAR2020 Wave 1 (PJ17, PJ19) and it may provide an update to these documents. This includes considerations on the emerging SWIM specifications on Service Descriptions, Information Definitions and Technical Infrastructure (yellow profile, purple profile), and data quality requirements (e.g. ADQ).

The SESAR solution shall consider cybersecurity and coordinate/cooperate with the solution #100 that is working on the required infrastructure where this should be addressed e.g. potential cyber-threats, especially considering the expected use of the information and services in an operational context, and identify measures to effectively mitigate any new or changed cyber threat.

This SESAR solution continues the work done under #18-04c on the use of AIM/MET in the cockpit. The development of the purple SWIM Technical Infrastructure profile by solution #17-01 in Wave 1 is a pre-requisite for the solution. The solution also requires the MET and AIM service definitions delivered in wave 1 by SESAR solution #18-04a and #18-04b, that addressed the acquisition, processing and distribution of MET and AIM information. This solution requires as wll coordination with candidate solution #100 "SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing".

Aircraft as an AIM/MET sensor and consumer	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required enablers for DS18b.

This SESAR Solution follows-up also the work performed by SESAR Solution #18-04c. The relevant enabler(s) need to be created in the ATM MP Level 2 in DS18b. Proposals have been made by SESAR solution #18-04c (to be considered for DS18b).

3.9.4.2 Solution PJ.14-W2-83 Surveillance Performance Monitoring

The SESAR solution “surveillance performance monitoring” is a technological solution that, in line with the performance-based Surveillance (PBS) approach, aims at enabling an improved performance monitoring of surveillance systems e.g. “quasi real-time” functionality and ensuring the correct functioning of the ATM surveillance function.

This applies both at the individual sensor level and at ATC end-to-end level (input to the controller working position) e.g. spotting degradation trends early in the process. The solution continues and completes the work performed under #14-04-01 in Wave 1.

The solution addresses shall consider both current and emergent surveillance techniques: WAM, ground-based and space-based ADS-B, independent non-cooperative surveillance sensors (INCS, including MSPSR), MLAT, SMR, etc.

In terms of performance benefits the solution will contribute to:

- Cost efficiency harmonisation, common tools and economies of scale amongst a larger user community;
- Capacity, safety and security through the early detection of degradation trends via real time monitoring.

The new methods and tools proposed by the SESAR Solution shall be assessed with reference to performance and conformity requirements given by relevant standards, such as:

For cooperative sensor level:

- EUROCAE ED-142A WAM (Draft in wave 1);
- EUROCAE ED-129B ADS-B (Wave 1) and ED-129C (Wave 2 if available on time);
- EUROCAE ED-117A MOPS MLAT (Wave 1) and ED-117B (Wave 2 if available on time);

For non-cooperative sensor level:

- EUROCAE WG-103 ED XXX Non-Cooperative Surveillance (Wave 2 if available on time);
- EUROCAE ED-116 SMR (Wave 1) and ED-116A (Wave 2 if available on time);

For “End-to-end” level:

- EUROCONTROL ESASSP V2 for ER and TMA (Wave 2);
- EUROCONTROL ESASSP V3 for Surface (Wave 2 if available on time);
- EUROCAE GEN-SUR SPR for ER and TMA (Wave 2).

The main activities in Wave 2 shall include:

- The adaptation of the methods and tools from Wave 1 to take into account the evolution of the emerging standards, and the completion of the work performed in wave 1 by solution #14-04-01 on enablers CTE-S07:

- Cooperative sensor level (CTE-S07a for ER & TMA and CTE-S07b for Surface): adaptation of methods and tools to the relevant standards that were not completed and published during wave 1 (i.e. EUROCAE ED-142A for WAM, ED-129C for ADS-B and ED-117B for MLAT);
- Non-Cooperative sensor level (CTE-S07c for ER and TMA, CTE-S07d for surface): adaptation of methods and tools to the relevant standard that were not available or dated during wave 1 (EUROCAE WG-103 ED-XXX and ED-116A for SMR)
- "End-to-end" level (CTE-S07e for ER and TMA and CTE-S07f for surface): adaptation of methods and tools to the relevant standard that were not available during wave 1 (EUROCONTROL ESASSP V2, ESASSP V3 and GEN-SUR SPR)

- Related tools and methods development and specification;
- Validation of tools (prototypes) and methods at TRL-6 level.
- Provide the results of tools verification are a potential input to the standardisation, in particular the EUROCAE documents, test sections, for possible improvements.

Note that the target TRL-6 only possibly concerns CTE-S07a and CTE-S07b for which the expected maturity at the end of wave 1 is currently TRL-4.

The rest of the enabler's initial maturity level is TRL-2 and all target a TRL-4 maturity level at the end of Wave 2. They depend on the timely availability of the related input standards: CTE-S07c (EUROCAE WG103), CTE-S07d (ED-116A for SMR),CTE-S07e (ESASSP V2, GEN-SUR SPR for TMA and ER), CTE-S07f (ESASSP V3, SPR standard for surface).

Based on the status of maturity of the different enablers and the scope of the solution, it is proposed to structure the delivery in three distinct data packs:

Surveillance Performance Monitoring - Cooperative sensor	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

Surveillance Performance Monitoring – Non Cooperative sensor	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

Surveillance Performance Monitoring –"end-to-end"	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-2	TRL-4

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-04-01 and covers the following enablers (some are proposed to be included for DS18):

- *CTE-S07a Coop sensor SPM Tool-ER&TMA*
- *CTE-S07b Coop sensor SPM Tool-Surface*
- *CTE-S07c Non Coop sensor SPM Tool-ER&TMA*
- *CTE-S07d Non Coop sensor SPM Tool-surface*
- *CTE-S07e Sur Chain SPM Tool-ER&TMA*
- *CTE-S07f Sur Chain SPM Tool-Surface*

3.9.4.3 Solution PJ.14-W2-84 New use and evolution of Cooperative and Non-Cooperative Surveillance

The SESAR solution "New use and evolution of cooperative and non-cooperative surveillance" covers major improvements of cooperative and non-cooperative surveillance systems in areas such as composite surveillance, multi-sensor data fusion, new non-cooperative surveillance systems, secured surveillance systems and future ADS-B communications link. The solution continues and completes the work performed in Wave 1 under #14-04-03.

In particular, the SESAR solution addresses:

- The evolution of cooperative and non-cooperative surveillance systems adding new capabilities (e.g. security screening and reporting methods for cooperative sensors) into existing technologies such as multi-sensor trackers, ADS-B systems, WAM/MLAT systems, video trackers; the MLAT component of the sensor shall receive video plot measurements and uses this data to solve ambiguities. This is a new composite type consisting of cooperative and non-cooperative surveillance;

- New surveillance technology (INCS – MSPSR as well as video cameras for azimuth and elevation angle measurements (without ranging) via Cat015 (as MSPSR));

- The evolution of ADS-B datalink and the exchange of data between sensors, and composite surveillance to improve sensor ambiguity resolution performance; range (via active interrogation) and range difference (via passive interrogation) measurements from Mode-S (without azimuth measurements) are used in #14-04-03 in wave 1 to update the track state (position, velocity, etc.). The intention is to enhance this processing in Wave 2 for ADS-B validation purposes;

- Security aspects beyond classical cybersecurity mitigating growing threat levels.

Composite surveillance has the potential to lower the implementation cost while delivering the appropriate level of performance for environments such as regional airports or remote tower environments. The use in combination of sensor data, both on tracker as well as at the sensor level, increases operational robustness and security. Non-cybersecurity aspects focussing on RF signals and RF content and the resulting alarming methods and performance are one of the key subjects of this solution. The security aspects will also help to remove barriers to entry for ADS-B.

The work done in Wave 2 shall complete the validation and the development of the technical specifications produced in Wave 1 (i.e. prepare standardisation and increase maturity level beyond TRL4), and in addition address those aspects that were not considered in Wave 1 such as:

- Use of induction loops in Composite Surveillance;
- No monostatic PSR or MSPSR FM/DAB of non-cooperative surveillance systems;
- Non-cooperative surveillance systems such as monostatic PSR, passive MSPSR (FM/DAB) and active MSPSR (own L-band TX) building on SESAR 1 results;
- Use of Video cameras as sensors for measuring azimuth and elevation angle measurements. Despite the sensor also the data processing infrastructure along simulation and analysis infrastructure has to be adapted;
- The enhancement of the non-cooperative solutions for mitigation of the adverse wind farm effects;
- Secured surveillance systems: development of an automated test suite; Full consideration of RPAS (video cameras are an interesting sensor technology in the detection of RPAS);
- Local enhancement of an existing surveillance layer by range and range differences (no complete position solution) is missing. In Wave 1 this is done in the vicinity of an airport; in Wave 2 it is intended to extend this region significantly by adding an MLAT remote unit at a strategic location e.g. Mount Brocken;
- Provide values for detection performances given that at the moment there are not standards for secured surveillance.

The SESAR solution shall provide inputs to relevant standardisation bodies e.g. EUROCAE WG51, WG4, WG102 and WG103, etc. and standards such as ED142 (WAM), ED100 (Video Surveillance), ED129 (ADS-B), ED87 (A-SMGCS), ED117 (MLAT), ED128 (Tracker). The results of the security implementation shall be presented to NEASCOG and the involved agencies with the goal to implement a common European security approach for surveillance in ATM. The output will also be directed to the Eurocontrol Asterix Management Group (AMG) to adapt existing Asterix categories so to convey security information at the appropriate level to various client systems or recipients.

New use and evolution of Cooperative and Non-Cooperative Surveillance	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #14-04-03 and covers the following enablers (some are proposed to be included for DS18):

- *A/C-48b — Air broadcast of aircraft data (ADS-B OUT) compliant with new DO260C standard.*
- *CTE-S02d — Video Based Surveillance.*
- *CTE-S02c — Multi Static Primary Surveillance Radar.*
- *CTE-S03c — New ADS-B station for future ADS-B applications.*
- *CTE-S07e Sur Chain SPM Tool-ER&TMA*
- *CTE-S06b composite NC & ADS-B*
- *CTE-S06c secured composite surveillance*
- *CTE-S08a Chain ER&TMA (MSPSR)*
- *CTE-S08b SUR Chain ER&TMA (Space-based ADS-B)*
- *CTE-S08c MRTC-Surveillance (Multi Remote tower Control – Surveillance)*

3.10 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ17 W2 SWIM infrastructure"

3.10.1 Problem statement and R&D needs

System Wide Information Management (SWIM) Technical Infrastructure (TI) Air-Ground (A/G) Solutions are required for supporting Information Exchange Services and SWIM-enabled Applications for the future ATM System. Further work is required to mature and validate SWIM A/G solutions (SWIM Technical Infrastructure purple profile) for safety critical services, and SWIM solutions supporting civil-military interoperability.

3.10.2 Performance expectations

While the technological solutions developed under this topic do not have direct impact on operational key performance areas, they are in the critical path to deliver the ATM Master Plan performance ambition in areas as efficiency, capacity, safety and security. Cost-efficiency of operating air/ground communication systems is expected to be greatly improved.

