SESAR JOINT UNDERTAKING

SESAR SOLUTIONS CATALOGUE

Second Edition

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SESAR JU Executive Director
Florian Guillermet

Editors
Triona Keaveney
Ewa Magnowska

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SESAR
JOINT UNDERTAKING

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Message from the founding members

Henrik Hololei, Director General,
Directorate-General for Mobility and Transport,
European Commission,
and Chairman of the SESAR Joint Undertaking
Administrative Board

The number of passengers passing through the world's airports will double over the next twenty years at current annual growth rates. Aviation is a hugely important global market and it is important that Europe plays a full role in the sector. In Europe, we need to ensure we can deliver to our citizens more and better connectivity and enable the competitiveness of industry for a sustainable growth.

The SESAR (Single European Sky ATM Research) project has an important role in strengthening the European aviation sector through the modernisation of air traffic management. One of the most important outcomes of the project has been the development of partnerships which link aviation stakeholders in a common desire to maintain and even improve air transport's safety levels, while making it more punctual, more affordable and all with an improved environmental footprint.

With the establishment of the SESAR Joint Undertaking (SESAR JU) in 2007 by the European Union and Eurocontrol, the ATM community was tasked to develop the technical and operational solutions to overcome fragmentation and meet the performance requirements for the future air traffic management system. The definition and development of these solutions, which are now beginning to be deployed across Europe, is a testament to that original vision of the Single European Sky and SESAR, first articulated by Transport Commissioner Loyola de Palacio in 1999.

This vision has now become a reality thanks to the commitment and collaboration of the ATM community. The following pages illustrate just how complex a challenge this is – but also how deep the reserves of technical and research excellence remain in Europe.

It is only by working more closely together that we will properly be able to exploit these reserves. If we are to meet the targets set for the future performance of the European air traffic management system we will have to ensure that we are at the start, not the end, of a new era of aviation collaboration.

Frank Brenner, Director General,
Eurocontrol, and
Vice-Chairman of the SESAR JU
Administrative Board

As one of the founding members, Eurocontrol has championed the work of the SESAR JU in bringing about a paradigm shift in ATM and a new way of working together in research and innovation. The solutions described in this catalogue are proof that this change is happening.

European ATM organisations have a long tradition of research and innovation. However, in the years before the Single European Sky was launched it became clear that the resources needed for all the intended research was not enough and that duplication was hampering the outcomes. A greater focus on modernisation under one roof and with validations much closer to real operational environments required a deeper involvement of the broader aviation and ATM industry. We have come a long way since the establishment of the SESAR JU. In SESAR we have now established a framework for research cooperation which is breaking down "silos" and bringing together all ATM stakeholders, from airspace users, air navigation service providers to airports, manufacturers, military, professional staff associations, research institutes and academia.

We wholeheartedly believe and subscribe to this approach which is why we have concentrated all our development resources and work within the SESAR project. In particular, we have taken the lead in those solutions with a pan-European network dimension, from free routing and advanced flexible airspace use to the network operations planning and the move towards trajectory-based operations. We are confident that these solutions will enable us to meet the performance ambitions of the coming years.

We are particularly proud of our role in building and maintaining the European ATM Master Plan, which has been key to achieving consensus in all stages of the ATM lifecycle, from definition and development through to deployment. Thanks to the Master Plan, we now have a clear link between research and deployment, ensuring that the solutions developed and validated by the SESAR JU are deployable in the real operational world of aviation and ATM. The fact that some of the solutions in this catalogue are already implemented or in the process of being deployed is proof that we are moving in the right direction.

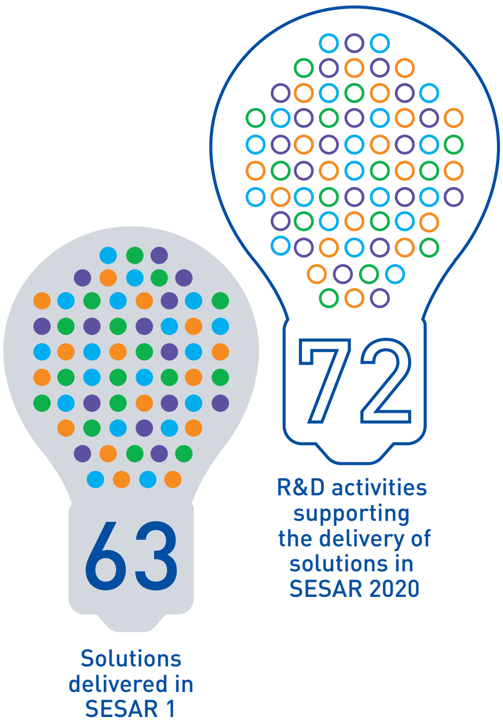
Foreword

Florian Guillermet,
Executive Director,
SESAR Joint Undertaking

This second edition of the Catalogue draws together the SESAR Solutions delivered by SESAR JU members and partners to modernise Europe's air traffic management system. Developed in line with the European ATM Master Plan - the main planning tool for ATM modernisation - these solutions serve as a basis for deployment activities and further research in SESAR 2020.

The contents of this catalogue are evidence of how European R&I are concretely delivering against European performance targets. Whether implemented individually or in combination, the solutions can bring benefits in key performance areas, such as cost and operational efficiency, capacity, safety, security and the environment. This is in keeping with the European ATM Master Plan, which recognises the wider context of the need for interoperability and linking technologies to achieve greater efficiency across the whole network; for example targeting improvements across an entire flight rather than in segments. And this reflects the change in mindset that the SESAR JU has helped to introduce through its unique public and private partnership structure.

The contents of this second edition range from baseline or quick-win solutions to those that address more complex operations. They cover solutions which have been fully validated and documented. Stakeholders have already taken steps to implement some of these into their operations. We have also delivered a set of these solutions to the SESAR Deployment Manager, which is preparing their synchronised and timely deployment across Europe over the next five years. This catalogue is a living document
and will be updated in the future as more solutions become ready for industrialisation and deployment within the framework of SESAR 2020.



SESAR in a nutshell

As the technological pillar of the Single European Sky to modernise Europe's air traffic management (ATM) system, SESAR is now making significant progress in transforming the performance of Europe's ATM network. The goal of SESAR is to contribute to the SES High-Level Goals of tripling capacity, halving costs per flight by 50 %, reducing emissions by 10 % and improving safety by a factor of 10.

Established in 2007, the SESAR JU, a public-private partnership, is responsible for defining, developing and validating these solutions in preparation for their deployment. The SESAR JU does so by harnessing the research and innovation expertise and resources of the entire ATM community, from the Network Manager and civil and military air navigation service providers, to airports, civil and military airspace users, staff associations, academia and research centres.

Established in 2014, the SESAR Deployment Manager is the official title of the organisation that is coordinating the upgrading of Europe's air traffic management infrastructure. The main task of the SESAR Deployment Manager is to develop, propose and maintain the Deployment Programme of SESAR concepts and technologies and ensure efficient synchronisation and overall coordination of implementation projects, as well as the related investments in line with the Deployment Programme. The tasks of the Deployment Manager are specified in Article 9 of Commission Implementing Regulation (EU) No 409/2013.

The following pages bring together in one volume the fully validated and documented SESAR Solutions delivered by the first wave of research and innovation (SESAR 1). Framed within the European ATM Master Plan, these solutions address all parts of the ATM value chain, from airports, air traffic services to the network, as well as the underlying systems architectures and technological enablers, which are validated in real day-to-day operations. On every page you will find evidence of how SESAR is contributing to improved ATM performance.

European ATM Master Plan
• A roadmap for ATM modernisation
• Meeting the performance objectives of the Single European Sky
• Ensuring support with ICAO's global air navigation plan

• Exploring & developing new operational & technology Solutions
• Validating & demonstrating benefits in real-operational environments
• Delivering a catalogue of Solutions to transform ATM

• Implementation of SESAR Solutions to answer local needs
• Synchronised deployment to deliver Europe-wide benefits

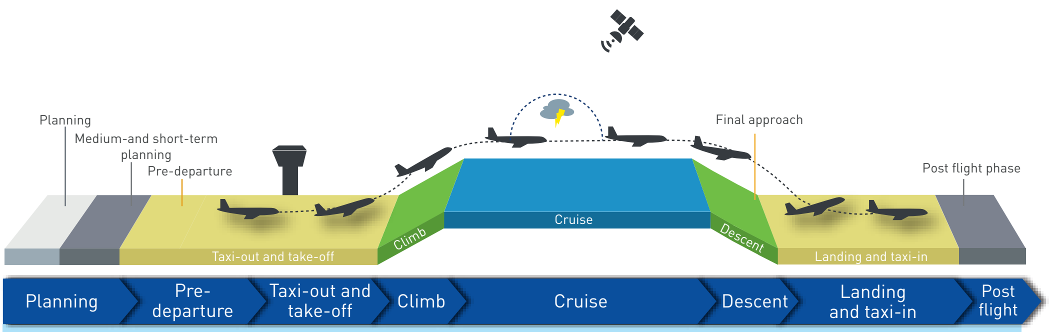
SESAR vision

It is widely recognised that to increase performance, ATM modernisation should focus on the flight's need as a whole and not in segmented portions, as is the case today. Mindful of this, the SESAR vision is realised across the entire ATM system including airport operations, offering improvements at every stage of the flight.

The vision sees the integration of all air vehicles with higher levels of autonomy and digital connectivity coupled with a more automated support to the management of the traffic. Operational predictability of flights and traffic flows is improved as the air vehicle trajectory is constantly kept up-to-date and shared across the various sub-systems (vehicle-to-vehicle and vehicle-to-infrastructure) through modern, mobile, terrestrial and satellite-based communication links. SESAR operational services also rely on a high level of digitisation and automation of functions, whether they are on board the air vehicle itself, or are part of the ground-based infrastructure and system environment.

The SESAR vision also addresses airport operational and technical system capacity and efficiency, introducing technologies such as satellite-based tools for more accurate navigation and landing and mobile communications to improve safety on the airport surface. Meanwhile, dig data analytics and better data sharing through system-wide information management are allowing for better flight planning, airport operations and their integration into the overall Network.

As European economic recovery remains slow; the aviation and ATM industries must increase their productivity, sustainability and competitive edge. In response to this, SESAR enables the development of leaner, modular and more scalable systems that are easier to upgrade and interoperable with each other. In the longer term, virtualisation and the move towards "digitally connected aviation" are allowing for safer and more efficient and flexible use of resources, substantially improving safety and the cost efficiency of service provision and relieving congested airspace.



- Integration of all air vehicles, including drones
- Higher levels of autonomy and connectivity
- Increased use of mobile, terrestrial and satellite-based communications
- Digital and automated tools (air vehicle/ ground-based infrastructure)
- Introduction of virtual technologies
- High-tech video, synthetic and enhanced sensor technologies
- Big data analytics and data sharing
- Greater system modularity

What are SESAR Solutions?

SESAR Solutions refer to new or improved operational procedures or technologies that aim to contribute to the modernisation of the European and global ATM system. Each solution includes a range of documentation, including:

- Operational services and environment descriptions;
- Safety, performance and interoperability requirements;
- Technical specifications;
- Regulatory recommendations;
- Safety and security assessments;
- Human and environmental performance reports.

What is in the second edition of the catalogue?

This second edition of the SESAR Solution Catalogue embeds the final list of SESAR Solutions delivered by the SESAR 1 programme, which closed at the end of 2016. This edition brings together the full range of solutions, which are essential for improving performance either at network or local level, subject to local business cases. In addition, the catalogue indicates solutions that have reached maturity but for which further refinements will be undertaken by interested stakeholders (Annex 1). It also gives an overview of the research and development (R&D) activities which are underway to support the delivery of solutions in SESAR 2020 for development in SESAR 2020 (see Annex 2).

To deliver solutions for deployment, the SESAR JU and its members have built a process, known as the release process, whereby solutions are tested or validated in real operational environments including direct airport interfaces. With validation sites across Europe, the SESAR JU and its members have taken R&I out of the lab and connected it with the real world.

Validations take place in simulation platforms, on board commercial flights, dedicated airport testbeds and air traffic control centres. Exercises are not limited to a specific location, but can be used to test multiple environments irrespective of the location where the physical validation is held. To date, over 350 validations have taken place, where pilots, controllers, engineers and other operational staff have worked with SESAR projects to put the solutions to the test.

To ensure their uptake, the solutions are developed taking into account existing ICAO and industry standards and also contribute to the definition or refinement of these standards.

SESAR validation techniques and tools

A number of techniques and tools are used to validate the SESAR Solutions, sometimes in combination with one another. These include:

Fast-time simulations: involve using models of ATM systems, several of which exist for both airspace and airport operations. These models are highly dependent on the data used to drive them, and hence must be carefully validated in order to assure realistic outputs. They are best used to test the sensitivity of a proposed solution to different assumptions and scenarios.

Real-time simulations: provide human-in-the-loop experience of a proposed solution in a relatively controlled and repeatable environment. Data collected may include simulator data logs, observer notes, video recordings, questionnaires and debriefing sessions.

Shadow-mode trials: involve the use of prototypes of operational tools to assess the effectiveness of a proposed solution. The prototypes are integrated with live operational systems and run in the background in parallel.

Live trials: involve the deployment of prototypes of operational tools and/or the use of proposed procedures in live operations. They have the advantage of exposing the proposed solution to reality but inevitably place high demands on rigorous safety assessment and understanding the effects (positive and negative) on impacted traffic.

Demonstrations: bring together a broader range of stakeholders from airlines, air navigation service providers, to the manufacturing industry and airports in order to demonstrate the benefits of SESAR solutions in real-life environments using commercial flights.

SOURCE: European Operational Concept Validation Methodology (EOCVM)

FIGURE 1 — Locations where solutions have been validated

Addressing the needs of the entire ATM community

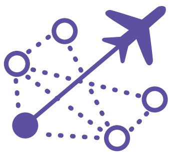
SESAR Solutions have been categorised according to four key areas of ATM (key features):

High-performing airport operations

The future European ATM system relies on the full integration of airports as nodes into the network. This implies enhanced airport operations, ensuring a seamless process through collaborative decision making (CDM), in normal conditions, and through the further development of collaborative recovery procedures in adverse conditions. In this context, this feature addresses the enhancement of runway throughput, integrated surface management, airport safety nets and total airport management.

Advanced air traffic services

The future European ATM system will be characterised by advanced service provision, underpinned by the development of automation tools to support controllers in routine tasks. The feature reflects this move towards further automation with activities addressing enhanced arrivals and departures, separation management, enhanced air and ground safety nets and trajectory and performance-based free routing.



Optimised ATM network services

An optimised ATM network must be robust and resilient to a whole range of disruptions, including meteorological and unplanned events relying on a dynamic and collaborative mechanism. This will allow for a common, updated, consistent and accurate plan that provides reference information to all planning and executing ATM actors. This feature includes activities in the areas of advanced airspace management, advanced dynamic capacity balancing (DCB) and optimised airspace user operations, as well as optimised ATM network management through a fully integrated network operations plan (NOP) and airport operations plans (AOPs) via system-wide information management (SWIM).

Enabling aviation infrastructure

The enhancements described in the first three key features will be underpinned by an advanced, integrated and rationalised aviation infrastructure, providing the required technical capabilities in a resource-efficient manner. This feature will rely on enhanced integration and interfacing between aircraft and ground systems, including ATC and other stakeholder systems, such as flight operations and military mission management systems. Communications, navigation and surveillance (CNS) systems, SWIM, trajectory management, Common Support Services and the evolving role of the human will be considered in a coordinated way for application across the ATM system in a globally interoperable and harmonised manner.

WHO BENEFITS?

SESAR Solutions meet the business needs of a range of ATM stakeholders. For each solution, the stakeholders targeted by the solution are indicated using the following key:

ANSP
Airspace navigation service providers (civil and military)

AO
Airport operators (civil and military)

AU
Airspace users (civil and military)

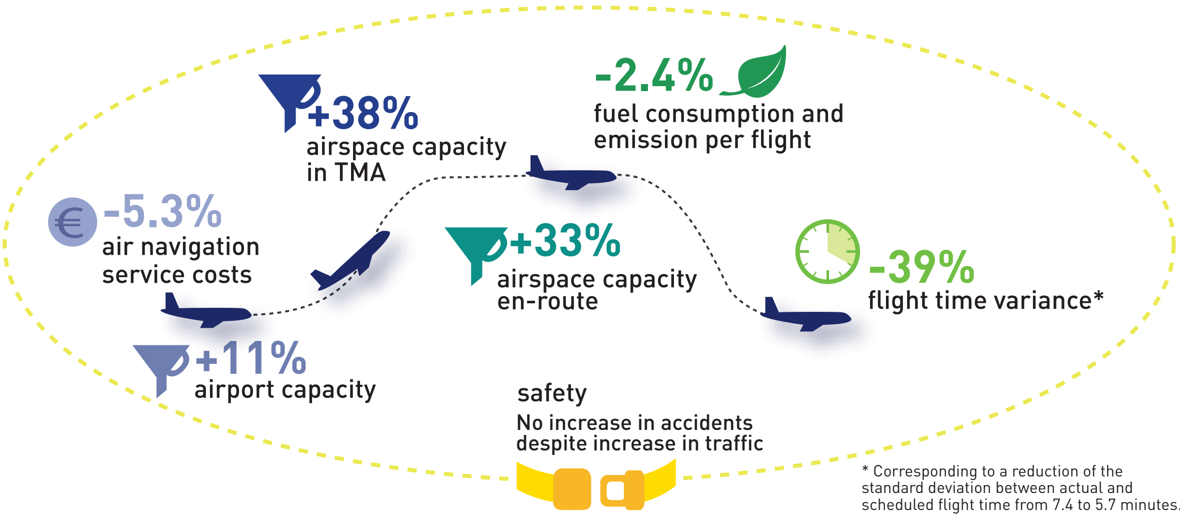
NM
Network Manager

Delivering performance

Performance is at the heart of SESAR, which is why every SESAR Solution is assessed and documented according to a set of key performance areas, notably safety, cost efficiency, operational efficiency, capacity, environment, security and human performance[1]. Some solutions bring specific local value, for example the introduction of remote tower services at small regional airports. Others are organised to deliver benefits in a synchronised manner across Europe. The performance of SESAR Solutions validated in SESAR 1, many of which are captured in this catalogue, can be measured as follows:

- **Improved predictability:** measured by the variability in the duration of the flight;
- **Reduced costs:** refers to the costs associated with air navigation service provision;
- **Increased airport capacity:** refers to runway throughput at 'best-in-class' airports which already operate close to their capacity limit;
- **Increased airspace capacity:** refers to airspace which is close to saturation in both en-route and in the surrounding area of airports (terminal manoeuvring area);
- **Reduced fuel consumption and emissions:** refers to the average reduction in fuel consumption per flight in Europe (at the level of European Civil Aviation Conference).

FIGURE 2 — SESAR 1 performance results



* Corresponding to a reduction of the standard deviation between actual and scheduled flight time from 7.4 to 5.7 minutes.

The performance of each Solution is available in their data packs, which can be downloaded from the SESAR JU website: www.sesarju.eu

(1) Source: 2015 Performance Assessment (B.5-D71). The figures refer to the performance assessment made on all the SESAR results captured by 2015 relative to the 2005 baseline. This includes solutions which are ready for industrialisation (V3), solutions for which more work is planned under SESAR 2020 (V2) and developments with regard the deployment baseline.

Framing SESAR Solutions

SESAR Solutions are very much the end product of the SESAR research and innovation pipeline. However these solutions would not see the light of day if it were not for a number of important transversal elements and activities that support and frame the operational and technological work. These transversal elements, working in the shadows of the programme, ensure that the end products fully fit with the SESAR vision and meet the necessary criteria, whether they have to do with the system, service and operational architectures, the key performance ambitions or the required cost-benefit analysis and business case. These elements are complementary to one another and are regularly reviewed to ensure alignment with the SESAR vision.

SESAR DICTIONARY

The SESAR Dictionary brings together close to 500 terms and definitions associated with SESAR research and innovation activities.

View the dictionary: https://ext.eurocontrol.int/lexicon/index.php/SESAR

Seeing the big picture

European ATM Master Plan

Set within the framework of the Single European Sky (SES), the Master Plan is the European planning tool for defining ATM modernisation priorities and ensuring SESAR Solutions become a reality. Both pragmatic and ambitious in its design, the Plan provides a high-level view of what is needed in order to deliver a high-performing aviation system for Europe. It also sets the framework for the related development and deployment activities, thereby ensuring that all phases of the SESAR lifecycle remain connected. The content of the Master Plan is structured into three levels, allowing stakeholders to view the information that is most relevant for them whether they are executives, planners or those implementing the plan. The Plan is accessible online via https://www.eatmportal.eu.

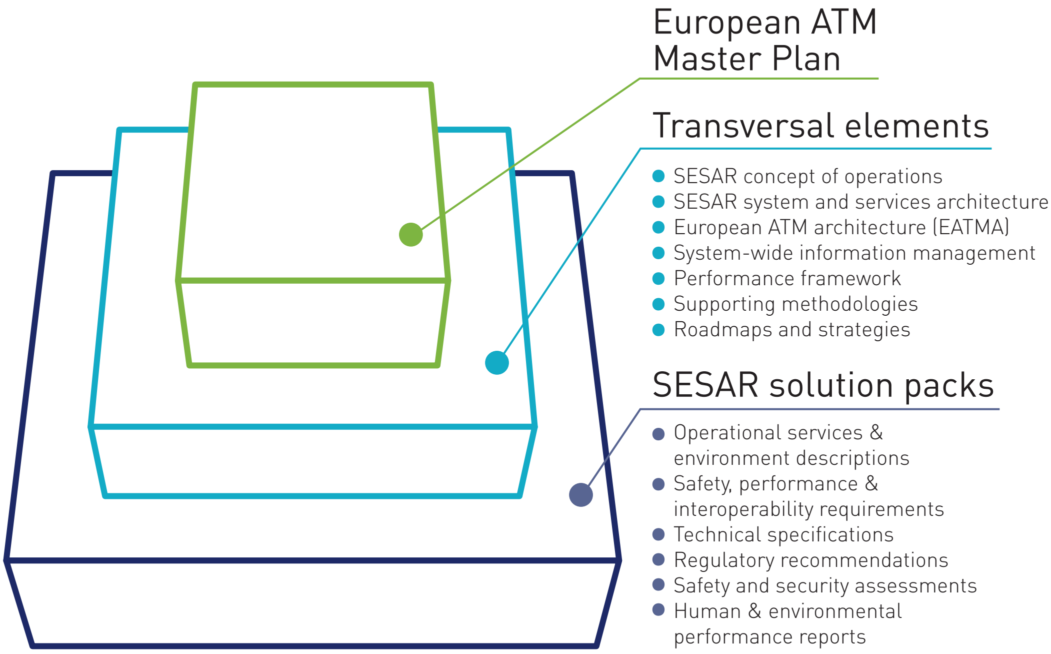
SESAR Concept of Operations

The Master Plan is supported by the SESAR Concept of Operations (CONOPS). It describes the operational target, namely to move ATM towards business or mission trajectory-based operations. The CONOPS allows all those in ATM, from the civil and military airspace users and service providers, to airports and the manufacturing industry to gain a common understanding of the system and a clear view of the phases to achieve the concept target. The SESAR CONOPS, which has been adapted for Europe from the ICAO Global Air Traffic Management Operational Concept, is an important reference for global interoperability and harmonisation.

SESAR system and services architecture

To meet the operational needs described in the CONOPs, SESAR has developed and described an overall technical architecture of the ATM system that highlights interconnectivity between the various technical systems through system-wide information management (SWIM) and message exchange interfaces. This is captured in the architecture description document, which is the entry point to more detailed architectural information hosted in the European ATM architecture (EATMA) framework.

FIGURE 3— SESAR transversal elements



European ATM Architecture (EATMA)

The EATMA is a repository of content and programme-related information that provided the structure to the work of the 300 projects that have made up the first SESAR R&I activities (SESAR 1). In doing so, the EATMA ensures a coherent architecture framework for developing interoperable solutions, as well as for identifying gaps or duplication of technical system work between projects. As a framework, the EATMA federates the performance framework as well as operational, systems and service architectures. The EATMA is accessible through the ATM Master Plan portal that captures, maintains, validates and reports on architecture-related content.

Information exchange at your service

SWIM represents a complete paradigm change in how information is managed and shared along its full lifecycle and across the whole European ATM system. It means sharing the right air traffic management information at the right time to the right people. SWIM results in a more cost and time efficient exchange of information between providers and users. SWIM is structured around three main layers:

- Information: Aeronautical information reference model (AIRM)
- Services: Information service reference model (ISRM)
- Technical infrastructure profiles.

All of these layers require appropriate standards to ensure interoperability. On top of these layers a transparent governance structure manages the development, deployment and evolution of these SWIM building blocks.

Making the case

Meeting the performance ambitions

Performance is the heart of the Single European Sky and therefore SESAR's work. It is no surprise then that the SESAR JU has integrated a framework to measure the performance of SESAR Solutions and aggregate the results to the level of the Master

Plan. This approach means that at the very outset, SESAR Solutions are designed with a range of performance ambitions in mind (operational and cost efficiency, capacity, safety, environment, security), aimed at contributing in a measurable way to reaching the SES performance targets and, in the long term, the SES High-Level Goals. The framework and process also allow for the traceability of performance throughout the development of the solutions until their delivery. Regular performance assessments are made providing the detailed calculations, assumptions and gap analysis for SESAR Solutions. The bottom-up results stemming from individual analysis on the different Solutions are then consolidated at a higher level to provide a holistic view of the performance of SESAR and to identify possible performance gaps.

Supporting methodologies

Supporting methodologies form part of the backbone of any R&I programme, since they ensure that a common approach to testing and analysis. In SESAR 1, a range of methodologies has been developed to support assessments of solutions. These assessments provide input to cost-benefit analysis and the overall business case of a solution. They also allow for forward and backward traceability between R&I and the High-Level Goals of the SES.

Safety: enables safety assessments to be carried out across the programme in a systematic way. The methodology framework is also validated by the European Aviation Safety Agency (EASA). It is documented in the safety reference material (SRM) and is based on a rigorous requirements-engineering (RE) approach.

Security: provides a holistic approach to assess ATM security, addressing personnel, procedures and the physical infrastructure, as well as information and communications technology (ICT) systems. The approach is documented in the SESAR ATM security risk assessment methodology (SecRAM) and can be applied in a tailored manner to the projects developing solutions. The methodology consists of several catalogues containing security assets (information and services) and controls that can be selected to mitigate risks. In addition the methodology uses a specialised database in which to store results for analysis and to automatically generate reports.

Human performance: ensures that human performance-related aspects are systematically identified and managed during the definition, development and validation of solutions. The methodology provides projects with a framework in which to assess whether a solution will contribute to expected human performance benefits and is within the scope of human capabilities and limitations.

Environment: offers a common approach to making the environmental impact assessments of solutions. The process, captured in a document called environment reference material (ERM), is derived from a mapping onto the SESAR validation framework of the globally-recognised process from ICAO[2]. The methodology provides guidance at each step of the validation process of a particular solution, indicating, for instance, types of environmental impact that should be assessed, and when and how they should be assessed. The methodology includes tools for assessing a solution's impact in terms of noise and fuel and emissions (IMPACT); local as well as global fuel and emissions (AEM); airport fuel and emissions and dispersion (Open-ALAQS); and for vertical flight path analysis (V-PAT). It should be noted that these tools have also been developed to be used for the research and future deployment phase of SESAR. The methodology also contains an appendix describing the assessment of fuel efficiency based on aircraft-derived data from flight trials, one of the main validation techniques used by the SESAR R&I programme.

Cost-benefit analysis (CBA) and business case development: provides an approach and common guidance to structure, organise and validate the many contributions stemming from the active involvement and support of all ATM stakeholder groups in

([2]) ICAO Guidance document (Doc 10031) "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" defining the economic, financial and business impact of SESAR. The reference material goes beyond strict CBA models and includes also the method to assess costs and to identify, structure and monetise the benefits in the validation activities. The solution integrates several different models including scheduled airlines, business aviation, general aviation, rotorcraft, ANSPs and airports as well as a cost model for the military.

It should be noted that these methodologies are valid under SESAR 1 and will evolve under SESAR 2020 with a view to closing the gap between the SESAR performance framework and the SES performance framework. Commission implementing Regulation (EU) No 409/2013 has established that SESAR deployment is 'essential to achieve the SES performance objectives' and that 'common projects shall be consistent with and contribute to the European Union-wide performance targets'. Thus, the definition and assessment of the performance ambitions and validated results of the SESAR Solutions need to be aligned and cross-readable with the SES performance framework, key performance areas and indicators. This has already been done in 2015 edition of the Master Plan.

Roadmaps and strategies

Communications, navigation and surveillance (CNS) roadmaps

CNS technologies on the ground and on board the aircraft are an essential underlying technical enabler for many of the operational improvements and new procedures of the future ATM system. Performance requirements for CNS systems are becoming increasingly complex and demanding and will be considered as part of an integrated air and ground CNS system, whereby convergence towards common infrastructure components may be considered, where appropriate, across the different CNS domains. In parallel, CNS systems and both airborne and ground infrastructure will take a more business-oriented approach that sees a more efficient use of resources, delivering the required capability in a cost-effective and spectrum-efficient manner.

These factors are taken into account in the CNS Roadmaps that provide a detailed vision of the European infrastructure evolution described in the European ATM Master Plan to support the evolving SESAR Target Concept (short, medium and long-term). It covers the airborne and ground communication, navigation, surveillance, as well as spectrum aspects, in an integrated perspective, starting from the current baseline and driven by updated strategy and planning information from stakeholders.

Spectrum Strategy

Radio spectrum is vital for safe, efficient and cost-efficient air transport, and in particular for enabling the provision of CNS. The SESAR Spectrum Strategy's main goal is to create a sustainable environment for spectrum-efficient aeronautical systems. It does so by identifying the means to optimise the current spectrum usage as well as developing more spectrum-efficient CNS technologies. Work is underway to integrate the SESAR strategy into the ICAO Handbook on Radio Frequency Spectrum Requirements for Civil Aviation Doc 9718 Vol 1 ICAO spectrum strategy, policy statements and related information. The strategy examines potential spectrum requirements, beyond existing strategic plans, in the timeframe 2035-2050 based on the European aviation vision set out in Flightpath 2050 (FP2050).