3.10.3 List 1 SESAR Solutions

The proposal shall address, as a minimum, one solution from List 1:

3.10.3.1 Solution PJ.17-W2-100 SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing

The SESAR Solution SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing allows the distribution of safety-critical information through A/G SWIM infrastructure and aeronautical telecommunications network/Internet protocol suite (ATN/IPS) networking, rather than legacy point-to-point contracted services. So far, CPDLC and ADS-C ATM services are used for point-to-point exchange of safety-critical data between aircraft and ground ANSP systems. With this SESAR Solution ADS-C style services for example (either continental or oceanic) may take advantage of aircraft using an information publication method over A/G SWIM infrastructure with several ANS (and possibly AOC) systems subscribing to this information over the Ground SWIM infrastructure.

Technical specifications will have to be defined to support safety and security requirements allowing exchange of safety critical information (It will need to be identified whether the specification of this solution for safety critical services will be dependent on the solution for advisory services or whether it will be described as a stand-alone solution).

The SESAR solution includes:

- Analysis of Service Description Documents (SDDs) provided by ATM Solutions as they might set (or imply) A/G safety critical information exchange requirements (e.g. expectations in terms of NFRs) on the underlying SWIM Infrastructure;
- Definition of SWIM TI Functional and Non-Functional Requirements on communication services, including security, performance, safety, accessibility, maintainability and reliability ones, starting from existing requirements for e.g. CPDLC and ADS-C services;
- Specifying interface requirements on the underlying IP communication infrastructure (e.g., for network-level security and mobility network etc.);
- Provision of possible updates to/evolution of SWIM Technical Infrastructure Profile Compliance Criteria for the Purple Profile or the creation of a new profile for safety critical A/G information exchange;
- Assessment on feasibility (and cost) to achieve required assurance levels. This may include discussions with relevant agencies (e.g., EASA);
- Provide technical and functional requirements to Solution 77 (FCI Services) with respect to the data exchanges with the A/G systems and ensure feasibility of implementing these requirements with the FCI solution;
- Provision of support for standardisation of the “Purple Profile for safety critical services”;
- Global coordination ensuring interoperability of the SESAR A/G SWIM-safety critical data sharing solution with the FAA Aircraft Access to SWIM (AAtS) and other global SWIM Technical Infrastructures and analysis, design and (if required) implementation of architectural elements that might be further needed to ensure such global interoperability;
- Definition of Security Controls required for protecting the airborne and ground SWIM assets for the safety critical A/G systems.

The SESAR solution shall coordinate with Solution 77 (FCI Services).

SWIM TI Purple Profile for Air/Ground Safety-Critical Information Sharing	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	TRL-2 on-going	**TRL-4**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed on SESAR Solution #17-07 under the umbrella of solution #17-01 for advisory services. The relevant enabler need to be either created or updated based on the available A/G SWIM enablers in the ATM MP Level 2.

3.10.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.10.4.1 Solution PJ.17-W2-101 SWIM TI Green profile for G/G Civil Military Information Sharing

SESAR Solution "SWIM TI Green profile for GG Civil Military Information Sharing" aims at enabling Ground/Ground civil – military SWIM based coordination at SWIM technical infrastructure level through SWIM profiles with an adequate quality of service, including (cyber) security/ resilience, needed by military stakeholders and agreed by civil stakeholders. The SESAR solution aims at improving cost-efficiency and civil-military cooperation and coordination KPAs.

The Green Profile (GP) aims at filling the gap between existing G/G profiles (i.e. currently in V4 stage for the Yellow Profile (YP) now defined by the Eurocontrol YP specification, still in V3 stage for the Blue Profile (BP) through wave 1 solution #18-02b) and what is needed to fully support SWIM-based civil-military coordination/cooperation, especially in terms of (cyber) security.

The European ATM Master Plan underlines the cost efficiency target associated to this SWIM-based coordination. The most straightforward way to satisfy this target is to broaden existing ground/ground profiles capabilities, i.e. yellow and blue profiles, in order to take into account military expectations. Both yellow and blue profiles are considered since services in the scope of this coordination (already known or to be identified) run preferably on top of one or the other profile. A subset of these services is concerned by military expectations, so may necessitate evolutions of existing profiles mainly for (cyber) security and resilience issues.

The work in Wave 1 faced a readiness issue regarding the blue profile because of on-going work on blue profile / IOP (interoperability, ED-133 standard based on the flight object concept) under solution #18-02b. IOP consolidation addresses the application level subset of ED-133, but its middleware subset, included in the blue profile, may be impacted. In addition, the yellow profile standardization is now completed (EUROCONTROL Specification for SWIM Technical Infrastructure (TI) Yellow Profile Ed 1.0 01/12/2017), and since the number of requirements has been drastically reduced compared to TRL6 in SESAR 1, this could also impact the blue profile.

Wave 2 work will enable to take into account refined or new civil-military information exchanges (e.g. 4D trajectory management, mission trajectories, dynamic airspace configuration (DAC), RPAS, etc.) together with the blue profile scope (especially flight objects) for real time resilient coordination in case such requirements are not met by the green profile. The work on Wave 2 covers:

- Green profile validation at TRL6 level;
- Submission for yellow profile standard extension (military profile part(s)) once TRL6 gate is achieved for initial green profile;
- Final green profile technical validation of main requirements of the technical specification;

- Blue profile – military capabilities to support military expectations mapped to blue profile.

SWIM TI Green profile for G/G Civil Military Information Sharing	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	TRL-4	TRL-6

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #17-03. The relevant enabler need to be updated / created in the ATM MP Level 2 in DS18b.

In wave 1, the enablers under the scope of solution #17-03 are the following:

- *GGSWIM-51c - SWIM ground-ground messaging services in Step3.*
- *GGSWIM-59c - SWIM security in Step3.*
- *SENA00136 – Enablers still under definition.*

3.11 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ18 W2 4D skyways"

3.11.1 Problem statement and R&D needs

The SESAR concept is based upon the fundamental element of trajectory sharing. The ultimate goal is a trajectory based ATM system where actors optimise business and mission trajectories through common trajectory information taking into account users priorities and ATC constraints. The objective is the sharing of the trajectories between the ATM actors including airspace users through an iterative process to take into account more accurate data once available (e.g. intentions, MET forecast, current traffic, airspace management). This will allow the Airspace User to choose the preferred way of integrating ATM constraints when required. There is a need to agree in more details on the elements that will constitute the reference business trajectory (RBT) in trajectory based operations (TBO) and better understand how these will be used operationally. The new ATM Solutions will need better trajectory predictions and additional data exchanges between systems.

A generic principle of the SES and the SESAR programme is that, where services can be delivered in a harmonised manner, they should be done so. The future high level architecture should offer an option for the de-fragmentation of the ATM system through the provision of harmonised or Common Services (a service to consumers that provides a capability in the same form that they would otherwise provide themselves). Introducing a Common Service will change how a solution is delivered and this is likely to change organisational relationships between the stakeholders due to the provision and consumption of the new service.

3.11.2 Performance expectations

The project will contribute to increase:

- Safety by generating and proposing conflict free clearance that considers aircraft performance
- Interoperability by sharing the same trajectory view between air and all ground actors;

- Predictability by improved trajectory accuracy and sharing information updates throughout the flight;
- Flexibility by matching the trajectory with the Airspace User needs;
- Flight efficiency: flight is managed closer to its optimal profile.

3.11.3 List 1 SESAR Solutions

The proposals shall address, as a minimum, two solutions from List 1:

3.11.3.1 Solution PJ.18-W2-53 Improved Ground Trajectory Predictions enabling future automation tools

The SESAR solution "Improved ground trajectory prediction enabling future automation tools" focuses on the operational validation of improved CD&R tools to improve separation management (tactical layer) in the en-route and TMA operational environments. The main goal is to increase the quality of separation management services reducing controller workload and separation buffers and facilitating new controller team organisations. The SESAR solution continues and completes the work performed in Wave 1 under #10-02a and #10-02b.

The improvement of the ground TP is the foundation for improved CD&R. This solution will build on Wave 1 work by solution #18-06 on the use of advanced data that will be used to increase the quality of the trajectory prediction and then the separation management services. In Wave 2, this must include the use of EPP data beyond weight and CAS e.g. estimated time over waypoints, predicted climb and descend speeds, the predicted CAS/Mach conversion altitude and potentially predicted vertical rates dependent on the altitude, etc. The improvement of the TP is fully allocated to this solution in Wave 2, but it is acknowledged that the work is relevant in other solutions. In particular, close coordination will be needed between this solution and the TBO solutions.

It is expected that the improved TP will allow current tools to have better performance (improved conflict detection and improved resolution proposals), which will already bring operational performance benefits (e.g. reduced ATCO workload). The solution shall validate these improvements, and may, in addition, address further improvements to the ground TP based, for example, on:

- Improved handling of known MET data or introduction of new MET data and capabilities: e.g. advanced wind consideration, taking into account a now cast wind field derived from actual wind data from aircraft Mode S enhanced surveillance data, consideration of "no fly" zones provided by meteorological services. Improved handling of the downlinked SFL by ground systems (e.g. consider SFL in combination with EPP in order to better predict what the aircraft will do);
- Improved integration of known ground trajectory constraints from the current ATSU or from an upstream or downstream ATSU;
- Consideration of the ATC intent (i.e. TP to consider the ground plan, which are clearances that have not yet been delivered to the aircraft but the ground anticipates will be delivered to the aircraft at a later stage).

In addition to the work on improving the ground TP, the solution may also develop:

- Improved CD&R tools, e.g. Further introduction of automation mechanisms for assisting the controllers in their separation tasks;
- Improved tools for conformance monitoring and for the resolution of the discrepancies that are identified;
- Improved monitoring of discrepancies between the air and ground trajectories and improved resolution of the discrepancies that are identified (i.e. improvement of solution #115 from SESAR 1); potentially combining EPP with other DAPs (downlinked CAS, SFL);
- Tools to support ATCOs for management of merging traffic.

The solution shall consider different levels of accuracy and reliability according to the capacity of a flight to provide data (i.e. between capable and not capable aircraft). Furthermore different equipage has to be taken into account with regards to 2D RNP equipage.

The operational environment is both en-route and TMA. The SESAR solution covers scheduled, non-scheduled, general aviation and training flights (military flights will be supported as long as they are treated as GAT traffic).

This solution is closely linked to the TBO candidate solutions 8 'Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations', 56, 'Improved vertical profiles through enhanced vertical clearances' and 57 'RBT revision supported by datalink and increased automation'. This solution is focused on the development of improved detection of separation conflicts and improved automated support to select the best resolution to a conflict, while the other solutions (8, 56 and 57) are focused on improvements to the subsequent RBT revision process that is necessary to apply the resolution.

The target maturity level of this solution has been set to V3 based on the expected target maturity of the EPP improvement to the TP in Wave 1 (#10-02a). However, it is acknowledged that the solution may research other aspects that will be at a lower level of maturity at the start of Wave 2 (e.g. output of #10-02b), and will not reach V3 at the end of Wave 2. The less mature aspects will be identified during the research and research results will be published in separate data packs for each maturity level (i.e. V2 and, if appropriate, V1 data packs).

The SESAR solution shall take into consideration the results of the "ADS-C opportunities" task conducted in wave 1 under solution #18-02a.