Solutions at a click of the button

The value of SESAR Solutions is dependent on the ability of the aviation industry to move forward with their implementation. For every validated solution, there is a significant amount of documentation on the deliverables required for their industrialisation. Each solution comes with recommendations on the regulatory and standardisation frameworks needed. This documentation has been assembled in the SESAR Solution Packs and made available online to allow that a much wider audience obtain the information they need.

The Solution Packs are displayed in three steps:

- **At a glance:** gives a brief description of the solution and the benefits it will bring to air traffic management
- **In context:** provides a summary of the validation process, performance achievements, benefits to ATM operations, and activities to be conducted before or as part of deployment
- **Getting technical:** provides a pack of reference documentation, including operational services and environment descriptions, safety, performance and interoperability requirements, technical specifications, standards and regulatory recommendations. Additional material may include safety and security assessments, and human and environmental performance reports.

The SESAR Solution Packs enable the entire ATM community to actively explore how they can best benefit from SESAR Solutions, according to their own needs, to ensure that these solutions become a reality. This Catalogue is complementary to the solution packs, offering a reference for stakeholders in order to pick and choose the solutions that are most relevant for their business.

Visit the SESAR Solution portal: http://www.sesarju.eu/activities-solutions

Deploying SESAR Solutions

Several of the SESAR Solutions are already in operation or are part of procurement specifications for implementation, demonstrating SESAR's role in transforming Europe's ATM network into a modern, cohesive and performance-based operational system. Examples of these local implementations are given in the catalogue and can be further referenced in the Master Plan Level 2 and 3.

Through its international cooperative arrangements, SESAR aims to foster interoperability, harmonisation and performance of the global aviation system. SESAR Solutions are promoted through these cooperation and demonstration activities, which in turn foster uptake in other world regions.

Furthermore, the decision by the European Commission to package a first set of SESAR Solutions into a Pilot Common Project (PCP), proved the readiness of the SESAR research and development activities for synchronised implementations across Europe. The SESAR Deployment Programme, which is managed by the SESAR Deployment Manager, is working to ensure that these solutions delivered by the SESAR JU are timely and operationally synchronised for entrance into everyday operations across Europe, resulting in significant benefits for airspace users and the environment.

> Several SESAR Solutions are due to be deployed across Europe in accordance with the Pilot Common Project. These are highlighted in this catalogue using a PCP stamp.
>
> PCP

Europe is therefore well on its way to building the ATM system that it needs to increase the performance and sustainability of its aviation sector.

High-performing airport operations

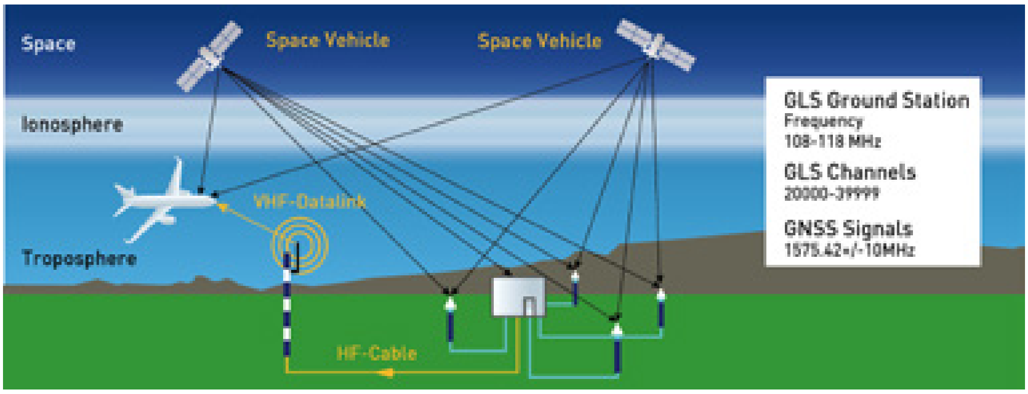
SJU references:
#55/Release 4

SATELLITES DELIVER PRECISION LANDING GUIDANCE

Precision approaches using GBAS Category II/III

STAKEHOLDERS

- ANSP
- AO
- AU
- NM



BENEFITS

- **Improved resilience by limiting the capacity reduction in degraded situations and by avoiding critical and sensitive areas)**
- **Reduced installation and maintenance costs compared to ILS**
- **Maintained level of safety**
- **Greater frequency efficiency**
- **Improved environmental impact due to shorter routes and noise abatement**

For more than 50 years airports have relied on instrument landing systems (ILS) to provide pilots with approach and landing guidance in low-visibility conditions, such as heavy rain and low cloud. Although the system has proved to be reliable and functional, ILS is costly to maintain and has operational limitations that reduce runway capacity in certain conditions. It is no surprise then that airports are turning to other solutions, such as ground-based augmentation of satellite navigation systems (GBAS), to meet their capacity needs and reduce delays and disruptions for airspace users and passengers.

GBAS uses four global navigation satellite system (GNSS) reference receivers and a VHF broadcast transmitter system. Its ground system measures distances to GNSS satellites (e.g. Galileo), and computes error corrections and integrity data based on signal quality and known fixed positions of the GNSS reference receivers. Together with the approach path and quality information the corrections are broadcast as digital-coded data to all GNSS landing system (GLS)-equipped aircraft within range. The aircraft receives this information, calculates the (differentially) corrected position and deviations from the selected approach path, allowing it to land automatically in low-visibility conditions.

GBAS CAT II/III can enable precision landing in low-visibility conditions, helping to maintain safety and capacity performance. SESAR validations have shown that the GBAS CAT II/III can overcome challenges posed by low-visibility conditions, reducing runway blocking times and thereby increasing arrival capacity (by between two and six aircraft per hour) compared to ILS.

Over 90 flights were conducted using several prototype systems, and the results are being used to help develop common standards at an international level. The work continues in parallel with the development of airborne GNSS landing system (GLS), the avionics required for GBAS-controlled landings. Assuming that standardisation and regulation progress as planned, the entry into service of GBAS Category II/III is expected in the 2018-2019 timeframe.

GBAS requires lower installation and maintenance costs compared to conventional instrument landing systems (ILS)

This solution is linked to ICAO's Annex 10 on Gast D standard and EUROCAE's ED-114

CAPACITY GAINS WITH TIME-BASED ARRIVALS

Time-based separation

SJU references:
#64/Release 2

STAKEHOLDERS

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Today, aircraft making their final approach to land are obliged to maintain minimum separation distances. These distances are fixed whatever the wind conditions. When keeping to these distances in strong headwinds longer gaps of time develop between aircraft. This means fewer flights landing per hour (reduced airport capacity), leading to delays and increased holding at busy times, which results in increased fuel burn.

SESAR's time-based separation (TBS) replaces current distance separations with time intervals in order to adapt to weather conditions. It provides consistent time-based spacing between arriving aircraft in order to maintain runway approach capacity.

The TBS software uses real-time information about the weather, airspeed, ground speed, heading and altitude to display time-based separation and arrival speed information to the approach controller. No changes are required on board the aircraft, but the controller uses the real-time separation indicators to manage the final approach separations.

TBS research included analysis of the arrival paths of over 100,000 aircraft using state-of-the-art equipment to measure the behaviour of aircraft wake vortices. The procedure now is in daily use at London Heathrow, where, in strong wind conditions, it delivers up to five additional aircraft landings with TBS per hour compared to traditional distance-based separation procedures. TBS results in an average reduction of 0.9 minutes holding time, and an average reduction of 1.4 minutes between stack-entry and touchdown times.

The SESAR Solution is available for industrialisation. TBS entered into full-time service at London-Heathrow in March 2015. The solution is due for synchronised deployment across Europe in accordance with the Pilot Common Project.

Analysis has shown that there has been no increased risk to wake turbulence encounters, and no increase in the number of go-arounds following introduction of time-based separation at London Heathrow

This solution is linked to Eurocontrol's TBS specifications (STD-065)

BENEFITS

- **Improved airport capacity as a result of increased aircraft landing rates in strong headwind conditions**
- **Reduction in holding times as well as stack entry to touchdown times**
- **Increased situational awareness**

PCP

SJU references:
#22/ Release 5

EFFICIENT PLANNING AROUND THE AIRPORT

Automated assistance to controllers for surface movement planning and routing

STAKEHOLDERS

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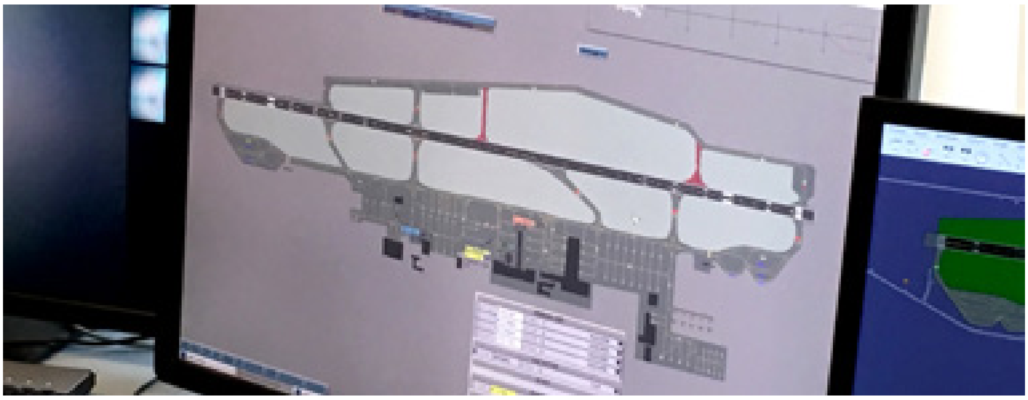

Selecting the most suitable route from the departure gate to the runway or from the runway to the arrival gate depends on the airport layout, aircraft type, operational constraints such as closed taxiways, arrival routes, as well as departure planning information such as target start-up times.

The SESAR surface route planning function automatically generates taxi routes which are then displayed on the controller working position. The software uses flight plans and current operational data to calculate the optimum route for each aircraft. It also calculates the taxi time, which can then be used for departure planning purposes. The controller can graphically edit the route before relaying it to the pilot by voice, or where possible by datalink.

By generating an electronic route plan, the information can be shared not just with the cockpit, but also with the airline operations centre, air traffic control and other operators on the airfield. It is less prone to error than route plans agreed solely based on controller/pilot communication, and it increases air navigation service productivity. The route plan is also available for use with other solutions such as enhanced guidance assistance tools (through airport moving maps in aircraft and vehicles or through the airfield ground lighting) to provide guidance instructions for pilots or vehicle drivers on the airfield.

Trials revealed a reduction in variability between the planned and actual taxi time compared with current operating methods. Efficiency of surface operations is also improved since pilots and vehicle drivers can receive optimum route plans. Safety is also enhanced, particularly in low visibility, as controllers can rely on a graphical display of the routes assigned to aircraft and vehicles.

This SESAR solution is available for industrialisation. The solution is due for synchronised deployment across Europe in accordance with the Pilot Common Project.

The route planning functionality allows controllers to graphically edit routes and automatically compute estimated taxi times, contributing to more predictable surface operations

This solution is linked to EUROCAE standards ED-87C and ED-87D

BENEFITS

- **Improved predictability**
- **Enhanced safety**
- **Increased capacity**
- **Improved taxi times resulting in reduced fuel burn**

IMPROVED COMMUNICATIONS THANKS TO DATALINK

D-TAXI service for controller-pilot datalink communications (CPDLC) application

SJU references: #23/Release 5

STAKEHOLDERS

- ANSP
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- AU
- NM

Radio channels become congested and hard to access during periods of busy traffic. Yet the majority of transmissions are routine exchanges between the controller and the flight deck to confirm instructions such as pushback clearance, start-up and taxi instructions. Datalink provides a more efficient means to relay these messages and is less prone to error.

Aircraft already use datalink in oceanic airspace to send position updates and request route changes, and the technology even now delivers pre-departure instructions to pilots at the gate. SESAR is testing message exchanges on the airfield using controller-pilot datalink communications (CPDLC) on board modern aircraft. The service is supported at some airports with advanced controller working positions, and simulations are also underway looking at protocols and operational procedures. The delivery by datalink of information and clearances during the taxi phase is known as D-TAXI. The solution aims to reduce voice communications by exchanging non-critical message between controllers and flight crew by datalink. Radio remains available at any time and is still used on first contact with the controller for radio check and for safety or time critical clearances like line-up and take-off.

A combination of simulations and live trials assessed the performance of the solution in different traffic densities, with different levels of aircraft equipage. Datalink messages were exchanged to initiate start-up, push back, taxi, revised taxi and further route information (such as de-icing). The exercises also used SESAR routing and planning functions to obtain the most suitable taxi route. The activity aims to improve the safety of surface movements.

This SESAR solution is available for industrialisation.

This service aims to reduce radio transmissions by exchanging routine and non-safety critical messages by datalink

This solution is linked to RTCA and EUROCAE standards, namely DO-350A/ED-228A, DO-351A/ED-229B

BENEFITS

- **Provides reliable, repeatable message sets for non-safety critical exchanges**
- **Frees up congested radio channels enhances safety at busy airports**
- **Delivers instructions more effectively, allowing the pilot and controller to focus on other operational issues**

SJU references:
#26/Release 5

TAXI ROUTE DISPLAY FOR PILOTS

Manual taxi routing function

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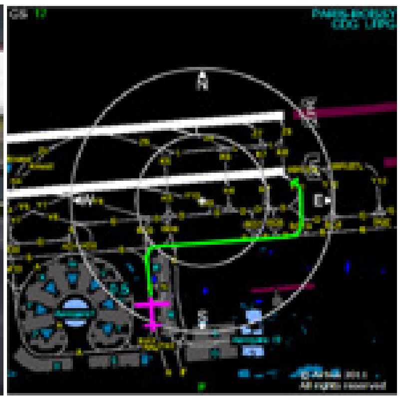

Navigating the route between the departure gate and the runway can be complex and becomes harder during low-visibility conditions or at night. To provide extra guidance - in addition to today's airfield signage and ground lighting - SESAR is developing other tools to help the pilot.

Presenting a graphical display of the taxi route instructions received from air traffic control provides another means for the flight crew to check they are following the right route. The on-board moving map of the airfield can be overlaid with the taxi route so the pilot can see exactly where the aircraft is in relation to the cleared route. If the taxi clearance is sent via datalink, through the D-TAXI service, the corresponding message is interpreted and translated as a graphical path by the on-board moving map database. If the taxi clearance is sent via voice, the flight crew can enter it manually into the airport moving map.

The solution uses technology, such as the electronic route planning system the controller employs, to select the optimum taxi route. It also makes use of controller-pilot datalink communications (CPDLC) to relay the route to the cockpit, and could be linked with airport safety nets to warn of potential hazards. The graphical display of the taxi route instructions increases the flight crew's situational awareness, notably in low-visibility conditions and at aerodromes with which they are not familiar. The solution provides an extra layer of safety for the flight crew, in addition to visual signals and voice communications. Aircraft are more likely to comply with taxi route instructions without delay.

This SESAR Solution is available for industrialisation.

A graphical display of the taxi route on the airport moving map increases the flight crew's situational awareness, notably in low-visibility conditions or an airport with which they are not familiar

This solution is linked to several industry standards: RTCA DO-272D/EUROCAE ED-99D, RTCA DO-291C/ EUROCAE ED-119C, RTCA DO-342/EUROCAE ED-220, ARINC 816-3

BENEFITS

- **Enhanced safety**
- **Improved predictability**
- **Increased efficiency in surface operations**
- **Reduced fuel burn and emissions**

FOLLOW-THE-GREENS

Guidance assistance through airfield ground lighting

SJU references:
#47/ Release 5

STAKEHOLDERS

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Airfield ground lighting offers a unique opportunity to guide aircraft and vehicles around the airport. By linking the lighting infrastructure with the taxi route management system, the airport can provide an unambiguous route for the flight crew and vehicle driver to follow.

The solution requires advanced technology within the lights themselves, and in the ramp control tower. The airfield lighting control system needs to turn on the lights ahead of an aircraft, and off immediately behind. To achieve this, taxiway centre line lights are automatically and progressively switched on in segments (or individually) as the aircraft (or the vehicle) moves along its assigned route. Pilots and vehicle drivers receive a single instruction to 'follow-the-greens' from ATC. If stop bars are implemented to protect no-go areas, they are also automatically commanded. The solution also relies on the surface movement guidance and control system to provide accurate aircraft position data.

The solution improves the safety of surface operations, especially during low-visibility conditions, through a reduction of runway incursions, taxi route deviations and holding position overruns. It increases situational awareness and improves the predictability of surface movement through a reduction in the variability of taxi times. The fewer speed changes also result in lower fuel consumption. As taxi speeds are globally increased, apron throughput is improved.

SESAR validations used a combination of simulation exercises, shadow-mode trials using vehicles to represent aircraft and several live trials with commercial aircraft. In all cases, the trials showed that the use of the lighting system can significantly help to reduce taxi times and also reduce the duration of stops during taxiing, improving efficiency. Fewer radio transmissions were required, freeing up controllers' time for other tasks. Based on more than 650 movements, one of the airports at which the solution was validated recorded a 25 % reduction in taxi time, while radio transmissions fell by the same amount. Clearance delays (the time between the pilot's push back request and actual clearance) fell by two thirds.

This SESAR solution is available for industrialisation.

This solution couples taxi route management with the airfield ground lighting, in order to provide flight crew and vehicle drivers with supplementary means of guidance

This solution is linked to EUROCAE standards ED-87C and ED-87D

BENEFITS

- **Improved predictability**
- **Enhanced safety**
- **Reduced fuel burn, noise and emissions**
- **Increased apron throughput**

SJU references:
#48/ Release 5

ENHANCING SAFETY WITH VIRTUAL STOP BARS

Virtual block control in low-visibility procedures

ANSP

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Supporting controllers and flight crew is especially important in low-visibility conditions. A line of red lights, known as stop bars, are already used to prevent aircraft entering a runway without air traffic control clearance. In addition to these physical safety nets, SESAR is advancing a novel virtual stop bar solution.

During low-visibility conditions, the ground controller can introduce procedural control to maintain safe separation, requiring clearance for aircraft to enter different areas. SESAR has developed virtual stop bars to support the ground controller in providing surface movement guidance at these times, displaying red stop lights on the controller's display. The virtual stop bars can be used by the controller to reduce block sizes according to the conditions.

If the airport surface surveillance system identifies an infringement, the controller's display receives an alert. These virtual stop bars are a valuable defence against aircraft and vehicles inadvertently entering an area without clearance from the ground controller. Providing alerts on the ground controller's display enhances safety.

Real time simulations tested the solution also investigating the use of datalink communications with aircraft as well as airfield vehicles.

This SESAR solution is available for industrialisation.

Virtual block control is an operational concept for improving weather resilience and safety at airports

Virtual stop bars alert controllers of any kind of unauthorised movement by aircraft or vehicles in the area of the runway

This solution is linked to EUROCAE standards ED- 87C and ED-87D

BENEFITS

- **Improved predictability**
- **Enhanced safety**
- **Reduced fuel burn and emissions**

ENHANCING SAFETY AT BUSY AIRPORTS

Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances

SJU references: #02/Release 5

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As traffic rises, airports face the challenge of more ground operations and surface traffic moving across runways, taxiways and aprons. In addition to safety initiatives driven by ICAO, a series of automation tools have been developed by SESAR partners to provide valuable safety nets in this area.

As part of advanced surface movement guidance and control systems (A-SMGCS) activities, new generation automation systems have been included in validations to see how various tools can operate together to provide integrated airport safety nets. These validations assessed the relevance of alerts to tower controllers in case of conflicting clearances (e.g. line up and landing clearances given at the same time on the same runway) and in case of mobile behavior (i.e. aircraft or vehicle) not complying with ATC instructions or procedures.

The introduction of electronic flight strips in many control towers means that instructions given by a controller are available electronically and can be integrated with other data such as flight plan, surveillance, routing and published rules and procedures. The integration of this data allows the system to monitor the information and alert the controller when inconsistencies are detected.

This solution highlights potential conflicts much sooner than current safety nets for runway operations which rely only on surveillance data to trigger an alarm. Moreover, the automatic conflicting ATC clearances (CATC) alert system can be configured to detect non-conformance to ATC instructions or procedures anywhere in the movement area.

This solution is linked to EUROCAE standards ED-87C and ED-87D

This SESAR solution is available for industrialisation. These airport safety nets are due for synchronised deployment across Europe in accordance with the Pilot Common Project.

BENEFITS

- **Increased situational awareness**
- **Improved safety in airport operations**
- **Enhanced safety and situational awareness**

PCP

SJU references: #70/Release 3

SURFACE SAFETY IN ALL WEATHER CONDITIONS

Enhanced ground controller situational awareness in all weather conditions

ANSP

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STAKEHOLDERS

BENEFITS

- **Operational acceptance of airport safety nets**
- **Increased situational awareness in low visibility conditions**
- **Enhanced safety thanks to the generation of real alerts**

Ground controllers face the challenge of managing not just arriving and departing aircraft, but also guiding the service and emergency vehicles that support safe operations at the airfield. Adding surface safety nets to the controller's display offers a means to provide early warning of potential conflict situations.

Developing and implementing airport safety tools is fundamental to SESAR objectives to triple capacity and increase safety by a factor of 10. Safety nets rely on information received from surface surveillance (automatic dependent surveillance – broadcast (ADS-B) messages emitted by aircraft and vehicles), flight data including clearances given, and taxi routes assigned. Built-in monitoring rules can be configured to an individual aerodrome in order to trigger alerts for the main conflict situations. Warnings can also be activated when meteorological data signals adverse weather.

The solution develops further ADS-B applications to improve ground surveillance systems in terms of safety, performance, interoperability and security. Data quality is increased with regard to the current surveillance system by means of improved surveillance data. The ADS-B ground station is enhanced to check the validity of the ADS-B derived data and to discard possible spoofing messages as well as messages transmitted by erratic ADS-B transponders, guaranteeing an improvement of the surveillance in terms of security and safety

SESAR validation activities demonstrated an increased situational awareness in low-visibility conditions. As a result of the operational acceptance of the research, the solutions were seen as suitable for development as part of surface movement guidance and control activity.

This solution is ready for industrialisation.

The solution provides the controller with the position and automatic identity of all relevant aircraft and vehicles in the movement area

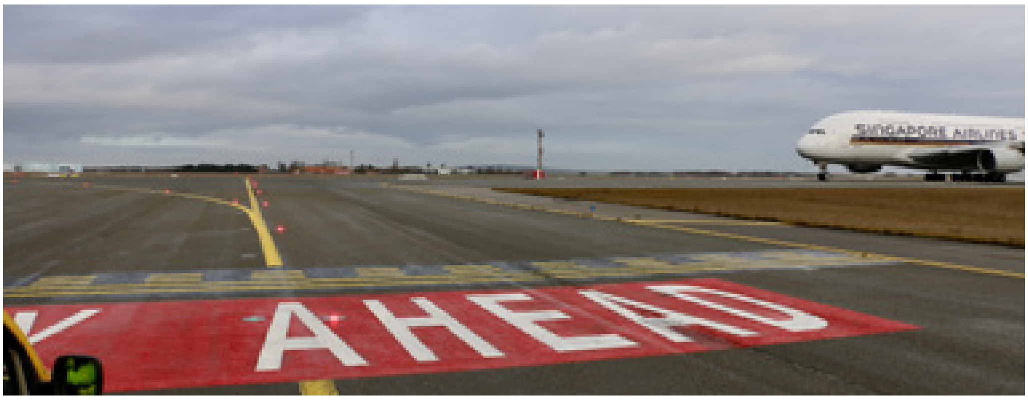
Developing and implementing airport safety tools is fundamental to SESAR objectives to triple capacity and increase safety by a factor of 10

This solution is linked to RTCA standard DO-260B

VISUAL SIGNALS TO SAFEGUARD RUNWAY USERS

Runway status lights

SJU references:
#01/Release 5



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Runway incursions are among the greatest risks in airport operations today. By installing lights which automatically alert when it is unsafe to enter a runway, airports can provide runway users with an early warning of a potential hazard.

Major airports rely on surface surveillance systems such as surface movement radar (SMR) to provide the tower controller with a visual picture of surface movements in real time. Adding safety tools for controllers, for example, to highlight non-conformance alerts or route deviation, ensure safe and accurate guidance around the airport by virtue of the advanced surface movement guidance and control system (A-SMGCS). A pilot navigating to and from the runway also relies on visual signage, and this equipment can receive information at the same time as the tower, saving crucial seconds.

Runway status lights (RWSL) include three types of high intensity LED lights: runway entrance lights (RELs), warning an aircraft about to enter the runway from a taxiway that the runway is not safe to enter, take-off hold lights (THLs) warning pilots that it is not safe to take-off from the runway, and runway intersection lights (RILs) to prevent flight crew and vehicle drivers from entering or crossing an active runway that is already occupied. Embedded in the pavement, the red warning lights alert the pilot or the vehicle driver the instant the runway is unsafe due to the detection of mobile behavior by the A-SMGCS.

Runway status lights (RWSL) are fully automatic and require no input from controllers, airport operators or flight crew

The RWSL are unique in providing instant visual alerts, and operate simultaneously with, and in addition to, other safety nets such as on-board alerts and air traffic control safety nets. The system improves awareness of runway usage, and reduces the risk of collisions on the runway. It applies equally to aircraft and vehicle traffic and does not require additional equipment in the cockpit or driver's cab.

Linking intelligence about airfield surface movements with airfield lighting enhances surface safety for aircraft and vehicle movements

This SESAR solution is available for industrialisation and was implemented at the beginning of 2017 at Paris Charles de Gaulle.

BENEFITS

- **Enhanced runway safety**
- **Increased situational awareness**

SJU references:
#04/Release 5

PROVIDING VEHICLE DRIVERS WITH ENHANCED VISUAL TOOLS

Enhanced traffic situational awareness and airport safety nets for vehicle drivers

ANSP

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STAKEHOLDERS

BENEFITS

- **Increased situational awareness**
- **Increased safety in airport operations**

Driving an airfield vehicle on the airport should be straightforward in normal operational conditions. But how do you ensure you are following the correct route when in dense fog, or at night, or when an unforeseen event occurs? And more importantly, how do you ensure that you are not entering a safety critical area without a clearance, putting you and the other mobiles' safety at risk?

Busy airports monitor airfield activity using a range of sensors and tracking systems. This information can also be used by vehicle drivers to improve safety. By fitting a screen in the vehicle, the driver can access an airport moving map, can see information regarding surrounding traffic, and can receive alerts if a dangerous situation arises. Warnings can include those related to possible collisions with an aircraft on a runway or taxiway, infringements of a runway, or a closed or restricted area.

SESAR has carried out a series of validation exercises in different locations in various traffic and visibility conditions. Alerts were generated either by an on-board system on the dashboard, or were uplinked from the ground aerodrome surveillance system enhanced with a dedicated function calculating alert situations relevant for vehicle drivers.

The trials developed the requirements for the display of information related to the surrounding traffic, including aircraft and vehicles operating on or near an active runway. The tests also established connectivity between the central system and vehicle, as well as the use of mobile devices.

This SESAR solution is available for industrialisation.

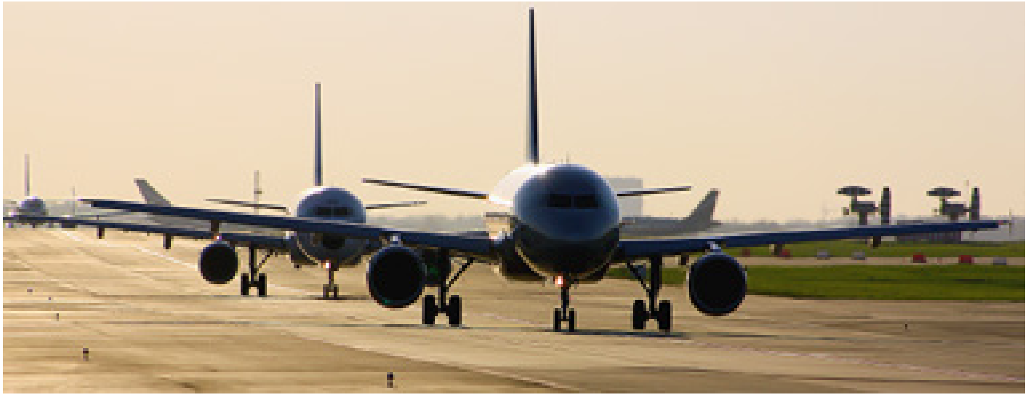
SESAR demonstrated through extensive live trials the significant benefits of this SESAR Solution in terms of situational awareness and safety

This solution is linked to EUROCAE standards ED-102, ED-102A and ED-102+

A BASELINE FOR ON-TIME DEPARTURE

Departure manager (DMAN) baseline for integrated AMAN DMAN

SJU references: #106/Release 1



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Waiting in a queue for take-off burns unnecessary fuel, generates delay and unpredictability and is frustrating for passengers. Fortunately, we encounter these queues less and less, due to a large extent to the way the departure management process is transforming departure time from an informed estimate into a precise art.

The departure manager (DMAN) tool takes into account the scheduled departure times, slot constraints, runway constraints and airport factors. In doing so, it improves traffic predictability, cost efficiency and environmental sustainability, as well as safety. By taking into consideration information such as the aircraft's readiness to leave its parking stand, runway capacity and slot constraints, tower controllers can optimise the pre-departure sequence.

In order to calculate reliable sequences, DMAN needs access to accurate information about the status of individual flights and airport resources from different systems. The airport collaborative decision-making (A-CDM) platform supports this information exchange. For example, the airline or ground handler can provide the target off-block time (TOBT), while the tower controller uses tables which generate variable taxi times to achieve the target take-off time (TTOT). Information about departure slots or calculated take-off times (CTOTs) is sourced from the Network Manager, responsible for flow control across the whole of Europe.