The .solution may take into consideration the more relevant and mature results from the ER project TBO-MET "Meteorological uncertainty management for trajectory-based operations".

Improved ground trajectory prediction enabling future automation tools	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V2	V3

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #10-02a and #10-02b in Wave 1 and covers the following OI steps (subject to be reviewed in future datasets):

- *CM-0206 — Conflict Detection and Resolution in the TMA using trajectory data.*
- *CM-0208-A — Automated Ground Based Flight Conformance Monitoring in the TMA in Step 1.*
- *CM-0209 — Conflict Detection and Resolution in En-Route using aircraft data in Predefined and User Preferred Routes environments.*
- *CM-0210 — Ground Based Flight Conformance Monitoring in En-Route using aircraft Data.*
- *CM-0211 — Advanced Support for Conflict Detection and Resolution for ATC planning in En Route.*
- *CM-0605 — Separation Management in En-Route using Pre-defined or User-preferred Routes with 2D RNP Specifications.*
- *CM-0606 — Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications.*
- *CM-0207-B — Automated Ground Based Flight Conformance and Intent Monitoring in En-Route in Step 2.*
- *CM-0208-B — Automated Ground Based Flight Conformance and Intent Monitoring in the TMA.*
- *CM-0407 — Enhanced Conflict Detection and Resolution in En-Route.*
- *CM-0408 — Enhanced Conflict Detection and Resolution in the TMA.*
- *CM-0607 — Separation Management in En-Route using RBTs with 2D RNP Specifications.*
- *CM-0608 — Separation Management in the TMA using RBTs with 2D RNP Specifications.*

3.11.3.2 Solution PJ.18-W2-56 Improved vertical profiles through enhanced vertical clearances

In current operations, ATCOs often issue instructions that constrain the rate of climb or descent of aircraft in order to ensure separation. This is done in some cases based on the ATCO prediction (with the support of the ground TP) of what the climb profile will be (e.g. whether it is feasible and reasonable to constrain the aircraft to maintain a certain vertical rate or to be asked to cross a certain waypoint at, at or above or at or below a certain flight level). In other cases, ATCOs ask the flight crew over R/T whether they can comply with a specific restriction (e.g. can you cross waypoint XYZ at FL340 or above?). In TBO, enhanced knowledge of the future aircraft performance is available through the eFPL or the EPP, and SESAR V&V results (e.g. VP-832) indicate that this improved knowledge is most relevant in the vertical dimension. The objective of this solution is to develop an automation support for ATCOs to issue vertical constraints that support more efficient flight profiles while ensuring separation provision.

The research would cover the following aspects:

- In a first development of this solution, for a certain flight still in climb, enhanced prediction of vertical profile data are presented to ATCOs in a way which facilitates their decision making on whether using constraints in the vertical dimension is appropriate and sufficient to achieve separation. SESAR 1 solution #27 already incorporated this kind of tools, but based on standard performance models (e.g. BADA). A first development of the solution could use eFPL 4D trajectory or performance data and would not require datalink, but it is expected that the performance would be better if downlinked EPP data are used. If EPP flight performance data beyond mass and speed schedule are used, ATN B2 would be required. This development builds on PJ.10-02a and PJ.18-06 work on incorporating eFPL and EPP data into the ground TP;

- In a second more advanced development of this solution, in the same situation the ATC system would generate proposals for conflict-free clearances that take anticipated aircraft performance into account, and those proposals are then presented to the ATCO for uplink to the flight crew. Once uplinked, the flight crew would auto-load this clearance in the FMS. Should there be a modification in the airborne planned profile once the constraint has been implemented in the FMS, a new EPP would be downlinked, thereby supporting improved A/G synchronization. This research builds on the PJ.10-02b work on the management of the vertical trajectory, and is based on ATN B2. The research may also look at proposing enhancements to ATN B2 to feed the development of ATN B3 (e.g. including information on vertical constraints in the FMS trajectory in a future updated EPP standard).

The application of enhanced vertical clearances is not necessarily limited to cases where there is a need for ATC to use a vertical constraint in order to ensure separation; enhanced vertical clearances may also be useful when the reason for the ATC constraint is airspace management (e.g. sectorization may require the use of vertical constraint for an aircraft to avoid a specific sector). This use case has been considered by solution #01-03b in Wave 1.

CPDLC has been validated for use only in en-route (the datalink mandate is restricted to airspace above FL285). It is expected that this solution will research the use of CPDLC below FL 285, building on the activities of the SESAR 1 demonstration ATC Full Datalink (AFD) and the result of SESAR 1 exercise VP-805[2], which explored the potential use of datalink. It is expected that this will require considerable research in the airborne domain, both in terms of procedures and in terms of development of improved on board HMI and auto-load capabilities. This builds on the research on CPDLC performed by Link2000+) and PJ.18-02a, and should take into account the feedback from the ongoing implementation.

As the advanced use of datalink and the extension of datalink below FL285 will open new communication possibilities, it is expected that the use of datalink between controllers and pilots will increase and the use of voice decrease. For this reason, the development of the concept of operations for the advanced use of datalink is inextricably linked to the overall evolution of the controller-pilot communication and the evolution of the voice concept of operations. The following open questions on the future of controller-pilot voice communications have been identified:

- Would the future voice communications need to be point-to-point or multi-point (with a channel with party-line like current VHF frequencies)?
- Would a hybrid system be useful, i.e. point-to-point with no party-line but with a free/occupied indicator to prevent simultaneous incoming transmissions for the same ATCO?
- What would be the acceptable latency?
- Which would be the encryption and security needs?
- What are the wide-area communications needs?
- Which are the future automation needs connected to voice communications (e.g. remotely tune the system on another channel, handover, priority call…) and which operational requirements would be required to support them?

[2] VP-805 was run by SESAR 1 project 05-03 and its main focus the integration of CTA and ASPA, but also included several validation objectives related to CPDLC.

The future of controller-pilot communications requires a new concept of operations that includes voice and datalink. It is expected that this new "Controller-pilot communications CONOPS" will be developed by a separate SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The research in this solution has been identified as highly relevant for this CONOPS; consequently, this solution should plan effort to support the development of the "Controller-pilot Communications CONOPS", e.g. by participating in the CONOPS development expert groups.

This solution is closely linked to solution 57 'RBT revision uplink supported by datalink and increased automation' and solution 8 'Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent and improved Arrival and Departure Operations'.

The SESAR solution shall take into consideration the results of the "ADS-C opportunities" task conducted in wave 1 under solution #18-02a.

Improved vertical profiles through enhanced vertical clearances	MATURITY LEVELS	
	Maturity Level at the start of Wave 2	Target Maturity Level at the end of Wave 2
	V1	V2

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required Operational Improvements steps (OIs) for future datasets.

Safe vertical clearances have been initially covered by solution #10-02b in SESAR 1 at a low level of maturity, relevant OI steps would need to be revisited to cover this SESAR Solution.

3.11.3.3 Solution PJ.18-W2-57 RBT revision supported by datalink and increased automation

This SESAR solution aims at supporting a continuous increase in the amount and the usefulness of information shared between air and ground and of the level of automation support to controllers and pilots, e.g. towards the automatic uplink of clearances with or without previous controller validation and towards increased use of the auto-load to FMS of uplinked clearances and of managed/automatic mode by the flight crew. The close collaboration of airborne industry, ground ATC industry and ANSPs is required for the development of the concepts in this solution and for their validation.

The airborne architecture based on FMS and FCU/MCP was designed to allow flight optimization in an environment where there was no data exchange between air and ground. As A/G data exchange possibilities become available, the ground systems get visibility of airborne data (downlink of SFL, CAS, airborne trajectory prediction (EPP), use of RNP and dynamic RNP). However, in order to allow the realization of the full benefits of the availability on the ground of these airborne parameters, it is necessary to synchronize the evolution of air and ground systems.

The SESAR solution shall address the medium-term evolution in airborne systems e.g. FMS, FCU/MCP and flight crew operating procedures synchronized with the medium-term evolution of ground systems and associated procedures for the G/G coordination between NM, ACCs and FOCs to address the DCB, Airspace User operations, Traffic Synchronisation and Separation needs. The research must aim at ensuring that the new procedures reduce or at least do not increase controller and flight-crew workload.

The SESAR solution objectives cover the development and operational validation of advanced ground and airborne procedures (and the tools required to support them) in order to facilitate the RBT revision including its uplink and RBT information sharing in a TBO environment including:

- Evolution and standardization of flight crew procedures/behaviours, e.g. with respect to FMS and MCP/FCU management in order to make EPP and SFL downlinked information more meaningful on the ground;

- Development of ATC support systems and operational procedures (e.g. in order to allow RBT modification in advance, including its ground-ground coordination and its uplink to the aircraft) which are complementary with or go beyond the procedures and system support developed in solution 8 and 56;

- Further development of CPDLC capabilities within ATN B2, e.g. validation of the use of an increased message set (restricted to ATN B2 messages that are in the standard but whose use has not been validated, validation of an extended set of auto-load capabilities, extension of the use of CPDLC to lower altitudes than it is possible today, uplink of lateral trajectory revision (potentially including dynamic RNP), uplink of complex climb/descent clearances, uplink of climb/descent planning information, etc.). These developments need to be validated with the involvement of both ANSPs, ground industry (for the ATC support tools) and airborne industry (for the development of cockpit procedures and systems). In particular, Solution 57 will coordinate with Solution 77 (FCI Services) to provide to this Solution functional and performance requirements;

- Improvement of the relevance of the Mode-S SFL downlink e.g. by standardizing flight-crew procedures with respect to the FMS and MCP/FCU, by improving the handling on the ground of the SFL downlink by considering it in combination with EPP in order to predict what the aircraft will do;

- Development of operational procedures and system support for ground-ground coordination in support of increased flexibility of RBT revision including the consideration of different time horizons to address different operational needs (DCB, traffic synchronization, separation) making use of SWIM technologies and beyond the scope of solution 53, e.g. to allow a revision up-linked by an ATSU that is upstream from where the change to the RBT will take place;

- Development of an operational concept, procedures and supporting tools to allow the FOC to be involved (through a CDM process) in RBT revision during the execution phase when time allows, e.g. for revisions with a look-ahead time above a certain threshold.

The SESAR solution aims at supporting a continuous increase on the level of automation e.g. towards automatic up-linking of clearances with controller validation or even without it.

This may include:

- Use of big data analytics and machine learning e.g. prediction of data-link or ground-ground messages for faster input by ATCOs;

- Use of machine reasoning, e.g. intelligent assistants or automation agents for ground and airborne operators;

- Multi criteria (economic, environmental, ….) ranking of resolutions trajectory in collaboration with Airspace users;
- SWIM.

The SESAR solution shall be based on ATN B2 and incorporate any additional required CPDLC messages. Therefore, the SESAR solution shall consider key aspects such as:

- The interaction between voice (current R/T, and future Digital voice) and datalink, in order to determine the operational requirements and procedures to optimise their use;
- Simultaneous voice and datalink clearances beyond the Link 2000+ work, e.g. resolution of inconsistencies;
- The potential use of voice recognition in the cockpit or on the ground;
- Latency issues and their impact on pilot and controller workload.