SESAR's baseline DMAN was validated in a series of live trials with a particular focus on delay reduction. Controllers were able to establish pre-departure sequences by using DMAN in conjunction with airport collaborative decision-making procedures involving local airport and airline partners. The system provides a baseline for further development of DMAN procedures, taking advantage of the wider adoption of airport collaborative decision making among stakeholders. The basic operational concept also supports DMAN integration with arrival manager (AMAN) and advanced surface movement guidance and control system (A-SMGCS).

The trials demonstrated improved performance in terms of predictability of off-block time by 7.8 %, with 85 % of flights achieving the five-minute window available. It decreased average taxi times by 9 %, and improved adherence to flow management slots, with 81 % of flights departing on their allocated slot compared with 76 % prior to DMAN. The solution contributed to average reduction of 14.6 kg of fuel per flight, and also supports enhanced tactical scheduling.

The solution has been implemented at Paris Charles de Gaulle Airport and is due to be deployed as part of the Pilot Common Project.

DMAN lends itself to tactical scheduling by calculating optimum pre-departure sequences based on information provided by airport, airline and air traffic control sources (A-CDM processes)

This solution is linked to EUROCAE standards ED-87C and ED-87D

BENEFITS

- **Improved predictability and stability of departure sequence, start-up approval time and off-time blocks**
- **Enhanced tactical runway scheduling**
- **Reduced waiting and taxi times and runway delays**
- **Significant reduction in fuel burn and CO_2 emissions**

PCP

SJU references:
#53/Release4

IMPROVING ON-TIME DEPARTURE

Pre-departure sequencing supported by route planning

ANSP

AO

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STAKEHOLDERS

A row of aircraft lined up ready to depart might deliver maximum runway efficiency, but contributes little to efficient fuel use and reducing noise and emissions. While all departures are carefully planned, SESAR is looking at ways to enhance the process and introduce efficiencies right from push-back.

BENEFITS

- **Reduced waiting time at the runway holding point, which saves fuel and allows air navigation service efficiency**
- **Increased accuracy of taxi time-out predication and hence take-off time predictability, which in turn allows the aircraft to adhere to their target take-off time (TTOT)**
- **Provision of a more stable pre-departure sequence**

Pre-departure management delivers optimal traffic flow to the runway by factoring in accurate taxi time forecasts and route planning derived from static data. This can help to reduce waiting time at runway holding points, and improve take-off time predictability. Accuracy can be improved if the departure manager (DMAN) takes into consideration data provided by the advanced surface movement guidance and control system (A-SMGCS). This can account for where the aircraft is parked, taxi route length and tactical adjustments such as temporary restrictions. Just how much current operations - which rely on collaborative decision making to estimate taxi times - can be enhanced by access to dynamic data depends upon the individual airport and the quality of data available.

SESAR trials using this dynamic route planning information resulted in more accurate calculations of the departure sequence, and improved predictability and stability of both target times and actual times. In particular, the sequence assigned to each flight for target start-up time, and for target take-off time, improved with the use of route planning information. For busy single runway airports, predictable operations result in better use of the available capacity.

Airports where taxi route lengths can vary significantly benefit the most from taxi times calculated using planning information from the surface movement guidance and control system

This solution is linked to EUROCAE standards ED-87C and ED-87D

Trials showed that the solution leads to reduced waiting time at the runway holding point, saving fuel and improving efficiency. It also increases the accuracy of estimated taxi time and hence take-off time predictability, which in turn allows the aircraft to adhere to target take-off time. Finally, the more stable departure sequence benefits airport operations overall, and is used in turn by the Network Manager to optimise traffic flow.

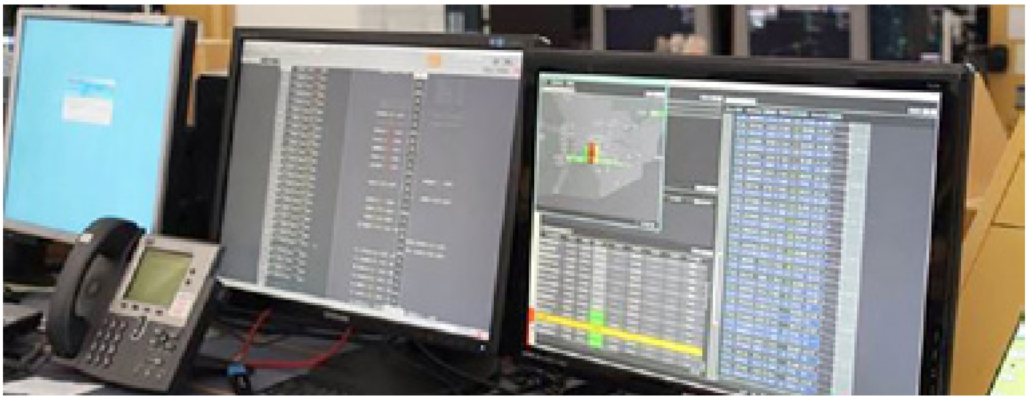
PCP

This solution is available for industrialisation. DMAN synchronised with pre-departure sequencing is planned for deployment across Europe in accordance with the Pilot Common Project.

EXTENDING THE PLANNING HORIZON

Flow-based integration of arrival and departure management

SJU references:
#54/Release 4



STAKEHOLDERS

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Knowing exactly when an aircraft is due to arrive has a direct impact on airport efficiency, especially if arrivals and departures are handled on the same runway, or on dependent runways. Improving coordination between en-route controllers, approach and tower controllers results in more accurate information about the arrival sequence that can lead to more predictable airport operations.

By integrating the activities of the arrival manager (AMAN) and the departure manager (DMAN) tools, an optimisation algorithm can calculate the ideal traffic flow that takes account of both arriving and departing aircraft. Departure flow to the runway is managed by the pre-departure sequencing planning tool, while arrival flow to the runway is managed by arrival metering. Arrival and departure flows to the same runway (or for dependent runways) are integrated by setting up a fixed arrival-departure pattern for defined periods. The successive pattern might be chosen by the operators or provided by an optimisation algorithm which takes account of arrival and departure demand. The solution is an enabler for accurate runway sequencing and facilitates long-range planning such as extended arrival management. It results in increased predictability, which leads to high capacity and less fuel burn, and better coordination between controllers.

The concept of coupling AMAN-DMAN to produce an accurate runway sequence has been validated at an exceptionally busy single-runway airport. The advanced surface movement guidance and control system also provided data on target push-back, taxi- and take-off times. The tests resulted in increased predictability in terms of target take-off time and target landing time, because the sequence offered by the system contributed to more accurate controller clearances.

Controllers delivered positive feedback about the integrated sequence, information sharing and the ability to input multiple runway patterns

The solution is available for industrialisation.

BENEFITS

- **Increased predictability resulting in increased runway throughput**
- **Reduced fuel burn**

SJU references:
#71/Release 3

REMOTE TOWER SERVICES FOR SMALL AIRPORTS

ATC and AFIS service in a single low-density aerodrome from a remote controller working position (CWP)

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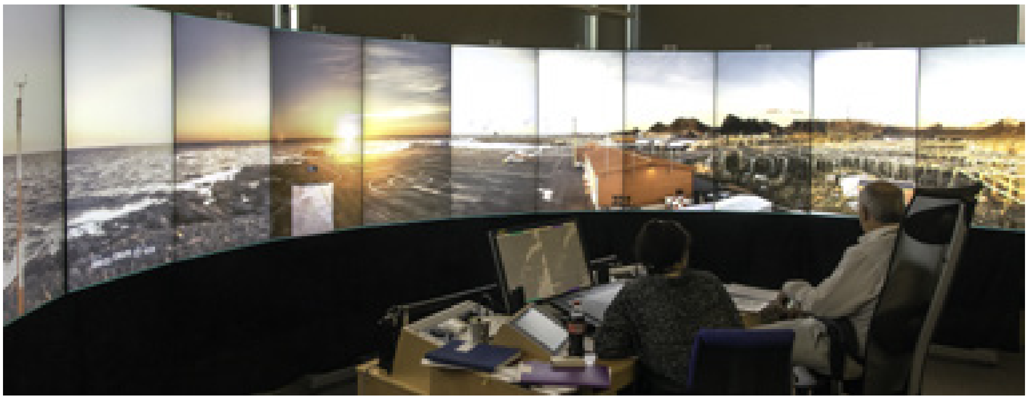

Small or local airports are a life-line for a local economy, however they cannot always afford to operate a control tower around the clock. SESAR's remote tower services offer the means to provide air traffic services in a cost-efficient way to such airports, as well as non-towered ones.

BENEFITS

- **Increased cost efficiency**
- **Increased accessibility to and support for regional economies**

By installing sensors (mainly video cameras) around the airfield, the operator can monitor activity such as runway occupancy, weather, and visibility in real time. Data is relayed back to a remote control centre where a qualified operator is on hand to provide aerodrome flight information services (AFIS) or air traffic control services for arrivals and departures. With access to a range of visual, audio, and meteorological data, the remote facility can provide services which may not be available onsite around the clock.

In a series of real-time simulations and passive shadow-mode trials (i.e. the controllers participating in the validation 'shadowing' the instructions given by the operational controllers in the real tower), controllers used high resolution imagery and enhanced functionalities to provide advisory services to a remote location. As a result, safety was maintained in normal and degraded conditions and controllers welcomed the enhanced visual tools. The concept supports extended operational hours with lower overall staffing costs. It also supports development of regional economies.

The solution is available for industrialisation. Conclusive validation results prompted Sweden to build the world's first remotely operated tower at Örnsköldsvik, controlled remotely from Sundsvall centre over 150 km away. The facility was fully certified by the Swedish Aviation Authority in 2014, and two more regional airports are implementing similar technology.

In 2014, the world's first remotely-operated tower was opened at Örnsköldsvik, controlled remotely from Sundsvall centre over 150 km away

Operational standards for remote tower services (addressed by EUROCAE WG-100) currently match those for real operations and approval is based on the same service delivery requirements as existing ICAO rules

REMOTE TOWER SERVICES BENEFIT MEDIUM-SIZED AIRPORTS

Single remote tower operations for medium traffic volumes

SJU references: #12/Release 5

STAKEHOLDERS

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Conventional control towers are expensive to operate and maintain, and even at a medium-sized airport can become too costly if the number of flights is insufficient to cover the running costs. SESAR's remote tower services offer the possibility to enhance safety and efficiency at airports where it is too expensive to build, maintain and staff conventional tower facilities and services. The solution is already deployed at small airports, and is under test at medium-sized airports.

Providing air traffic control services from a remote location can spread staffing costs, improve service continuity with the option to extend hours of service, and share training and support costs. The out-of-the-window view from the tower can be captured and reproduced at a remote facility where controllers can access all the information usually found in the tower. The visual reproduction can also be overlaid with information from additional sources and enhanced through technology for use in all visibility conditions. In addition, the controllers have access to all the necessary remote controls, including communications, lighting, flight data, and meteorological information.

Tests have demonstrated the solution's feasibility using different technology and sensors. Sophisticated camera equipment, some sourced from the military sector, are considered in the scope of this solution; while day/night cameras, infrared, and pan-tilt-zoom functions deliver the level of detail and accuracy required to safely provide ATS services. The tower-like environment at the remote facility can be enhanced with visual alerts, track labels added to flight targets, and hot spots regularly camera-checked to deliver additional safety features.

Shadow-mode exercises used a video-based panorama camera system as well as infrared technology to give controllers a detailed view of the airfield. The tests provided enhanced views of the airfield and terminal area, even during adverse weather conditions and at night. Single airport operations will apply in each case, but controllers will have the option to cross-train for more than one airport.

The SESAR Solution is available for industrialisation.

Single remote towers offer an efficient way to deploy operational staff resources by means of a remote tower centre providing single tower services to a number of airports

The standardisation work on remote towers is addressed by EUROCAE WG-100

BENEFITS

- **Increased cost efficiency**

SJU references:
#52/Release 4

MANAGING MULTIPLE SMALL AIRPORTS, REMOTELY

Remote tower for two low-density aerodromes

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Having proved controllers can provide air traffic control services to an airport remotely, SESAR validated the feasibility of providing simultaneous services to two airports from a single location.

The solution offers new possibilities for small or local airports where building, maintaining, and staffing a conventional tower is unaffordable. It promises more efficient and cost-effective deployment of operational resources, improving service continuity and maintaining safety at the same time.

The concept draws on a range of advanced technology, including high-definition cameras, Infrared, and pan-tilt-zoom cameras to deliver the information the controller wants to see in real time. Video camera data can be integrated with existing surveillance sources to identify and track targets.

In SESAR validations, a control facility provided controllers with an out-of-the-window view and working position that supported two low-traffic density airports located remotely, and allowed the controller to switch seamlessly between the two. Like an onsite manned tower, the controller has access to data from supplementary sensors and software tools that significantly enhance the visual information on display, and SESAR partners have identified a core set of functionalities needed to deliver air traffic services to multiple airports.

This solution is available for industrialisation. Norway plans to deliver aeronautical flight information services to five small airports from one central facility at Bodø in 2017.

Multiple remotely controlled airports contribute to SESAR cost-efficiency performance targets

The standardisation work on remote towers is addressed by EUROCAE WG-100

BENEFITS

- **Operational and technology-related cost efficiency**

PROVIDING BACKUP REMOTELY

Remotely-provided air traffic services for contingency situations at aerodromes

SJU references: #13/ Release 5

STAKEHOLDERS

- ANSP
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Security alerts can shut down control towers. How does the airport ensure minimum disruption in an emergency? This question has been addressed by SESAR looking at contingency situations for airports.

Contingency towers are not new, and already operate at London, Brussels, and near-completion at Budapest. They provide operational resilience and safety assurance should the primary tower be compromised. This solution brings additional technology into play, and addresses issues including accessibility, training and security to deliver more resilience and a higher efficiency in degraded situations.

A remote facility offers a cost-efficient alternative to building new infrastructure onsite. It can provide air traffic control services as close to full-operating capacity as possible, and can feature additional information feeds to enhance the data available. Most importantly, it can maintain safe flight operations, with minimum disruption to the flights operating to and from the airport affected.

Shadow-mode exercises have been carried out to examine exactly how a remote tower facility can provide contingency services at medium-sized airports. The exercises assessed the transition time necessary to switch from the primary tower to the contingency facility, what level of service can be provided in the absence of an out-of-the-window view, and what information can be accessed by controllers. They also looked at controller workload, situational awareness, and human performance.

The SESAR Solution is available for industrialisation.

Contingency towers deliver increased operational resilience for medium-sized airports

Building infrastructure off-site is more cost-efficient, and easier to maintain

The standardisation work on remote towers is addressed by EUROCAE WG-100

BENEFITS

- **Increased cost efficiency**
- **Improved resilience in degraded situations**

SJU references:
#61/ Release 1

LINKING SMALL AIRPORTS TO THE NETWORK

A low-cost and simple departure data entry panel for the airport controller working position

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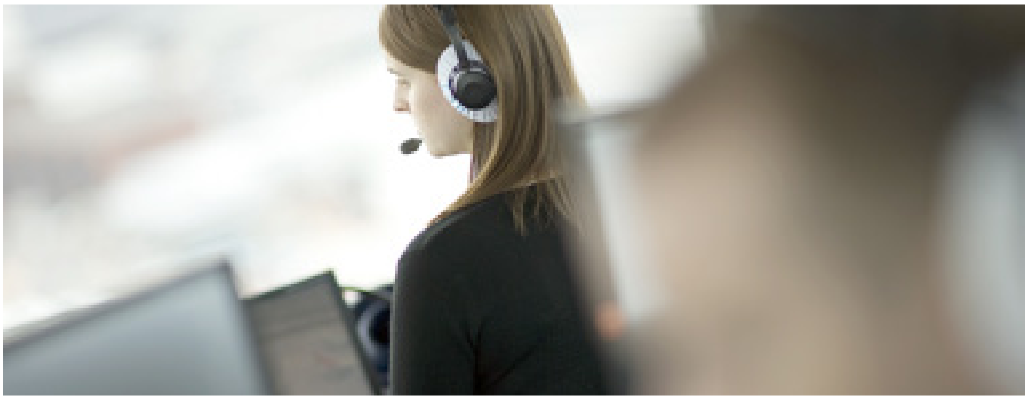


BENEFITS

- **Significant improvement in traffic predictability**
- **Increased network capacity**
- **Better runway configuration and management**

Many airports in Europe, particularly regional and small airports, are not equipped with electronic flight data processing systems (eFDPs) but rely on paper flight strips and voice communications. As a result, the integration of these airports into the air traffic management network is often limited and leads to a lack of predictability of air traffic from these airports. SESAR has developed affordable ways to link these airports to the wider network.

The use of a simple airport departure data entry panel (ADDEP) provides a low-cost solution to compute and share aircraft electronic pre-departure data across the air traffic management network, between the tower and approach controllers, as well as the tower and the Network Manager. Trials carried out at a small airport tested a standalone panel which the controllers used to input data such as push-back clearance, taxi and cleared for take-off. This ADDEP then generated departure messages which could be used to update the local flow management centre and the Network Manager.

The validation activities showed that the application of the solution improved accuracy of estimated take-off times when compared with operations without the panel. Previously, over 40 % of take-off times were at variance with estimated times (often set hours in advance), and this dropped to less than 10 % when controllers had access to the ADDEP. The extra panel did not impact on safety, and could be easily accommodated by the controller working position.

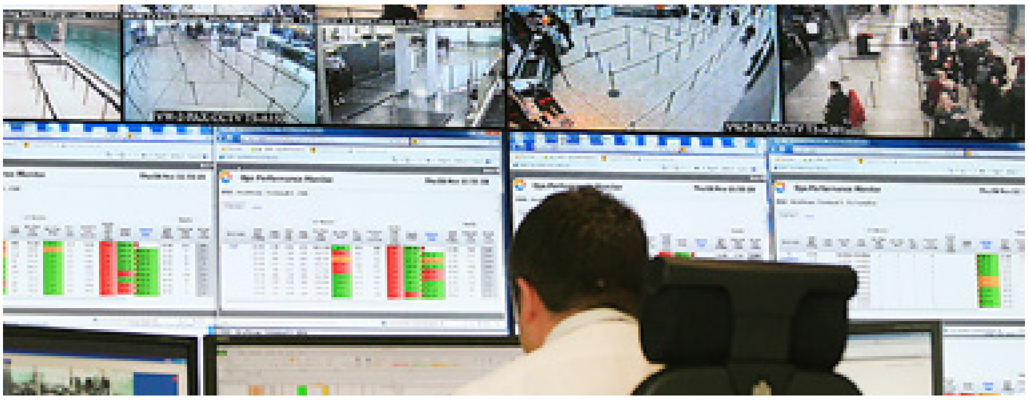
Once an airport has installed an ADDEP application, it can be adapted to provide other services, such as combined arrivals and departures provision for the tower

This solution is available for industrialisation. The solution has been deployed in several locations, in particular in the UK.

AIRPORTS ARE THE NODES OF THE NETWORK

Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP)

SJU references: #21/ Release 5



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Airports are the nodes of the airspace network, linking flights for seamless traffic flow. They can also act as bottlenecks of the network and need to be integrated into the system as a whole. The network operates according to a pre-defined network operations plan (NOP), so why not airports? SESAR is introducing the additional means to manage airport operations in a collaborative and proactive way, through the airport operations plan (AOP) and the airport operations centre (APOC).

The AOP is a single, common and collaboratively-agreed rolling plan for an individual airport. The AOP relies on information from different players including airlines, ground handlers, air traffic control, security, emergency services, meteorology and airport management. Set against specific performance targets, the airport monitors the progress of the plan and mitigates the impact of any deviations that may occur.

Daily airport operations are managed by the APOC, which can be a physical facility or a virtual collaboration between stakeholders. The alignment between planned and executed operations is continuously monitored, with changes being made to the AOP as required. As stakeholders update their intentions, or accurate flight progress information is received, the AOP is refined and used to manage resources and coordinate operations. Integration with the NOP extends the planning activities to include air traffic demand and improved target time coordination.

The aim with this solution is to provide processes and tools to maintain airport performance in all operating conditions, and to share information with the wider network. Two principal services are provided by this solution: to establish appropriate performance goals and to monitor the performance during the execution timeframe. Ultimately the AOP and APOC make airports more resilient to disruptions by enhancing the common situational awareness of ATM stakeholders through the sharing of real-time information.

This solution contributed to the revision of Eurocontrol's Airport CDM manual

SESAR validations looked in detail at information requirements, alerts and information sharing in order to optimise the use of airport capacity and resources. Real-time simulations as well as shadow-mode exercises were used to validate airport performance monitoring and management. Finally, a live trial took place to integrate landside operations with the airside environment by integrating data related to passenger milestones in the AOP.

In 2014, London Heathrow and Paris Charles de Gaulle partially implemented the solution. The full solution is now available for industrialisation and synchronised deployment is planned as part of the European Commission's Pilot Common Project.

BENEFITS

- **Enhanced predictability**
- **Improved airport resilience/limiting capacity reduction in degraded situations**

PCP

SJU references:
#116/Release 5

IMPROVED WINTER WEATHER FORECASTING FOR DE-ICING OPERATIONS

De-icing management tool

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The winter season at European airports can last from a few days to many months and during this time de-icing services may be needed. The procedure of applying required de-icing fluids to aircraft at most airports is primarily a business process that takes place between an airline and a specialised ground handling agent. The SESAR de-icing management tool (DMIT) refers to a system capable of improving the predictability of aircraft de-icing operations at European airports by taking data inputs from meteorological service providers and involving the relevant airport stakeholders.

The solution increases the accuracy of information related to when the procedure is going to take place, how long it will take and when the aircraft will be ready to taxi for departure, which is currently calculated by predetermined estimates. The solution means that air traffic controllers no longer need to work without situational awareness of de-icing activities and needing to make their own estimates of when aircraft are ready for departure. The solution envisages that de-icing operations are no longer characterised by the A-CDM concept as 'adverse conditions', i.e. a state that is in need of collaborative recovery procedures, but rather a part of normal operations in the winter period.

The DIMT allows for the scheduling and monitoring of de-icing operations. It is an internet browser-based tool that addresses three distinct procedures for de-icing:

- Remote de-icing, which occurs at a specific location on the airport away from the parking stand;
- On-stand de-icing, which occurs just before the aircraft leaves its stand; and
- After-push de-icing, which occurs after the aircraft has pushed back from the stand and is positioned to start taxiing after de-icing.

The tool was validated during a series of exercises, which took place in Helsinki, Oslo and Stockholm airports during late 2015 and early 2016. The focus of the exercises was to analyse the impact of a planning phase for de-icing operations on the predictability of the air transit view (ATV) through the introduction of a de-icing management tool. With the involvement of airport operations data base (AODB), the tool subscribes to flight information and produces information in the form of time stamps for use by coordinators, managing the de-icing of aircraft.

This solution is available for industrialisation.

The de-icing coordinator and the de-icing agent can refine the sequence through the DIMT user interface to account for any ad hoc situations that are not handled by the tool

The DIMT produces estimated de-icing time (EDIT), estimated commencement of de-icing time (ECZT) and estimated end of de-icing Time (EEZT) time stamps and publishes these to the A-CDM platform, both improving the quality of de-icing milestone information and increasing common situational awareness for other airport actors

BENEFITS

- Improved situational awareness of aircraft de-icing operations
- Increased predictability

Advanced air traffic services

SJU references:
#05/Release 4

ASSIGNING HOLDING STACKS TO HISTORY

Extended arrival management (AMAN) horizon

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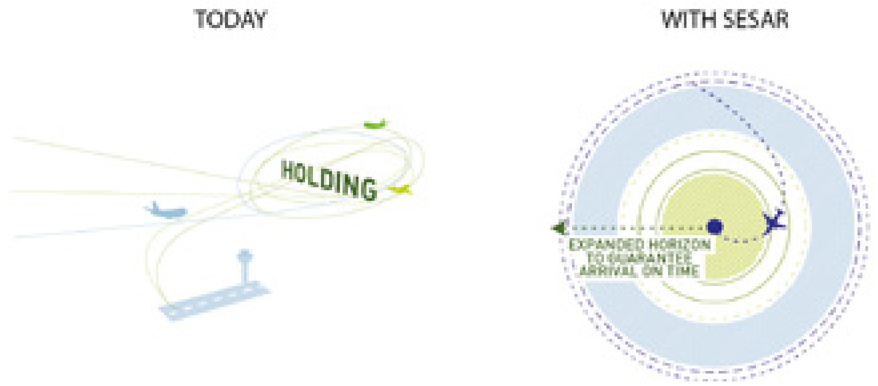

Today, arriving traffic is managed and sequenced in the airspace close to the airport. Faced with increasing traffic, airports are looking for ways to overcome congestion and reduce the need for holding. Planning arrivals into a busy airport an hour or more before touchdown cuts down holding time, reduces noise and saves fuel.

BENEFITS

- **Improved operational efficiency by reducing holding times**
- **Improved operational efficiency by reducing fuel burn and emissions**
- **Efficiency in terms of air navigation service provision**
- **Improved safety and quality of service**

Extended-AMAN (E-AMAN) allows for the sequencing of arrival traffic much earlier than is currently the case, by extending the AMAN horizon from the airspace close to the airport to further upstream and so allowing more smooth traffic management. Controllers in the upstream sectors, which may be in a different control centre or even a different functional airspace block (FAB), obtain system advisories to support an earlier pre-sequencing of aircraft. Controllers implement those advisories by, for example, instructing pilots to adjust the aircraft speed along the descent or even before top-of-descent, thus reducing the need for holding and decreasing fuel consumption.

E-AMAN is supported by sharing the airport's arrival management information with upstream sectors in real time. All parties share the same information using a system-wide information management (SWIM) service.

SESAR partners have shown that E-AMAN can be extended up to 200 nautical miles (NM) from the airport.

This solution is available for industrialisation. Already used at London Heathrow, the solution is due to be deployed across Europe in accordance with the Pilot Common Project.

London-Heathrow has cut holding times in its arrival stacks by one minute, reducing noise emissions and saving airlines EUR 2.9 million in fuel savings and a reduction of over 4,700 tonnes of carbon dioxide annually

This solution is related to the EUROCAE standard covering the extended horizon AMAN upstream coordination service (AMAN SWIM Service)

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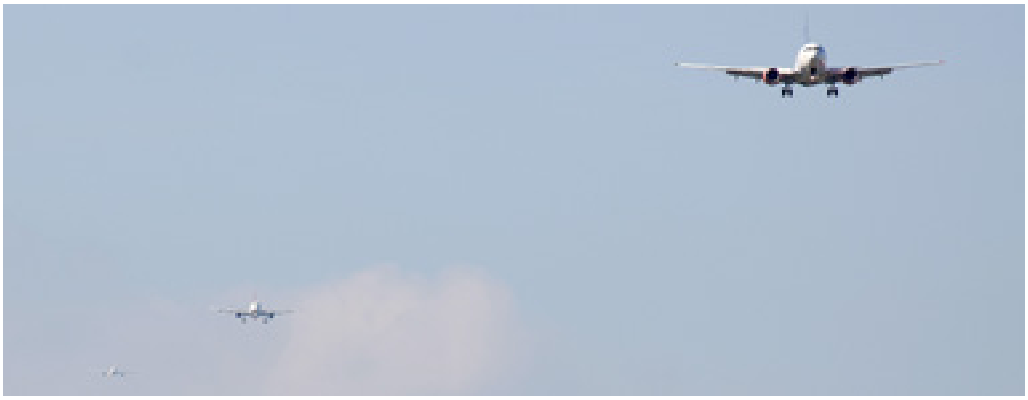
IMPROVING ARRIVAL EFFICIENCY AND PREDICTABILTY

Point merge in complex terminal airspace

SJU references: #107/Release 2



The point merge route structure provides a more efficient way to vector aircraft down to the final approach path. It allows departure and arrival streams to operate independently without risk of conflict, and delivers more predictable arrival times. The concept is simple. By designing standard sequencing legs ahead of the final approach point, aircraft can be guided along shorter or longer distances in order to reach a single entry point. For a busy terminal area controllers can start to sequence arrivals at an earlier stage, while pilots receive fewer interventions so can fly a more efficient approach path down to the runway.

At the extremity of the terminal airspace, arriving aircraft are vectored along an arc from where the timing of their turn towards the merge point determines the landing sequence. The procedure takes advantage of precision navigation technology (P-RNAV) on board modern aircraft, enabling them to fly precise pathways in the sky. The simplicity of point merge means that it is intuitive for the controllers to use, and requires fewer radio exchanges with the pilot. Fewer radar vectors also means less uncertainty on the flight deck with regard to the anticipated tactical route and the distance to go. The pilot can fly a continuous descent approach (CDA) path - rather than stepped height changes – consuming less fuel, while non P-RNAV equipped aircraft can still be vectored to the final approach point.

Live trials have demonstrated the potential to increase airspace capacity in more complex environments, while maintaining or improving safety, air navigation provision efficiency and reducing emissions.

Point merge systems provide a high degree of structure and standardisation, which can be applied to multiple airports

Point merge requires no changes on board the aircraft, however does require redesign of the terminal airspace

This solution is available for industrialisation. SESAR validation activities successfully demonstrated the application of point merge procedures in complex TMAs. Point merge is already providing more efficient arrival streams into Ireland's Dublin Airport, Oslo in Norway and the Canary Islands.

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BENEFITS

- **Increased capacity in the terminal airspace**
- **Improved safety levels**
- **Improved air navigation service provision**
- **Reduced fuel consumption and emissions**

SJU references: #108/Release 2

ELIMINATING HOLDING PATTERNS IN THE EXTENDED TERMINAL AREA

Arrival management (AMAN) and point merge

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Point merge not only delivers a more efficient arrival route structure in the terminal airspace, it can be applied to the extended terminal airspace area for pre-sequencing traffic. SESAR has developed point merge for this environment to enable the arrival manager (AMAN) to establish a more predictable arrival sequence. Integrating and optimising arrival streams contributes to the overall arrival management process both in terms of aircraft efficiency and airport operations. It is this predictability which can significantly improve capacity in dense and complex terminal airspace, and avoid unnecessary holding.