CPDLC has been validated for use only in en-route (the datalink mandate is restricted to airspace above FL285). It is expected that this solution will research the use of CPDLC below FL 285, building on the activities of the SESAR 1 demonstration ATC Full Datalink (AFD) and the result of SESAR 1 exercise VP-805[3], which explored the potential use of datalink. It is expected that this will require considerable research in the airborne domain, both in terms of procedures and in terms of development of improved on board HMI and auto-load capabilities. This builds on the research on CPDLC performed by Link2000+) and PJ.18-02a, and should take into account the feedback from the ongoing implementation.

As the advanced use of datalink and the extension of datalink below FL285 will open new communication possibilities, it is expected that the use of datalink between controllers and pilots will increase and the use of voice decrease. For this reason, the development of the concept of operations for the advanced use of datalink is inextricably linked to the overall evolution of the controller-pilot communication and the evolution of the voice concept of operations. The following open questions on the future of controller-pilot voice communications have been identified:

- Would the future voice communications need to be point-to-point or multi-point (with a channel with party-line like current VHF frequencies)?
- Would a hybrid system be useful, i.e. point-to-point with no party-line but with a free/occupied indicator to prevent simultaneous incoming transmissions for the same ATCO?
- What would be the acceptable latency?
- Which would be the encryption and security needs?
- What are the wide-area communications needs?
- Which are the future automation needs connected to voice communications (e.g. remotely tune the system on another channel, handover, priority call…) and which operational requirements would be required to support them?

The future of controller-pilot communications requires a new concept of operations that includes voice and datalink. It is expected that this new "Controller-pilot communications CONOPS" will be developed

[3] VP-805 was run by SESAR 1 project 05-03 and its main focus the integration of CTA and ASPA, but also included several validation objectives related to CPDLC.

by a separate SESAR exploratory research project (a suitable topic will be included in the upcoming ER4 call). The research in this solution has been identified as highly relevant for this CONOPS; consequently, this solution should plan effort to support the development of the "Controller-pilot Communications CONOPS", e.g. by participating in the CONOPS development expert groups.

This solution is closely linked to solution 8, 'Dynamic TMA/E-TMA for Advanced Continuous Climb and Descent Operations and improved Arrival and Departure Operations' and solution 56 'Improved vertical profiles through enhanced vertical clearances', as well as to solution 53, 'Improved ground trajectory prediction enabling future automation tools' and solution 38 'Enhanced integration of AU trajectory definition and network management processes'. The solution shall also coordinate with solution 77 "FCI services".

The solution is expected to bring benefits not only in terms of improved predictability of the trajectory on ground, but also in terms of reduction of ATC and flight crew workload and reduction in fuel burn thanks to the increased use of managed/automatic mode (thereby allowing the FMS to optimise the flight). Benefits by including the FOC in coordination and decisions may also be investigated.

One of the specific objectives of this solution is to increase ATCO productivity thanks to the increased use of automation. The fulfilment of this objective requires that the new concepts allow a reduction of controller workload during peak times. For example, the solution may develop procedures that when used decrease controller workload but can't really be used at times of high traffic load, e.g. uplink of some clearances may be possible at times of medium traffic load and allow improved flight efficiency and reduced controller workload at those times, but the uplink of the same clearances may not be possible or may become impractical at peak times, for example due to the latency of the data link (which may be unacceptable at peak times) or due to it not being possible for controllers to anticipate clearances and at the same time ensure separation when traffic is high; in such cases, the measured reduction of ATCO workload at periods of medium or low demand can't be considered to contribute to the performance objective of ATCO productivity.

Regarding the reduction of flight crew workload, the research must consider the need for pilot workload reduction in the context of reduced crew operations, datalink and auto-load management, etc. This aspect will require the development of automation in the cockpit, with the consideration of the associated human performance aspects, e.g. need to increase flight crew awareness about the current automation state, improvement of the data link HMI including filtering out of data link messages that may not require the flight crew to be in the loop, for example because they are routine system messages – logon completed, availability of data link, etc. - rather than clearances.

The introduction of higher level of automation, together with use of complex and advanced approaches such as machine learning, machine reasoning, and voice recognition creates requirements on regulatory and standardization side. Therefore, the research should consider from an early stage the challenges that may be faced for the certification of the new systems that will be necessary before their implementation. It is anticipated that a new certification approach will become necessary in order to allow the certification of non-deterministic systems, and this has been included as a generic research topic for SESAR Exploratory Research. The generic research into novel certification methodologies is out of the scope of this industrial research solution, but the research in this solution should at least identify the certification challenges specific to the systems developed by this solution, and may also address how to overcome them, also specifically for these systems.

The solution builds on the following previous SESAR work:

- SESAR demonstration ATC Full Datalink (AFD) work on extending the use of datalink;

- SESAR demonstration Optimised Descent Profiles (ODP) work on identifying potential areas for improvement (e.g. interpretation of SFL downlink, deletion of FMS constraints in descends via);
- SESAR 1 05.06.06's work on CPDLC in exercise VP-805;
- PJ.18-02a work on advanced use of ATN B1 and ATN B2.

It is acknowledged that this solution has a very broad scope, with elements at different levels of initial maturity. The target maturity level has been set to V3 in anticipation that the research will be able to progress some elements to V3. However, it will not be possible to progress all elements to V3. The solution must also deliver V1 and V2 data packs at the end of Wave 2 in order to ensure that those elements that do not reach V3 are also properly documented.

RBT revision uplink supported by datalink and increased automation	**MATURITY LEVELS**	
	Maturity Level at the start of Wave 2	**Target Maturity Level at the end of Wave 2**
	V2 on-going	**V3**

The SESAR solution shall take into consideration the results of the "ADS-C opportunities" task conducted in wave 1 under solution #18-02a.

Relevant links to the ATM Master Plan Level 2 (DS18a):

This is a new SESAR Solution that needs to be created together with the required Operational Improvements steps (OIs) for future datasets.

Its scope of this solution has been initially covered by solution #18-02a in SESAR 1 at a low level of maturity, relevant OI steps would need to be created/revisited to cover this SESAR Solution. The initial list includes:

- *SDM-0213 — Enhanced A/G data exchanges for Trajectory Based Operations (TBO).*
- *SDM-0214 — Improved trajectory management based on enhanced G/G data sharing among ATC and Network Management.*

3.11.4 List 2 SESAR Solutions

The proposal may cover the following two solutions covered in list 2.

3.11.4.1 Solution PJ.18-W2-88 Trajectory Prediction Service

The SESAR solution "Trajectory Prediction Service" (TPCS) is a technical service conceived as being provided to Europeans ANSPs, AUs, AO, Military and the Network Manager (NM) in support of trajectory operations. Although the Business Model is limited to these stakeholders, there is no intent to limit the actual deployment of the services. TPCS is intended to provide a single point of truth for a specific trajectory in the time frame from creation in long term pre-flight planning through to the flight execution phase. TPCS is not intended to replace today's flight data processing systems and consequently the service can be used as an input to ATC systems but not used directly for control purposes.

The Trajectory Prediction Common Service solution aims to define the minimal set of features that would enable the essential interoperability without unnecessarily restricting implementation.

Common Services are intended to reduce overall cost of service provision. Over the lifetime of the service, in the case where there is an existing Trajectory Prediction service or a new service is being created, the overall service provision cost is required to be reduced compared to the cost of independent service provision

Function of the service:

- To provide an accurate single point of truth about planned route, constraints, AU preferences etc. for a given flight, and to calculate a 4D trajectory prediction based on that information, to support SBT/RBT planning related activities in the pre-flight and execution phases;
- Provision of timely access to the TPs required by authorised stakeholders to perform their operational functions, and in a format appropriate to the needs of the wider trajectory management concept. A TPCS may be able to rationalise the TP calculations required to meet the needs of multiple consumers;
- A single service provider (SP) is associated with each flight (generally associated with an AU and essential for the provision of a single point of truth for a flight). In the nominal case, one SP would provide the TPCS for the entirety of a given flight. Consumers will obtain a complete picture of the airspace by combination of the trajectories supplied by the SPs;
- ANSP / Military will be provided with trajectories relating to their operational needs (for example military trajectory management will be based on a reference mission trajectory (RMT) concept, and include support for transit to and from, and operations in, military airspace reserves);
- Other consumers will be able to access trajectory information for a given flight based on flight ID information, subject to appropriate access rights.

Safety and Security considerations shall be addressed.

In Wave 2, the work shall be focused on completing the work on the implementation option/options retained from those analysed in Wave 1.

	MATURITY LEVELS	
Trajectory Prediction Service	**Maturity Level at the start of Wave 2**	**Target Maturity Level at the end of Wave 2**
	TRL-2	**TRL-4**

Relevant links to the ATM Master Plan Level 2 (DS18a):

This SESAR Solution follows-up the work performed by SESAR Solution #15-08 and covers the following Business Improvement:

- *SDM-0403 Trajectory Prediction Common Service (Business Improvement).*

3.12 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ19 W2 Content Integration, Performance Management and Business Case Development"

The SESAR 2020 Programme requires guidance and steering to achieve the objectives of the Master Plan. While the decisions will be taken by SJU management and SESAR governance, the project will coordinate and integrate operational and technical solutions, and as such will support and guide the execution of the transversal processes (e.g. safety, security assessment, CBA) to ensure their completeness, consistency and coherency from a holistic perspective. The content Integration activities will also cover the maintenance and support of the performance framework and ensuring its applicability by the projects. These activities will provide support to the activities that monitor the programme and that will lead to the further decision making necessary by SJU management and SESAR governance.

The **mission** of the project is **to support Programme execution and solution projects developments for delivering the SESAR Solutions in line with the ATM Master Plan**. To achieve that mission, the project will support the SESAR JU in:

- Organising and executing Content Configuration Change process: support the evolution and breakdown of the master plan into configuration items (Solutions) and facilitate the evolution and change management of these (Integrated Roadmap - Dataset maintenance):
    - Deliver CR management and updated Integrated Roadmap Data Sets.
- Organising on a continuous basis the activities needed at programme level aiming to coordinate, consolidate and integrate SESAR ATM and Technological Solutions, and as such to support and guide the processes to ensure their completeness, consistency and coherency from a holistic perspective. The activity facilitates and supports integration of detailed operational and technical system and services including support to OTSC and maintenance of common taxonomy: ensure synergy between operational scenarios and processes and support integration of system and services to guarantee coherent and consistent outcome (includes drones integrator):
    - Deliver inputs for the Master Plan Level 1 (Solution groupings, identification of impacted ATM systems/Services, Essential Operational Changes, Deployment Scenario, Stakeholder Roadmaps);
    - Delivers the architectural content + integrated roadmap (including OI, EN + proposed IOC and FOC dates; and stakeholders allocations, initial DS, EOCs) and as such supports the publication and reporting of the Master Plan level 2 as done by the MP project. The information is captured via EATMA;
    - Deliver targeted architecture options for each phase of the MP focusing on the evolution of business services as well as supporting capabilities and as such support the publication and reporting of the Master Plan Level 1 and 3;
    - Deliver Reporting on integrated and consolidated architectural content (e.g. SESAR Solution content progress and architecture maturity, Gap analysis, Cyber security status);
    - Deliver Ops and technical issues management;
    - Deliver OTSC support.

- Supporting preparation of maturity gate data-packs and self-assessments including reporting how the Solution contributes to the MP from a ops/technical perspective (e. g. ops & tech report in the form of gap analysis) and from a performance perspective (e. g. performance quality measurement assessment report): contribute to maturity gate assessment:
    - Deliver Solution architecture and requirements quality assessment and gap analysis;
    - Deliver quality assessment related to project solution performance work.
- Ensuring the translation of the MP performance ambition into validation targets:
    - Deliver and maintain validation targets per SESAR Solution.
- Facilitating/enabling performance measuring and reporting and solution CBA development including training and coaching & follow up community of practices organised per KPA domain:
    - Deliver training and coaching to SESAR Solution projects for performance reporting and CBA development matters;
    - Deliver Reporting on the progress and process related to integrated performance measurements.
- Although the responsibility of conducting the performance assessments and CBAs lies with the SESAR 2020 projects, this project will:
    - On a continuous basis, support the process of performance evaluation to ensure alignment with expectations outlined in the European ATM Master Plan and that performance results can be exploited not only at local level but also for decision making at European level;
    - Aggregate solution performance and CBAs;
    - and deliver:
        - aggregated performance reports and assessment;
        - performance issues management;
        - business cases.
- Ensuring the evolution of future envisaged concept of operations (CONOPS) aligned with the SESAR Vision and Performance Ambition as set at the Master Plan level 1. This CONOPS will also build upon the W1&W2 achievements in order to propose a new baseline for a potential SESAR 3. This CONOPS activity will only be launched as of T0+24 months and will be completed by T0+32 months, involving all members' expertise.
- Enabling and support system engineering data management framework:
    - Set-up and maintain a SE requirement management framework to maintain and enable requirements identification and traceability:
        - Deliver SE requirement management framework;

        - Deliver training and coaching to requirements practisers working in solution projects.
    - Support the capturing of information done by solution project to ensure consistency, coherency, and coverage at programme level of requirements:
        - Deliver traceability reports (e.g. validation objectives/results).

The project will participate, support and contribute to the definition of the future SESAR artefacts organised and delivered in ad-hoc or on demand basis by the SJU and to be shared at governance and consultation bodies levels.

3.13 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "PJ20 W2 Master Planning"

The SESAR Joint Undertaking is responsible for the execution and maintenance of the Master Plan (MP), as the plan evolves following the results of the research and development activities, coordinated by the SJU, and the deployment plans, implemented by the other stakeholders of the SESAR project.

The Master Plan is composed of three levels: Level 1: Executive view, Level 2: Development planning & reporting and Level 3: Deployment planning and reporting. The TA master planning project is the programme focal point to ensure the maintenance and evolution of the European ATM Master Plan. It consists in the yearly update of Level 2 and 3 Plans and Reports, updating and publishing as and when necessary the ATM-MP and in supporting ATM-MP update campaigns, every 2-3 years where is carried out a major and simultaneous update of all three levels of the ATM-MP.

The **mission** of the MP project is **to apply top-down logic to facilitate the strategic steering of the SESAR project as a whole in line with Policy priorities**. To achieve that mission, the Project will support the SESAR JU in:

- Organising the Master Plan update campaign (one update campaign is tentatively planned to take place in 2022, precise year to be confirmed by the SJU and its Governance Bodies), and in particular, from the review of SESAR 2020 and SESAR Deployment results:
    - Refine the core SESAR Vision and Performance Ambition based on latest results from SESAR development and deployment activities as well as broader changes in policy priorities;
    - Refine the critical path for rolling out SESAR with a particular attention to priorities for future development and deployment activities;
    - Refine the high-level SESAR roll-out plan showing clearly what belongs to respectively SESAR development and deployment activities;
    - Develop the Business view of the Master Plan, including a holistic view of the SESAR performance gains in time as well as investment needs;
    - Review the standardisation and regulatory needs developed by the Solution Projects to allow the development of S&R needs in the Master Plan Level 1, fully aligned with the EPAS and the EASCG rolling plan;

- Review the SESAR project Risk Management Plan taking into account the main risks reported via SESAR development and deployment activities (Levels 2 and 3);
- Establish a clear connection between the MP and EASA's EPAS as well as the ICAO GANP.

- Yearly Development Planning & Reporting ATM MP Level 2: monitor the evolution and publish Level 2 of the Master Plan to ensure that it remains "SESAR Solutions centric":

  - Provide yearly planning alignment analysis of consistency between MP Level 1 and 2 and provide a view of the progress of the development activities in the perspective of Level 1 of the MP (in time and in scope, % coverage of the different phases, alignment with targeted maturity dates, expected % completion with regards to targeted performance ambition, any issues to be brought the attention to the SJU Governance with regards to the contribution of development activities to Level 1 of the MP – e.g. could trigger major update of Level 1). This analysis should include a clear and unambiguous information on every SESAR Solution and every Essential Operational Change, and the assessment of their readiness for deployment and eventual implementation. The analysis should include an executive summary and be readable by SJU ADB member;
  - To this effect, participate in CR process as conducted by the TA content integration project (Data set maintenance) and in particular for the purpose to ensure that CRs do not affect MP Level 1. In case a change would or may affect substantially the Master Plan, bring the issue for consideration of the decision-making level, i.e. the SJU and its Governance Bodies;
  - In the year of a Master Plan update campaign, the delivery planning of the ATM MP Level 2 shall be synchronised with that of Level 1.

- Yearly Deployment Planning & Reporting ATM MP Level 3:

  - Ensure update, maintenance and evolution of the Level 3 of the Master Plan ensuring that at its heart it is SESAR Solutions centric;
  - Deployment planning translates Level 2 of the ATM MP into an implementation view (Level 3); it relies upon a transparent and efficient decision-making and monitoring process;
  - The project shall deliver each year a Master Plan Level 3 Plan and Report, providing an exhaustive view of SESAR deployment planning and progress. In the year of Master Plan update campaign, the delivery planning of the Level 3 plan and report shall be synchronised with that of Level 1;
  - This requires a very strong coordination with the Deployment Manager to avoid duplication, gaps or contradiction with the Deployment Manager reporting obligations on the deployment of common projects through its Deployment Programme (Regulation (EU) No 409/2013, Article 9 (h) and (i));
  - In line with the audit recommendations and the 2018 Master Plan update campaign, the Master Plan Level 3 Report will provide an exhaustive view of the state of deployment of all SESAR Solutions, meaning that it will not only report on the Solutions

that are being deployed, but also on those not deployed and will expose the reasons for this lack of deployment;

- o Deliver:
    - Proposed rules for promoting SESAR Solutions from Level 2 to Level 3. If decisions are taken on a case by case basis, the rationale should be clearly described in the Level 3 plan;
    - Yearly update proposal of the MP level 3 Plan ensuring the maximum possible coverable of SESAR Solutions;
    - Yearly update proposal for MP Level 3 Plan taking into account validated data provided via EUROCONTROL, the SESAR Deployment Manager as well as other relevant SES reporting mechanisms.

The MP project will also participate, support and contribute to the definition of the future SESAR artefacts organised and delivered in ad-hoc or on demand basis by the SJU and to be shared at governance and consultation body levels, such as common projects or any specific mandate received from the SJU governance structure and related to Master Planning activities.

4 Requirements Work Area 2: Very Large Scale Demonstrations

This section provides full descriptions of the topics to be demonstrated within Work Area 2.

Some topics address SESAR Solutions already validated within the SESAR programme. Full details of the SESAR Solutions can be found on the SESAR web site.

Other topics cover solutions that are expected to achieve V3/TRL6 at the end of Wave 1, and further details on these solutions can be found on the solution datapacks made public during the Wave 1 activities. In addition, some topics represent an opportunity to cover complementary activities for SESAR solutions still under development during Wave 2. In those cases, for further details on these solutions refer to section 3.

An important aspect of the VLDs is the development of the local safety case in support of the introduction of the new concept in live operations, which may require regulatory approval. VLDs must follow the processes as described in the SESAR proof-of-concept document (available in the Stellar programme library) , and include in their demonstration report a description of any issues found along the way and how they were overcome.

4.1 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD01 W2 GBAS/SBAS precision approaches including variable approach paths"

The VLD scope includes a number of GBAS/SBAS-enabled advanced approach procedures developed in solution #02-02 in SESAR 2020 Wave 1 that aim at delivering even further benefits. The VLD shall provide a sufficient coverage of the proposed advanced procedures listed below:

- Enhanced Arrival Procedures using Dual Thresholds (DT) are applicable to airports with at least a pair of runways (either parallel or divergent but dependent in all cases when both used for arrival operations). The DT concept will allow inbound aircraft to shift their touch down point on one of the runways with the aim of reducing wake vortex separations (leading to potential increased airport capacity) while reducing noise footprint (environmental benefit). DT means establishing, on one of the runways, an additional runway threshold (displaced typically 1200 metres away from the nominal threshold) with corresponding glide slope and runway ground markers, lights and visual aids.

- Enhanced Arrival Procedures using Second Runway Aiming Point (SRAP) allow inbound aircraft to reduce runway occupancy time and/or taxi-in time (potentially leading to increased airport capacity) while reducing noise footprint (environmental benefit). The SRAP concept consists in enabling aircraft to land on one of two published runway aiming points. Landing further down from original aiming point allows shifting the noise footprint towards the airport area. SRAP could also serve as an enabler for reducing the wake vortex encounter risk, therefore potentially bringing a secondary benefit in reducing wake vortex separation minima for specific combination of leader/follower aircraft pairs.

- Enhanced Arrival Procedures using Increased Glide Slope (IGS) allow inbound aircraft to reduce noise footprint (environmental benefit). IGS procedures are published approaches which feature a glide slope between the published one (commonly 3 degrees) and 4.49 degrees (limit above which steep approach concept applies), in order to provide a significant reduction in ground noise level.

- Enhanced Arrival Procedures using Adaptive Increased Glide Slope (A-IGS) allow inbound aircraft to reduce noise footprint (environmental benefit) while optimizing, thanks to an on-board feature, the vertical flight profile (hence, having a potential positive impact on fuel consumption). The use of A-IGS aims at flying a more suitable glide slope that the aircraft is able to fly naturally according to its state (weight and landing configuration chosen by pilots), considering the external environment, i.e. the destination airfield weather (wind, temperature, pressure). Note that this is not certified yet.

- Enhanced Arrival Procedure using an Increased Glide Slope to a Second Runway Aiming Point (IGS-to-SRAP) applies an Increased Glide Slope (above the approach angle in use to the considered runway threshold and up to 4.49°) to an Aiming Point further down the runway threshold (as specified in the published chart). It will enable inbound aircraft to reduce noise footprint (environmental benefit) and possibly reduce runway occupancy time and/or taxi-in time depending on local runway/taxiway layout.

The scope may include the demonstration of similar concepts (when possible) based on RNAV (Baro LNAV/VNAV) rather than GBAS/SBAS.