The solution is composed of a point merge system coupled with an arrival management tool that provides sequencing support based on trajectory prediction. Rather than entering holding patterns, aircraft in the extended terminal area enter performance-based navigation (PBN) routes referred to as point merge legs, where they fly briefly in a level-off lateral holding situation where the distance to the merge point remains constant. When the spacing with the preceding aircraft is attained, the controller will instruct the next aircraft on the leg to turn direct to the merge point. Unlike conventional traffic streams which are individually vectored, the turn the aircraft needs to perform in the point merge leg is always the same, which simplifies the controller's tasks. The flight crew's task is also simplified by the use of this standardised manoeuvre which is predictable and repeatable.

Flight trials have demonstrated the workability of the concept. Controllers commented on the reduction in radio communications and experienced a more orderly traffic flow. There was better adherence to AMAN advisories before aircraft reached terminal airspace, and delays tended to be absorbed in the extended terminal area, reducing noise emissions at lower altitudes.

Airspace users have the opportunity to fly continuous descent operations from the point merge legs to the merge point. The point merge legs can be flown with different PBN capabilities, which allows a mixed navigation capability to operate within the same airspace.

Point merge is one of the ICAO Aviation System Block Upgrades and is referenced as a technique to support continuous descent operations

Applicable for terminal airspace handling over 100 hourly movements and en-route airspace handling over 300 hourly movements during peak hours

This solution is available for industrialisation. Following SESAR validations, the solution has been put into operation in several large European airports such as Paris Charles de Gaulle.

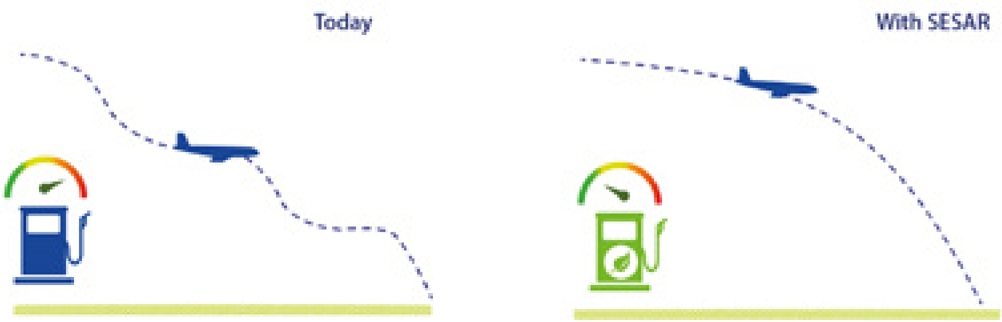
BENEFITS

- **Better management of human resources**
- **Improved pilot situational awareness through the application of more standardised procedures**
- **Enhanced safety**
- **Reduced noise impact**

SMOOTHER, QUIETER, AND MORE EFFICIENT

Continuous descent operations (CDO) using point merge

SJU references: #11/Release 5



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Aircraft engines have become quieter but an aircraft's flight path can also help reduce noise levels by following a smooth descent down to the runway threshold rather than a conventional stepped approach. Up until now, these continuous descent operations (CDOs) have been restricted to low and medium traffic density environments due to their impact on airport capacity. By combining it with point merge techniques, SESAR has extended the solution so it can be applied to high-density traffic environments at a lower altitude and in a small and very constrained airspace.

During the validation of the solution, aircraft were vectored to a common merge point from where they followed a single air navigation trajectory (RNAV) procedure to intercept the instrument landing system (ILS). Since all sequencing procedures were completed by the merge point, from there pilots could follow an unconstrained descent path. In this procedure, controllers do not need to issue any level-off clearances after the merge point, while fewer level-offs are required earlier during the vectoring to merge point procedure. This results in higher profiles in the vicinity of the airport.

Results showed that noise levels for inhabitants living near the airport were reduced with the introduction of the vector to point merge procedure. The solution also allows better control of the geographical area impacted by the noise using the RNAV trajectory capabilities, which allows the concentration or dispersion of traffic depending on the characteristics of the local area. This data is collected using a series of noise stations placed under the arrival paths to test the noise impact of the traffic before and after the flight trials.

This SESAR solution is ready for industrialisation.

Making CDOs possible in complex airspace

Simulations and live flight trials allowed aircraft to fly higher approach paths resulting in less noise impact and lower emissions in the vicinity of the airport

This solution is linked to the ICAO PBN Manual (Doc 9613), EUROCAE ILS standards and ICAO's PANS OPS (8168), as well as various avionics sensor standards

BENEFITS

- **Reduced fuel burn and emissions**
- **Reduced environmental impact of airports on their neighbouring communities**
- **Noise reduction**

SJU references:
#62/Release 1

FLYING MORE EFFICIENT ROUTES

Precision area navigation (P-RNAV) in a complex terminal airspace

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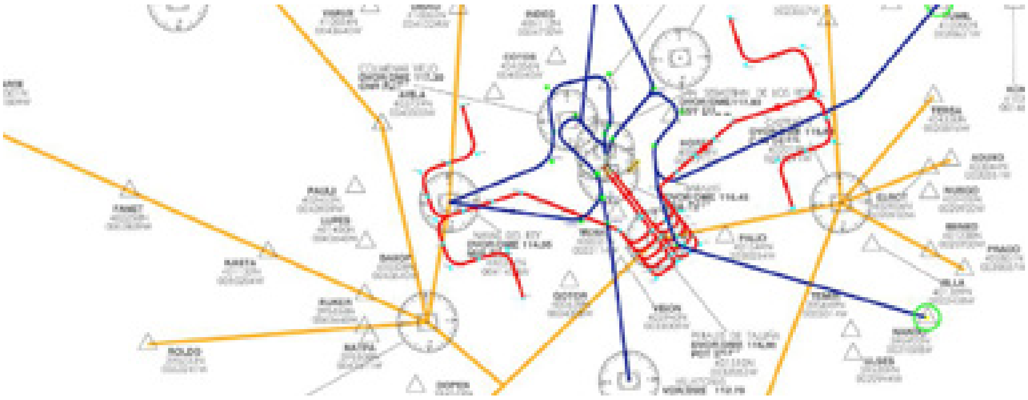

Equipped to fly to within an accuracy of one nautical mile (NM), modern aircraft have the capability to follow very flexible routes, for example reducing noise impact on populated areas and easing bottlenecks. This navigation capability is especially useful in busy terminal airspace, where the increased accuracy allows more approach paths, which can release capacity, reduce holding and cut emissions.

BENEFITS

- **Enhanced safety thanks to better precision**
- **Reduced fuel burn and emissions**
- **Improved air navigation service provision**

Introducing precision area navigation (P-RNAV) procedures improves the design and organisation of the airspace allowing the aircraft's on-board navigation system to fly optimised flight paths.

P-RNAV supports more efficient continuous descent approaches and continuous climb departures in place of traditional stepped flight profiles issued by a controller. P-RNAV also supports curved approach paths which can avoid complex interaction between inbound and outbound traffic, heavily populated areas, and can reduce track miles for inbound aircraft.

SESAR partners carried out real-time simulations of P-RNAV implementation, where the new approach paths were introduced to reduce congestion experienced with existing arrival streams. P-RNAV procedures were integrated with conventional routes, resulting in a reduction of airborne holding time enabled by the path-stretching possibilities offered by the new route structure.

The validation site used is representative of many high-density terminal airspace encountered elsewhere in Europe, where the introduction of P-RNAV procedures offer the possibility of reducing fuel consumption and environmental impact as a result of the increased flexibility in airspace design, which allows strategic de-confliction of routes that enable better climb and descent profiles.

The solution is already implementedin several airports, including Madrid. The solution is to be deployed in accordance with the Pilot Common Project.

P-RNAV procedures can deliver reductions in fuel burn and emissions as they allow increased possibilities for strategic route de-confliction, which enable smooth, low fuel consumption continuous descent and climb operations

This solution is linked to the ICAO PBN Manual (Doc 9613), EUROCAE ILS standards and ICAO's PANS OPS (8168), as well as various avionics sensor standards

DESIGNING MORE EFFICIENT AIRSPACE

Optimised route network using advanced required navigation performance (RNP)

SJU references:
#10/Release 5

New possibilities in advanced airspace design solutions and options are now possible thanks to the precision in airborne navigation using the improved navigation performance provided by required navigation performance (RNP) on board modern aircraft. This solution supports connectivity between free route airspace and TMAs thanks to advanced RNP below flight level 310.

Aircraft with RNP specifications are equipped with on-board performance monitoring and alerting to continually check conformance. Aircraft flying advanced A-RNP procedures can be relied on to stay within one mile on either side of the nominal flight path whether flying a straight leg or a turn. In practical terms, this means that controllers can have greater confidence in the track-keeping performance of the aircraft and this greater confidence translates into being able to place routes closer together. Nominal RNP1 routes can be designed as close as seven nautical miles (NM) in en-route sectors and as close as five NM in terminal airspace. Advanced RNP (A-RNP) routes support precise flight profiles such as spaced parallel routes, fixed radius transition (FRT) and tactical parallel offset (TPO).

One of the main benefits provided by A-RNP is the potential to increase the overall efficiency of the air traffic management system, as a result of the greater flexibility of airspace design. This allows, for example, being able to place flight paths, arrival and departure routes, in the most convenient place. The predictable turn performance inherent in A-RNP in en-route and terminal airspace also makes it possible - due to enhanced track keeping in the turn - to place routes where they cannot necessarily be placed today using less advanced navigation capabilities.

The solution is available for industrialisation.

A-RNP with on-board performance monitoring results in more predictable aircraft behaviour

This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)

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BENEFITS

- **Enhanced safety**
- **Improved operational efficiency by reducing fuel burn and emissions**
- **Improved air navigation service provision**

SJU references:
#09/Release 5

FLEXIBLE ARRIVALS AND DEPARTURES

Enhanced terminal operations with RNP transition to ILS/GLS

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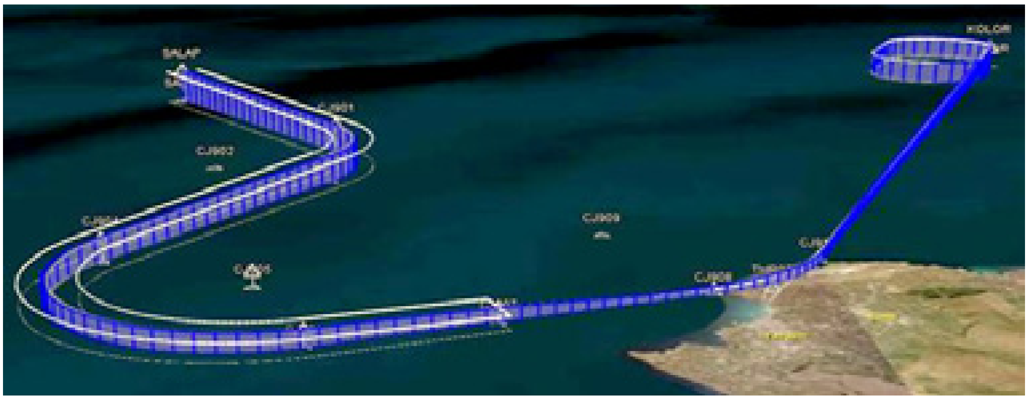


The focus on efficient, green operations at European airports has led to the development of more flexible arrival and departure routes which take advantage of the satellite-based navigation capability on board modern aircraft. This solution refers to the use of curved procedures enabled by advanced required navigation performance (RNP) with a transition to ILS/GLS. This allows aircraft to follow new approach paths, for example to avoid noise emissions over populated areas, reduce track miles, and add new flight paths, while also achieving ILS landing guidance to low-minima of 200 ft and below.

BENEFITS

- **Improved fuel efficiency**
- **Increased runway throughput (GBAS)**
- **Enhanced safety**

Modern flight management systems have the ability to fly a repeatable curved trajectory, known as radius-to-fix (RF), which some airports are adding to their arrival and departure procedures. SESAR has worked on the introduction of these turns by supporting the design of new procedures that connect the route structure to the final approach path. Final approach guidance may be provided by existing ILS, but for GBAS-equipped airports they may also be provided by new ground-based augmentation system (GBAS) landing systems (GLS), using constellations such as Galileo.

Flight trials were carried out to validate new arrival procedures based on the use of different glide path angles for two arriving aircraft aiming at different touchdown zones on the runway to reduce the risk of wake encounter. The exercise sets out to confirm the operational feasibility of the procedure, including its impact on the situational awareness of controllers and pilots.

This solution is available for industrialisation and is due to be implemented across Europe in accordance with the Pilot Common Project.

Advanced RNP procedures improve access to busy airports, help to maintain all-weather operations, and reduce environmental impact

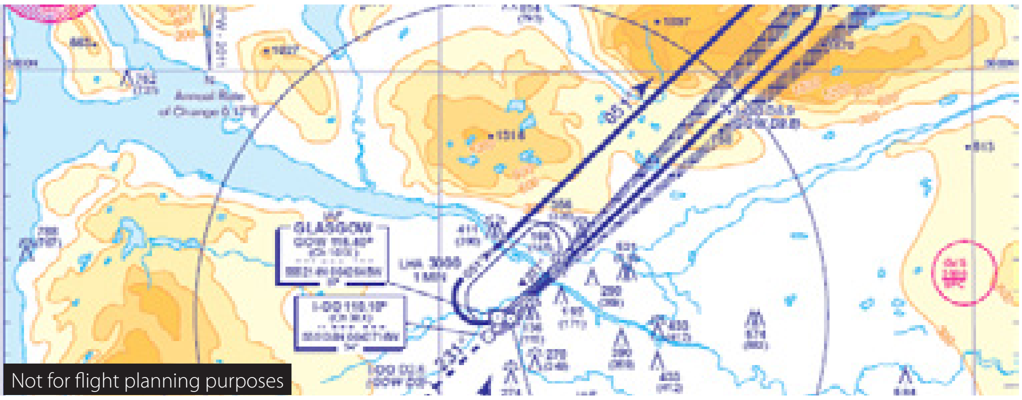
This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)

PCP

TRANSITIONING TO FINAL APPROACH

Enhanced terminal operations with RNP transition to LPV

SJU references:
#51/Release 4



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Satellite-based navigation systems, including Galileo, enable aircraft to follow precise flight paths independently of ground-based infrastructure. The technology supports additional approach paths without the need to add instrument landing systems (ILS), and can be used as part of a fall-back procedure in case of airborne or ground ILS equipment malfunction.

This SESAR solution defines required navigation performance (RNP) transitions to localiser performance with vertical guidance (LPV) to enhance terminal operations. SESAR supports wider use of advanced RNP to enhance terminal area operations. SESAR's advanced approach procedures with vertical guidance (APV) include the smooth transition from RNP arrival routes into RNP approach flight paths with barometric descent guidance that then transition to the LPV approach segment with geometric descent guidance. The transitions may include radius-to-fix (RF) turns that leave the aircraft aligned with the runway as close as three nautical miles (NM) before the threshold. From that point, the satellite-based guidance allows the pilot to descend safely down to a decision height of 200 ft which is equivalent to ILS Cat I minima. Advanced APV allows increased flexibility in planning arrival paths in terminal airspace, making it possible to design procedures that control the noise impact of the airport or reduce track miles to cut fuel consumption.