The advanced approach procedures validated in Wave 1 are not applicable in all airport layouts. All listed solutions and procedures shall be demonstrated and, should it not be possible to demonstrate them all at a single location, multiple locations shall be included in the VLD flight programme'. Note that this list is limited to those procedures that are likely to achieve end of V3 in Wave 1 under solution #02-02, this will be confirmed before the elaboration of the call specifications. The VLD shall consider different airport layouts, setting-up various airport platforms at the level of pre-operational or operational status to support the Proof of Concept. The airborne and ground systems required to support the platform development for this demonstration shall be based on existing standards where applicable. In the case an update of a given standard is deemed necessary the project should coordinate with the relevant standardisation body (e.g. EUROCAE) and provide feedback and any relevant material (e.g. demonstration reports etc.) to the involved standards development group.

This VLD requires AU participation, the equipage of aircraft with GBAS/SBAS and may require a GBAS installation at the airport or airports. The demonstration must ensure a minimum number of flights to demonstrate the benefits of the concepts.).

The following standards need to be taken into consideration by the VLD as a reference:

- DO-246E "GBAS ICD" airborne systems

- DO-253D "GBAS MOPS"

- ED-114B - MOPS for GBAS ground systems to support precision approach and landing (CATIII)

- Annex 10 - SARPs for CAT II/III using GPS L1 (GAST-D) and associated required changes in EUR Doc.13 / PANS ATM / PANS

VLD-1 may include activities aiming at completing TRL-6 maturity for the following aspects:

- The extended scope (beyond the outcome of SESAR 1) of GBAS GAST-D under candidate solution 79 "Dual Frequency / Multi Constellation DFMC GNSS/SBAS and GBAS", addressing adverse ionospheric conditions and conditions outside the mid latitudes (high and low latitude issues), large and complex airport environments and GBAS Expanded Service Volume (ESV) and increased Dmax requested by airspace users beyond 23 Nautical Miles. The solution will therefore contribute to enlarge the potential deployment locations for the GBAS-enabled advanced procedures under the scope of VLD-1;

- The mid-term alternative Position, Navigation and Timing (A-PNT) under candidate solution 81, an aircraft technological enhancement to support RNP-based Operations in the TMA e.g. RNP1 SIDs and STARs (mid-term A-PNT) in case of a GNSS degradation or outage. Therefore, it can contribute to ensure the required resilience for the advanced procedures under the scope of the VLD.

4.2 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “VLD02 W2 Airport Surface Management, Airport Safety Nets and ATSAW”

The importance of moving aircraft on the airport surface from stand to runway and vice versa in a safe, controlled and organised manner is paramount for airports and even more when capacity restrictions resulting from weather or other circumstances affect operations.

The VLD aims at demonstrating the following SESAR solutions that improve airport surface management and safety:

- Solution #03b-05 ‘Traffic alerts for pilots for airport operations’.

The VLD may also cover:

- Solution #47 ‘Guidance assistance through airfield ground lighting’;
- Solution #01-07 ‘CAVS’;
- OBACS (On-board Braking Action Computation System), an airborne system considered under solution #03b-06 for the development of safety support tools for avoiding runway excursions in wave 1.

For all solutions the participation of AUs is required; for #03b-05 aircraft will need to be equipped with ADS-B-in, whereas for #47 no extra airborne equipage is required. The VLD will use the same aircraft equipped with ADS-B-in for the demonstration of solution #03b-05 to perform flight trials of the V2 CAVS concept (solution #01-07). The reason for the inclusion of this V2 concept in the VLD is to take the opportunity of performing these trials with minimum cost (by using the same ADS-B-in aircraft for two solutions).

The first solution, delivered in SESAR 2020 Wave 1, is solution #03b-05 ‘Traffic alerts for pilots for airport operations’ that aims at warning pilots in case a traffic conflict is detected on airport surface. The key performance driver is to significantly decrease the risk of collision with any mobile on runway and taxiways, improving safety on airport surface. The solution is applicable to both mainline and business aircraft and the demonstration shall cover exercises for both. Note that the performance and quality reception of broadcast aircraft data (ADS-B) is a key enabler for the solution.

The VLD represents a substantial step compared to Wave 1 V3 validation activities that only involved flight test aircraft.

The VLD scope covers the two implementation options addressed under the scope of the solution in wave 1:

- The demonstration activities shall address SURF-A (warnings) on the runway;
- The demonstration activities may address as well SURF-ITA (warnings, cautions and indications) on the runway;

The VLD shall consist of a technology demonstration in the real environment implementing the traffic alerts in flight test aircraft interacting with other aircraft in the real operational environment. The VLD requires highly reliable equipment meaning a pre-certified equipment but with extensive validation and certification design.

The airborne systems required to support the platform development for this demonstration should be based on existing standards. In the case an update of a given standard is deemed necessary the project should coordinate with the relevant standardisation body (e.g. EUROCAE, RTCA) and provide feedback and any relevant material (e.g. demonstration reports etc.) to the involved standards development group.

The following standards need to be taken into consideration by the VLD as a reference: RTCA DO-323 and SURF IA Minimum Operational Performance Standard (MOPS)

The second SESAR solution under the scope of this VLD is solution #47 “Guidance assistance through airfield ground lighting” that was delivered in SESAR 1. It is a ground-based service, intended for controllers, flight crews and vehicle drivers, and supported by the Advanced Surface Management Guidance and Control Systems (A-SMGCS) Guidance function. The solution provides individual guidance information to any mobile by automatically and progressively activating taxiway centreline lights, either in segments of several lights or individually, along the route cleared by the controller. If this cleared route includes a limit and if a physical stop bar exists at this point, this stop bar is also automatically activated when the mobile nears it.

The automation in this SESAR Solution also includes the management of priorities at intersections, based on pre-defined criteria (e.g. aerodrome rules, speed or target times). However, controllers are able to override the guidance decisions via their working position, which shows activated lights on the radar display. This SESAR Solution also provides adequate longitudinal spacing between mobiles on a same taxiway by attaching a segment of definitely de-activated lights behind each mobile and reducing the length of the activated lights in front of the trailing mobile if it closes on the leading one. Working procedures for the controllers have to be adapted to ensure that detailed taxi clearances given to aircraft and vehicles are input in the system by the controllers and that appropriate phraseology, instructing the flight crew or vehicle driver to follow the greens up to a given destination point, is used.

In terms of performance benefits the solution provides improvements on human performance and safety (flight crew can rely on visual cues to navigate on the airport rather than on complex taxi clearances and maps as in current operations, ATCO have to provide fewer instructions to mobiles operating on the aerodrome and have a better awareness of the traffic situation with the additional information displayed on their working position, etc.) and reduced environmental impact of taxiing operations (because flight crews taxi with more confidence, resulting in more regular speeds and fewer stops and restarts. Consequently, gaseous emissions and fuel burn are reduced).

Solution #01-07 is developing a concept for delegation of separation from ATC to the flight crew on final approach: CDTI-assisted visual separation (CAVS). The concept is based on the flight crew using the CAVS application on the CDTI, which requires ADS-B-in information. The demonstration will collect data on the flight crew human performance aspects related to their management of the separation task. The CAVS flights should take place at airports where flight crew visual separation is allowed and commonly used.

Solution #03b-06 in wave 1 develops safety support tools for avoiding runway excursions. In the context of this solution, the system OBACS (On-board Braking Action Computation System) airborne system (also called CORSAIR) has been used for the runway condition assessment. CORSAIR considers the aircraft as a measuring device, a "sensor in itself" and collects in real-time all relevant raw on-board data (engine settings, aircraft weight, aerodynamic braking, speed, deceleration, directional control etc.) to compute an on-board braking action. This on-board computed braking action is transmitted to the ground system to be considered and integrated in the RWYCC assessment algorithm.

VLD-2 may include activities aiming at progressing the maturity of candidate solution 61 "Hyper Connected ATM" given that it is expected that airport operations are the first scenario where hyper-connectivity will be deployed and the number of stakeholders participating in the demonstration activities represent a good opportunity to start capturing requirements for this solution. In particular enabling potential data exchanges with mobiles in the airport domain (aircraft and airport vehicles) and between the full set of airport stakeholders could support the solutions under the scope of VLD-2.

4.3 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD03 W2 Improving runway throughput in one airport"

The VLD scope covers a number of solutions and concepts that have achieved V3 maturity in wave 1 under the scope of solutions #02-01, #02-03 and #02-08. These solutions concern ATCO procedures and support tools. AU involvement is not required for this VLD, because there will be no change in AU operations - they will receive clearances as usual, and should report any safety incidents like they routinely do in operations.

Optimised wake separation minima for arrivals and departures:

Solution #02-01 has validated in Wave 1 a number of concepts that aim at optimizing wake turbulence separation minima for arrivals and departures to enhance airport runway throughput, whilst maintaining acceptable levels of safety:

- Arrival concept Static-Pairwise (S-PWS or PWS-A) provides a more precise definition of the minimum safe wake separation required for a pair of ICAO aircraft types through an optimization of the ICAO wake turbulence separation classes. The concept is based on the comparison of wake generation and wake resistance between aircraft types, using aircraft type characteristics, to align on reference pairs considered as acceptable baseline.

- Wake Turbulence Separations (for Departures) based on Static Aircraft Characteristics aims at optimizing the ICAO wake turbulence separation classes by use of longitudinal wake turbulence static pair-wise separation (S-PWS) minima on departures for the initial common departure path from the runway, applicable in all operating conditions. The specification is based on the comparison of wake generation and wake resistance between aircraft types, to reference pairs considered as acceptable baseline for wake turbulence risk, and using aircraft type characteristics. These new more efficient wake turbulence separations consist of the time-based 'seven wake category (7-CAT)' wake separation minima, or the distance-based '96 x 96 aircraft type' pairwise wake separation minima, in conjunction with the 'twenty wake category (20-CAT)' wake separation minima for departure pairs involving other aircraft types. Also under development it is the time-based variant of the '96 x 96 aircraft type' concept, in conjunction with the development of the time-based variant of the 20-CAT concept.

- Depending on the final maturity of weather-dependent concepts, weather-dependent reductions of separation may also be demonstrated.
- To mitigate the impact on ATCO workload and human performance, and to deliver cost efficiency targets, ATC separation delivery support tools such as Optimised Runway Delivery (ORD) for arrival that have been also developed in the solution shall be used. These tools make use of Target Distance Indicators (TDIs) to enable consistent and efficient delivery of the required separation or spacing between arrival pairs on final approach up to the runway landing threshold. For departures, the Optimised Separation Delivery for Departure is the controller tool support to facilitate the Tower Runway Controller to consistently and efficiently deliver to the more efficient wake turbulence separations that have been developed and are under approval by EASA through the re-categorisation programme by the RECAT-EU-PWS activities.

Wake decay enhancing concepts

The highest risk of encountering wake vortices prevails during final approach in ground proximity, where the vortices cannot descend below the glide path but tend to rebound because of the interaction with the ground surface. This is aggravated by the fact that the opportunity for the pilot to recover from a vortex encounter is limited by the low flight altitude. In SESAR a method has been developed and demonstrated at an international airport that accelerates wake vortex decay in that critical height range.

In this demonstration, a technical design of the so-called plate lines shall be elaborated that is compatible with airport structural requirements (e.g. stability, frangibility) and approval of authorities for the installation of the plate line shall be obtained. While the design and approval for installation is under way, a measurement campaign shall be conducted at the same airport employing several LIDARs for wake vortex measurements, supplemented by a suite of advanced meteorological sensors to determine the atmospheric conditions. Once the plates are installed, a new data collection campaign shall be conducted. The data collected before and after the installation will be analysed in order to quantify the acceleration of the decay of the wake vortices close to the ground.

The data will also be used to assess if a reduction of separation minima is possible without negatively affecting safety and, if so, comprehensive documentation shall be elaborated to form the basis for the preparation of regulations to be endorsed by competent authorities.

Reduction of radar separation to 2NM for in-trail pairs on final approach

Solution #02-03 (researched in Wave 1) refers to the concept of Minimum Pair Separation Based on Required Surveillance Performance (RSP) in support of a reduction of the in-trail Minimum Radar Separation from 2.5 NM to 2 NM on final approach at Large and Medium Airports and TMA High Complexity and TMA Medium Complexity sub-operational environments so as to provide a direct positive impact on runway throughput during periods of capacity constrained operations.

The demonstration shall take place at a large European airport that has significant over-demand at certain days/times. The demonstration activities will include the conduct of a local safety assessment in support of getting regulatory approval by the competent authorities to reduce the separation to 2NM, the elaboration of training material for operational staff, the training of a sufficient number of operational staff to demonstrate the concept and the live demonstration and collection of arrival throughput and radar data in order to quantify the benefits of the concept.

Integrated AMAN-DMAN

SESAR solution #02-08 has addressed in wave 1 a number of concepts that aim to optimize runway operations by providing dynamic assistance to controllers and supervisors in TWR and TMA. Their objectives are to increase runway throughput through the optimisation of arrival/departure spacing. The improvements include the use of a Runway Manager (RMAN) to optimise the planning of the runway use, and the sequence-based coupling of AMAN and DMAN including a sequence update a few minutes before touchdown and the use of TDIs between arrivals to support ATCOs to create the right gap between arrivals. This VLD will demonstrate the application of these concepts in order to optimise the use of the runway capacity for single or multiple runway airports.

The following concepts are proposed to be under the scope of this VLD:

- Optimised integration of arrival and departure traffic flows in one runway with coupled AMAN/DMAN. This concept applies namely to execution phase and addresses mainly TWR and TMA ATCOs.
- Optimised use of RWY capacity for multiple runway airports with coupled AMAN/DMAN and RMAN. This concept applies namely to planning phase and addresses TWR Supervisor although considers inputs from execution phase.

VLD-3 may include activities to complete the TRL-6 maturity for candidate solutions 83 “Surveillance Performance Monitoring” and 84 “New use and evolution of Cooperative and Non-Cooperative Surveillance”. Both solutions can be understood as optional enabling capabilities for solution #02-03, which aims at reducing the in-trail Minimum Radar Separation from 2.5 NM to 2 NM on final approach based on Required Surveillance Performance (RSP). The application of this reduced separation minimum will demand stringent surveillance performance requirements in terms of latency, continuity, availability, integrity and accuracy, to be supported by the overall surveillance chain.

4.4 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic “VLD04 W2 Advanced Rotorcraft and Business Aviation (BA) Operations”

The VLD aims are demonstrating a number of SESAR solutions that aims at improving the access into small airports in low visibility conditions and to improve access and equity for rotorcraft and business aviation operations.

Solutions #01-06 and #02-05 addressed in Wave 1 enhanced Rotorcraft operations in the TMA. The VLD shall cover the following aspects:

- GNSS- based (e.g. APV SBAS/Baro) approach/departure procedures with vertical guidance procedures at busy airports by using Rotorcraft specific independent IFR procedures to/from FATO (Final Approach & Take- Off area) located at airports in order to remove IFR rotorcraft from active runways and allow fixed wing aircraft and rotorcraft to perform simultaneous non-interfering (SNI) operations. These rotorcraft-specific independent IFR operations will be enabled by Point-in-Space (PinS) procedures to allow approach to/departure from a VFR FATO. When reaching the PinS, the pilot shall decide either to proceed to a landing or to abort the approach. The PinS is also the MAPT (Missed Approach Point). Dedicated IFR SNI concepts can provide an alternative IFR capability to small airports where the installation of traditional navigation aids is not financially viable or unfeasible due to other specific constraints.

- Advanced (e.g. curved) SBAS/GBAS guided PinS RNP approaches towards landing locations and PinS departures from landing locations are created with connections to/from Low Level IFR route network. The curved segment of the advanced PinS can be placed in the initial, intermediate or missed approach segment. The procedures can contribute to a reduced noise footprint and improved access to VFR FATOs. There is also a contribution to safety (fewer VFR approaches in marginal VMC, IFR approaches with vertical guidance). Use of a Head-Mounted Display (HMD) facilitates both the execution of curves in approach segments and departure procedures, and the transition from instrument flying to aviating and navigating via external visual cues. In this case, a three-dimensional path that the pilot has to follow (or to be more precise, a corridor in which the pilot has to stay) is displayed in the HMD; such a three-dimensional path has to give both lateral and vertical guidance. The HMD provides, with "eyes-out" of the cockpit, the information that can be used to facilitate safe flying along the PinS procedure (take-off and approach), facilitating the transition from IFR instrument phase to visual phase (for "proceed visually" PinS) or from IFR to VFR (for "proceed VFR" PinS) and vice-versa, and reduces pilot workload.

Solution #03a-04 "Enhanced visual operations" consists of taking credit of emerging visual based technologies such as EFVS and SVS combined through CVS and displayed in coloured HMD in order to increase the operational efficiency in both taxi and landing while significantly improving situational awareness.

A unique advantage of the solution is that it is mainly supported by the aircraft system instead of airports and the need of complex and costly ground infrastructures.

From a global ATM network standpoint, the vision systems will increase accessibility at most of secondary aerodromes providing operational credit at most of runway ends with precision or non-precision landing minima (LPV, LNAV/ VNAV, ILS CAT1…).

In addition, as Vision Systems provide the crew with a simple and comprehensive image of the situation, they require less mental effort and potentially allow for alleviated crew training and reduced operator constraints.

These advantages will make the Vision Systems a key operational capability especially for the business aviation community that is mainly composed of small/ medium operators with limited resources and operating frequently at small/ medium airports.

Beyond operational credit, the Vision Systems will boost situational awareness in all weather conditions for all operators at all airports contributing to increase safety margin all the time.

4.5 H2020-SESAR-2019-1 IR VLD WAVE 2 Topic "VLD05 W2 Virtual Centre"

This VLD aims at demonstrating solution #16-03, which is expected to reach TRL6 in Wave 1. The solution allows an innovative Virtual Centre architecture between a Virtual Centre ATSU and ATM Data Service Provider (ADSP). The demonstration shall provide added value with respect to the technical validation performed by 16-03 e.g. increased number of validated services for the SOA architecture including cross validation of the services.

This VLD could consists of a technical demonstrations of virtual centre architecture:

- Connecting real data (i.e. radar OLDI) following the work done by #16-03 in their validations in wave 1. Although demonstrations are normally aiming at live trials, in this case it is acceptable to achieve the objectives through other techniques such as shadow mode. In any case, connection to real data is expected;

- Increased number of validated services for the SOA architecture including cross validation of the services;

- The VLD may cover the Application of the Virtual centre for remote training use case.

The technical use cases may include demonstration validation of the required quality of service is met, in particular for the transfer of data between geographically separated locations, remote installation of HMI, remote supervision, transversal technical features as recording. Although demonstrations are normally aiming at live trials, in this case it is acceptable to achieve the objectives through other techniques such as shadow mode. In any case, connection to real data is expected.

A final report shall be delivered containing any lessons learned on any aspect related to the Virtual Centre concept, including operational, human factors, procedural, technical, performance, network, QoS issues. The report shall also contain detailed feedback on the documentation (FRD, TS) of #16-03, w.r.t. applicability, validation results, proposals for change.

The VLD shall coordinate with solution 93 and, in particular, it shall plan effort to contribute to the solution 93 datapack e.g. contribution to requirements based on the work performed during the VLD project.

List of acronyms

Acronym	Long Name / Definition
4D	4 Dimensions
ABAC	Accrual Based Accounting
ACAS	Airborne Collision Avoidance System
A-CCD	Advanced Continuous Climb Departure
A-CDA	Advanced Continuous Descent Approach
A-CDM	Airport Collaborative Decision Making
ADB	AdMinistrative Board
ADDEP	Airport Departure Data Entry Panel
ADQ	Aeronautical Data Quality Requirements
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
ADEXP	ATS Data Exchange Presentation
ADSP	ATM Data Services Provider
AEEC	Airlines Electronic Engineering Committee
AeroMacs	Aeronautical Mobile Airport Communications System
AFISO	Aerodrome Flight Information Service Officer
AFUA/ASM	Advanced Flexible Use Airspace/Airspace Management
A/G	Air/Ground
AGL	Airfield Ground Lighting
AHRS	Attitude and Heading Reference System
AI	Artificial Intelligence
AIGS	Adaptive Increased Glide Slope
AIM	Aeronautical Information Management
AIXM	Aeronautical Information Exchange Model
AM	Amplitude Modulation
AMAN	Arrival Manager
AMC	Acceptable Means of Compliance

AMDAR	Aircraft MET Data Relay
AMG	Eurocontrol Asterix Management Group
AOC	Airlines Operational Communication
AOC	Airline Operation Communication
AOP	Airport Operation Plan
A-PNT	Alternative Position, Navigation and Timing
APOC	AirPort Operations Centre
APP	Approach Centre
AR	Augmented Reality
ARAIM	Advanced Receiver Autonomous Integrity Monitoring
ARES	Airspace Reservation/Restriction
ASAS	Airborne Separation Assistance System
A-SGMCS	Advanced Surface Movement Guidance and Control System
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
ATS	Air Traffic Services
ATSA ITP	Air Traffic Situation Awareness- In-Trail Procedure
ATSAW	Airborne Traffic Situation Awareness
ATSEP	Air Traffic Safety Electronics Personnel
ATSU	Air Traffic Services Unit
AU	Airspace Users (Civil)
AUP	Airspace Use Plan
AUTOMETAR	Automated Meteorological Terminal Air Report

B2B	Business-to-Business
BA	Business Aviation
BADA	Base of Aircraft DAta
CA	Collision Avoidance
CANSO	Civil Air Navigation Services Organisation
CAS	Calibrated airspeed
CATC	Conflicting ATC Clearances
CAVS	CDTI (Cockpit Display Of Traffic Information) Assisted Visual Separation
CBA	Cost Benefit Analysis
CCD	Continuous Climb Departure
CCO	Continuous Climb Operations
CCS	Capacity Constrained Situation
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CD&R	Conflict Detection and Resolution
CDO	Continuous Descent Operations
CDTI	Cockpit Display Of Traffic Information
CFSP	Computer Flight Plan Software Provider
CMAN	Centre Manager
CMAC	Conformance Monitoring Alerts for Controllers
CMAC	Civil-Military ATM Coordination
CNS	Communication, Navigation, Surveillance
COM	Communication
COTS	Commercial off-the-shelf
CP	Common Project
CPDLC	Controller–Pilot Data Link Communications
CSA	Coordination and Support Action
CSA	Critical Sensitive Area
CSPO	Closely Spaced Parallel Operations

CSPR	Closely Spaced Parallel Runways
CTA	Controlled Time of Arrival
CVS	Combined Vision System
CWP	Controller Working Position
DAA	Detect and Avoid
DAB	Digital Audio Broadcast
DAC	Dynamic Airspace Configuration
DAP	Downlinked Aircraft Parameter
DART	Data-driven Aircraft Trajectory
DCB	Demand and Capacity Balancing
dDCB	Dynamic Demand and Capacity Balancing
DFMC	Dual Frequency Multi-constellation
DCPC	Direct Controller Pilot Communication
DEVG	Derived Equivalent Vertical Gust
DL	DataLink
DMA	Dynamic Mobile Area
DMAN	Departure Manager
DME	Distance Measurement Equipment
DPI	Departure Planning Information
DS	Data Set
DT	Dual Thresholds
E-AMAN	Extended-AMAN
E-TMA	Extended-TMA
EASA	European Aviation Safety Agency
EASCG	European ATM Standards Coordination Group
EATMA	European ATM Architecture
EBS	Enhanced Braking System
EC	Executive Controller

EDA	European Defence Agency
EDR	Eddy Dissipation Rate
EFB	Electronic Flight Bag
eFPL	Extended Flight Plan (FF-ICE / FIXM based FPL)
EFVS	Enhanced Flight Vision System
EHS	Enhanced Surveillance
EGNOS	European Geostationary Navigation Overlay Service
EOC	Essential Operational Change
EOCVM	European Operational Concept Validation Methodology
EPAS	European Plan for Aviation Safety
EPP	Extended Projected Profile
ER	Exploratory Research
ER/APP	En-route/Approach
ESV	Expanded Service Volume
EU	European Union
EUR	ICAO European Region
EUROCAE	European Organisation for Civil Aviation Equipment
EVS	Enhanced Vision System
FAA	Federal Aviation Administration
FCFS	First Come First Serve
FCI	Future Communication Infrastructure
FCU	Flight Control Unit
FDPS	Flight Data Processing System
FF-ICE	Flight and Flow Information for the Collaborative Environment concept
FIS	Flight Information Service
FIS-B	Flight Information Service - Broadcast
Flightpath 2050	Report of the High Level Group (HLG) on Aviation and Aeronautics Research established by the European Commission in December 2010, setting out a new vision for the aviation sector by 2050
FM	Frequency Modulation

FMP	Flow Management Position
FMS	Flight Management System
FO	Flight Object
FOC	Final Operational Capability
FOC	Flight Operations Centre
FPL	Flight Plan
FRA	Free Routing Airspace
FRAP	Further Runway Aiming Point
FSFS	First Scheduled First Served
GA	General Aviation
GA/R	General Aviation & Rotorcraft
GANP	Global Air Navigation Plan (from ICAO)
GAST	GBAS Approach Service Type (of different types GAST-C, GAST-D, GAST-F)
GAT	General Air Traffic
GBAS	Ground Based Augmentation System
G/G	Ground/Ground
GLS	GBAS Landing System
GML	Geography Mark-up Language
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	European GNSS Agency
H2020	Horizon 2020 Framework Programme
HF	High Frequency
HMD	Helmet Mounted Display
HMI	Human Machine Interface
HP	Human Performance
HUD	Head-Up Display
JTIDS	Joint Tactical Information Distribution System
I4D	Initial 4 Dimensions

iAMAN	Initial AMAN (pre-departure target time allocation based on local AMAN logic)
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICAO CP	ICAO Communication Panel
ICNS	Integrated CNS
ICT	Information and Communication Technologies
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
IGS	Increased Glide Slope
ILS	Instrumental Landing System
IM	Interval Management
IMU	Inertial Measurement Unit
INAP	Integrated Network Management and extended ATC Planning Function
INCS	Independent Non-Cooperative Surveillance
INS	Inertial Navigation Systems
IOC	Initial Operational Capability
IOP	Interoperability
IoT	Internet of Things
IPS	Internet Protocol Suite
IR	Industrial Research & Validation
IRS	Inertial Reference System
KPA	Key Performance Area
KPI	Key Performance Indicator
LCS	Low Cost Surveillance
L-DACS	L-band digital aeronautical communications system
LIDAR	Light Detection And Ranging
LNAV	Lateral Navigation
LPV	Localiser Performance with Vertical guidance
LTE	Long Term Evolution

LTM	Local Traffic Management
LVC	Low Visibility Conditions
LVP	Low Visibility Procedure
MAC	Mid-Air Collision
MASPS	Minimum Aviation System Performance Standards
MAWP	SESAR 2020 Programme Multi-Annual Work Programme, as adopted by the SJU Administrative Board through decision ADB(D)-05-2015
MC/MF	Multi Constellation / Multi Frequency
MCP	Mode Control Panel
Members	2 Founding Members (the European Union and EUROCONTROL) and 19 stakeholder Members of which all apart from the EU are signatory to a Membership Agreement or Accession Agreement
MET	Meteorological / Meteorology
METAR	Meteorological Aerodrome Report
MGA	SESAR JU Model Grant Agreement for Members
MGAM	SESAR JU Model Grant Agreement
MIDS	Multifunctional Information Distribution System
MLAT	Multilateration
MOPS	Minimum Operational Performance Specifications
MP	Master Plan
MRAP	Multiple Runway Aiming Points
MRS	Minimum Radar Separation
MSP	Multi Sector Planning
MSPSR	Multi-Static Primary Surveillance Radar
MTCD	Medium-Term Conflict Detection
MULTILAT	MULTILATeral Surveillance
MWS	Minimum Wake Separation
NACC	North American, Central American and Caribbean ICAO region
NAV	Navigation
NEASCOG	NATO/EUROCONTROL ATM Security Coordinating Group

NFR	Non-Functional Requirements
NM	Network Manager
NMf	Network Management Function, organised as integrated regional / sub-regional / local layers and supporting Collaborative Network Management
NMOC	Network Manager Operations Centre
NOP	Network Operation Plan
NOTAM	Notice to Airmen
NOZ	Normal Operating Zone
NRA	Non Radar Airspace
NSP	Navigation Systems Panel
NTZ	No Transgression Zone
OAT	Operational Air Traffic
OBACS	On-board Braking Action Computation System
OCC	Operations Control
OFZ	Obstacle Free Zone
OLDI	On-Line Data Interchange
OOA	Out Of the European Regulation Area
OPS	Operations
ORD	Optimised Runway Delivery
OSI	Open Systems Interconnection
PANS-ATC	Procedures for Air Navigation Services – Air Traffic Control
PANS-ATM	Procedures for Air Navigation Services – Air Traffic Management
PANS-OPS	Procedures for Air Navigation Services – Aircraft OPerationS
PBAOM	Performance Based Aerodrome Operational Minima
PBN	Performance Based Navigation
PBS	Performance Based Surveillance
PC	Planning Controller
PCP	Pilot Common Project
PENS	Pan-European Network Services

PFD	Predicted Flight Data
PI	Performance Indicator
PinS	Point in Space
PIREP	Pilot REPort
P-RNAV	Precision Area Navigation
PSR	Primary Surveillance Radar
PTR	Profile Tuning Restriction
PWS	Pair Wise Separation
QoS	Quality of Service
R&D	Research and Development
R&I	Research & Innovation
R/T	Radio Telephony
RA	Resolution Advisory (ACAS)
RAIM	Receiver Autonomous Integrity Monitoring
RC	Rotorcraft
RBT	Reference Business Trajectory
RECAT-EU	European Wake Vortex Re-CATegorisation
RF	Radius to Fix
RFI	Radio Frequency Interference
RIA	Research and Innovation Action
RLP	Required Link Performance
RMT	Reference Mission Trajectory
RNP	Required Navigation Performance
RNP-AR	Required Navigation Performance Authorization Required
ROAAS	Runway Overrun Awareness and Alerting System
ROC	Rate Of Climb
ROD	Rate Of Descent
ROT	Runway Occupancy Time
RPAS	Remotely Piloted Aircraft System

RSP	Required Surveillance Performance
RTA	Required Time of Arrival
RTC	Remote Tower Centre
RTCA	Radio Technical Commission for Aeronautics
RTM	Remote Tower Module
RTS	Real Time Simulation
RWC	Remain Well Clear
RWY	Runway
RWYCC	Runway Condition Code
S&M	Sequencing & Merging
SARPS	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SBB	Swift BroadBand
SBT/RBT	Shared Business Trajectory/Reference Business Trajectory
SDD	Service Description Document
SDN	Software-defined networking
SDM	SESAR Deployment Manager
SE	System Engineering
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 the coordinated set of activities described in this document and being undertaken by the Members and managed by the SESAR JU
SES PS	Single European Sky Performance Scheme
SID	Standard Instrument Departure Route
SFL	Selected Flight Level
SJU	SESAR Joint Undertaking
SMART	Specific, Measurable, Agreed, Relevant, Timely
SMT/RMT	Shared Mission Trajectory/Reference Mission Trajectory

SNE	Seconded National Expert
SNI	Simultaneous Non-Interfering
SoA	Service oriented Architecture
SOIR	Simultaneous Operations On Parallel Or Near-Parallel Instrument Runways
SP	Service Provider
SPI	Surveillance Performance and Interoperability
SPO	Single Person Operations
SRAP	Second Runway Aiming Point
STAM	Short Term ATFCM Measures
STAR	Standard Terminal Arrival Route
STCA	Short Term Conflict Alert
SUR	Surveillance
SV	Synthetic Vision
SVGS	Synthetic Vision Guidance System
SVS	Synthetic Vision System
SWIM	System Wide Information Management
SWIM BP	SWIM Blue Profile
SWIM GP	SWIM Green Profile
SWIM YP	SWIM Yellow Profile
SWIM-TI	System Wide Information Management Technical Infrastructure
TA	Temporary Agent
TA	Traffic Alert (ACAS)
TACAN	TACtical Air Navigation
TAM	Total Airport Management
TBO	Trajectory Based Operations
TCAS	Traffic alert and Collision Avoidance System
TMA	Terminal Manoeuvring Area
TOBT	Target Off-Block Time
TP	Trajectory Predictor

TPCS	Trajectory PrediCtion Service
TRL	Technology Readiness Level
TT	Target Time
TTA	Target Time Arrival
TTG	Time To Gain
TTL	Time to Lose
TTOT	Target Take Off Time
TWR	Tower
UAS	Unmanned Aerial System
UDPP	User Driven Prioritisation Process
UPMS	User Profile Management Systems
UTM	UAS Traffic Management
UUP	Updated Airspace Use Plan
VC	Virtual Centre
VDL	VHF Datalink (VDL)
VHF	Very High Frequency
VLD	Very Large-Scale Demonstration
VLL	Very Low-Level
VNAV	Vertical NAVigation
VOIP	Voice Over IP
VPA	Variable Profile Area
VSB	Virtual Stop Bar
VTS	Vehicle Tracking System
WAM	Wide Area Multilateration
WDS	Weather Dependent Separation
WG	Working Group
WOC	Wing Operations Centre
WVE	Wake Vortex Encounter
XML	eXtensible Markup Language