Several validation exercises focused on preparing ways to introduce A-RNP transition to LPV procedures by examining the impact on both the ground and air segments. The new transitions increased predictability for controllers and pilots, while reducing track miles, saving fuel and emissions.

This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)

This solution is available for industrialisation. Enhanced terminal operations with LPV procedures are planned for synchronised deployment across Europe in accordance with the Pilot Common Project.

BENEFITS

- **Increased flexibility in the design of TMA route layouts and landing procedures, which result in fuel savings and reduced noise impact on the communities neighbouring the airport**
- **Increased predictability**
- **Improved safety**

SJU references:
#103/Release 1

PREPARING TO LAND

Approach procedures with vertical guidance

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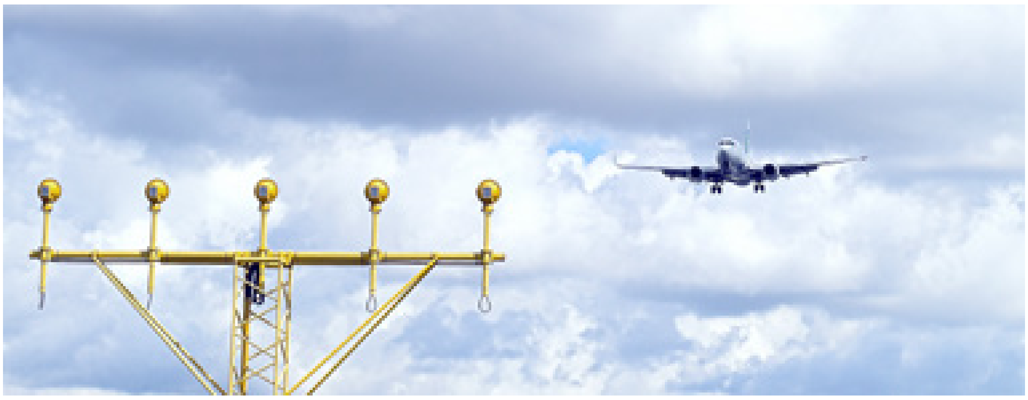


Satellite-based technology, supported by constellations such as Galileo, provides approach guidance without the need for ground-based navigational aids, increasing accessibility and safety at many airports. An aircraft can fly instrument approaches similar to a conventional instrument landing system (ILS) - down to a 200ft decision height. A localiser performance with vertical guidance (LPV) approach uses global navigation satellite system (GNSS) signals augmented by the European geostationary navigation overlay service (EGNOS), the three-satellite constellation that improves the precision of GNSS in the European area and was certified for safety of life (SoL) service in 2011.

LPV procedures do not require any new equipment at the airport which makes them an ideal low-cost alternative to increase access to secondary airports that may not be ILS-equipped on all runways. For ILS-equipped runways, the new approach design may be useful either to shorten the flightpath for certain traffic flows or simply to overlay the existing ILS and be used as a fall-back procedure in case of airborne or ground ILS equipment malfunction.

SESAR validation activities demonstrated that LPV approaches can be safely integrated into the operational environment. The exercises showed that the implementation of LPV procedures allowed aircraft coming from a downwind inbound route saved track miles compared to the traditional ILS approach. Moreover, in low traffic conditions controllers were able to safely integrate LPV aircraft flying short downwind approaches with ILS aircraft flying longer downwind approaches while allowing the LPV aircraft to execute the LPV descent profile. Using satellite-based technology also means avoiding costs associated with airport closure or flight diversions due to bad weather conditions. The exercises provided valuable lessons learnt for the design of LPV procedures, such as the importance of defining and using standard phraseology.

By the end of 2015, more than 250 LPV procedures had been published across Europe, and the number continues to rise sharply. The new procedures have enabled some states to decommission ILS services at some regional airports, saving costs.

The solution is available for industrialisation and is due for synchronised deployment in accordance with the Pilot Common Project.

ICAO supports integration of satellite-based navigation with vertical guidance into the airspace environment

Airport landing rate can be maintained with LPV procedures

This solution is linked to the ICAO PBN Manual (Doc 9613), EASA AMC 20-27 and ICAO's PANS OPS (8168)

BENEFITS

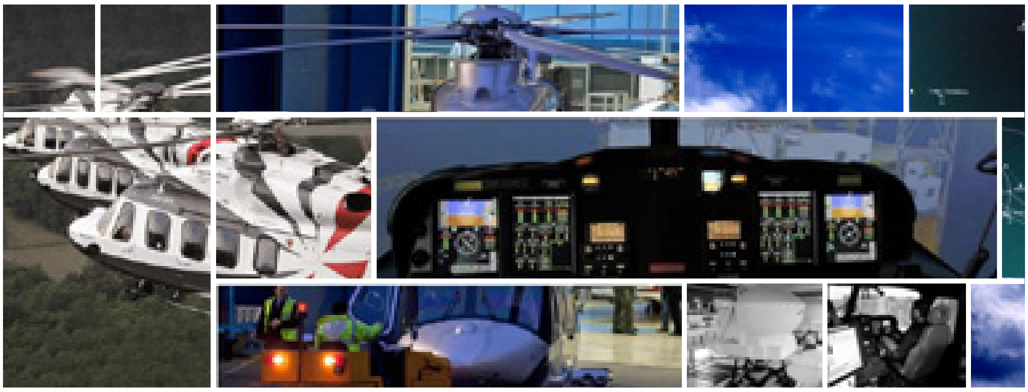
- **Improved access to airports in all weather conditions, without the need to install ground equipment**
- **Improved descent profile and reduced track miles, resulting in reduced fuel burn**
- **Reduced noise footprint**
- **Improved safety**

PCP

ENABLING ROTORCRAFT OPERATIONS IN BUSY AIRSPACE SURROUNDING AIRPORTS

Optimised low-level instrument flight rules (IFR) routes for rotorcraft

SJU references: #113/Release 5



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Due to their different operational characteristics to fixed-wing aircraft, especially their lower speed and vulnerability to bad weather, rotorcraft operations inside controlled airspace and terminal manoeuvring areas (TMA) are often limited to visual flight rules (VFR) flights in visual meteorological conditions (VMC). Flights under instrument flight rules (IFR) are often severely constrained or even prohibited altogether. The introduction of IFR procedures specifically designed for rotorcraft enables their safe integration into controlled airspace without adversely affecting existing fixed-wing operations.

This SESAR Solution enables the design of IFR routes at very low level, based on the ability of suitably-equipped rotorcraft to navigate very accurately using global navigation satellite systems (GNSS) using the European satellite-based augmentation system (SBAS): the European Geostationary Navigation Overlay Service (EGNOS). Routes are designed to an enhanced required navigation performance (RNP) standard that allows an optimised use of the airspace within medium and dense/complex TMAs. Routes are designed to either RNP 1 or RNP 0.3 depending on the altitude and degree of precision needed as a result of neighbouring procedures, airspace and/or terrain.

Provision of the IFR routes in controlled airspace procedurally separates rotorcraft and fixed-wing traffic. The integration of an optimised low-level IFR route network for rotorcraft can enhance flight safety and weather resilience of rotorcraft operations. Benefits for the environment may also be expected due to fewer VFR flights at very low altitude and avoidance of noise-sensitive areas thanks to narrow and/or curved low-level procedures.

These low-level IFR routes can be directly linked to dedicated point-in-space (PinS) arrival and departure procedures, where published, enabling simultaneous non-interfering (SNI) operations that are procedurally segregated from conventional fixed-wing operations.

Dedicated low-level IFR routes for rotorcraft not only improve safety, equity and accessibility in the airspace inside the TMA, but may also increase TMA capacity

This solution is linked to the ICAO PBN Manual (Doc 9613) and PANS OPS (8168), as well as various avionics sensor standards

BENEFITS

- **Increases access to TMAs for rotorcraft**
- **Increases safety and resilience of rotorcraft operations**
- **Reduced noise**

SJU references:
#08/Release 5

STREAMLINING TRAFFIC FLOW INTO MULTIPLE AIRPORTS

Arrival management into multiple airports

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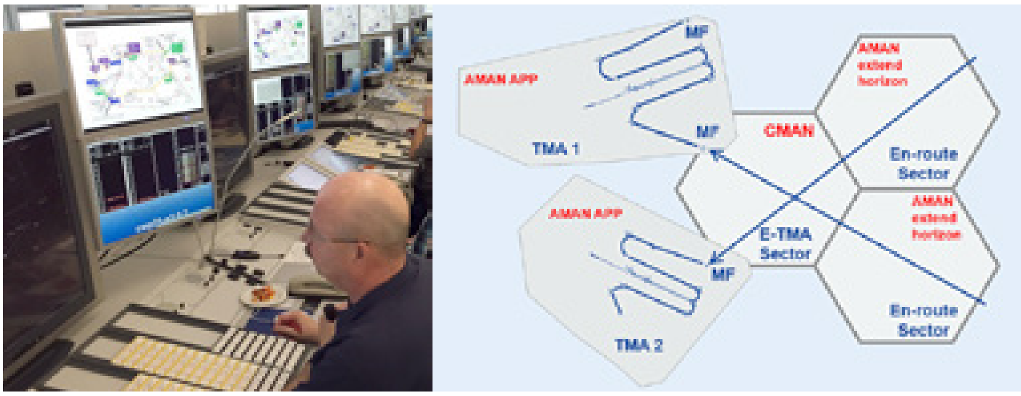


Some airports in Europe are located very close to one another, which means that they must share the surrounding airspace, or terminal manoeuvring area. However, in today's air traffic management, airports are considered as separate entities rather than integrated nodes in a wider network. As a result, aircraft cannot always access the most efficient routes in terminal airspace.

This SESAR solution coordinates traffic flows into multiple airports by means of a centre manager (CMAN). The solution operates in conjunction with the arrival management systems of the different airports to develop optimum arrival streams, based on balancing the demand and capacity. The CMAN uses airport data including predicted departure times and the extended arrival management horizon in order to calculate the most efficient arrival streams.

This solution looks at converging arrival streams, and spacing the aircraft to optimise traffic flow in order to reduce the need for tactical interventions by controllers. By imposing a time-to-lose (TTL) constraint, aircraft can be sequenced efficiently in the extended terminal area, reducing the need for subsequent radar-vectoring. The aim is to establish a new multi-airport arrivals concept that is expected to increase air navigation service efficiency, in particular the use of tactical voice communications, and deliver more fuel-efficient arrival streams.

The solution offers the most benefit in more complicated terminal airspace, where airports already use arrival management tools to smooth queues. A series of real-time simulations looked at converging arrival streams, spacing aircraft to optimise traffic flow in order to reduce the need for tactical interventions by controllers. The validation exercises also assess training and staffing requirements.

The SESAR Solution is available for industrialisation.

BENEFITS

- **Enhanced predictability**
- **Improved fuel efficiency**
- **Better use of available capacity**
- **Enhanced safety**

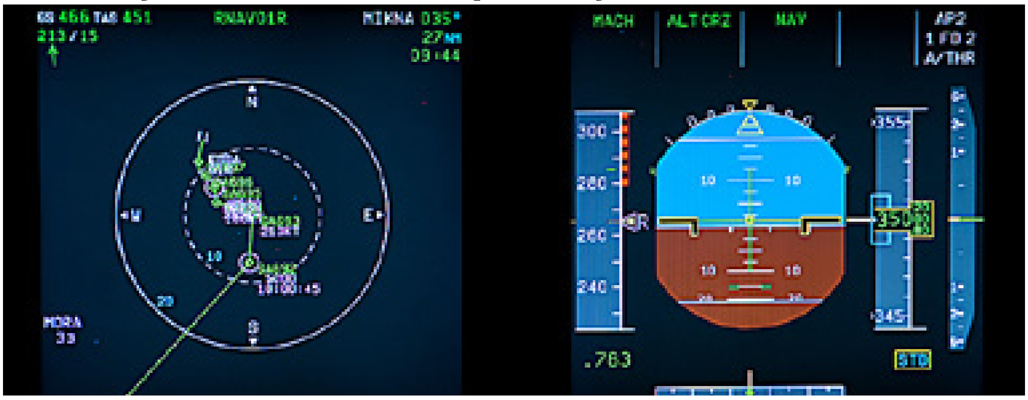
More predictable arrival streams reduce the need for tactical interventions by controllers

CMAN helps to adjust capacity to match predicted demand in a complex terminal environment serving multiple airports

AIRBORNE SELF MANAGEMENT FOR MORE PRECISELY TIMED ARRIVALS

Controlled time of arrival (CTA) in medium-density/medium-complexity environments

SJU references: #06/Release 5



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Building an arrival sequence in medium- and high-density environments calls on controller resources from an early phase in the approach procedure. The process is predominantly ground-based and can result in late vectoring and unnecessary holding rather than fuel-efficient strategies based on en-route speed management for efficient delay absorption. By combining time management capabilities on board aircraft with ground-based system support, the arrival management process can be more predictable and deliver more efficient operations.

Controlled time of arrival (CTA) is a time constraint defined by air traffic control that allows an aircraft to self-manage its speed in order to arrive at a specific time at a defined point associated with an arrival runway. The controller calculates the CTA as part of the arrival management process and relays this information to aircraft equipped with this advanced navigation capability. While arrival management systems are not able to evaluate the most fuel-efficient strategy for each individual aircraft, each aircraft's flight management system will optimise the flight speed according to aircraft type and wind conditions.

SESAR validated how CTA operations can be applied in medium-density and complex terminal airspace. Many aircraft are already equipped with flight management systems that support flying to a time constraint through the use of the required time of arrival (RTA) airborne function.

This SESAR Solution is available for industrialisation.

More inclusive use of airborne technologies provides better investment return for airspace users on equipment that many have already installed in their aircraft

This solution is linked to EUROCAE standards ED-228A, ED-229A and ED-75D

BENEFITS

- **Improved fuel efficiency per CTA flight**
- **Enhanced predictability**
- **Improved flight crew situational awareness**

SJU references:
#104/Release 1

SUPPORTING TEAM WORK

Sector team operations - en-route air traffic organiser

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The sustained traffic growth in the 1980s prompted the launch of the en-route air traffic organiser concept, to design electronic decision-making tools to help controllers. It recognised that there was a need to optimise service provision by assisting with detecting and monitoring tasks, freeing up mental resources to focus on resolving conflicts between flights.

In this framework, the SESAR solution is a medium-term conflict detection (MTCD) tool that allows controllers to filter aircraft and extrapolate their future positions. The tool is based on providing assistance to controllers particularly when faced with stress, fatigue or other disturbing agents. The solution does a number of things to help the controller. It shades out – according to pre-determined criteria – flights which are not relevant to a particular situation. It provides visuals aids to help the controller schedule tasks. It also extrapolates the predicted trajectory of specific flights to aid the controller to identify potential conflicts well in advance. In addition, it provides geographical markers to provide the controller with task reminders at specific locations.

The solution allows controllers to perform control tasks more effectively using the support tools and working methods. The solution can bring benefits to any busy en-route environment.

This solution is ready for industrialisation.

The SESAR tool improves information and task sharing, and enhances cooperation between planner and executive controllers

SESAR validation results demonstrated a real potential for increasing the effectiveness of controllers in performing their tasks

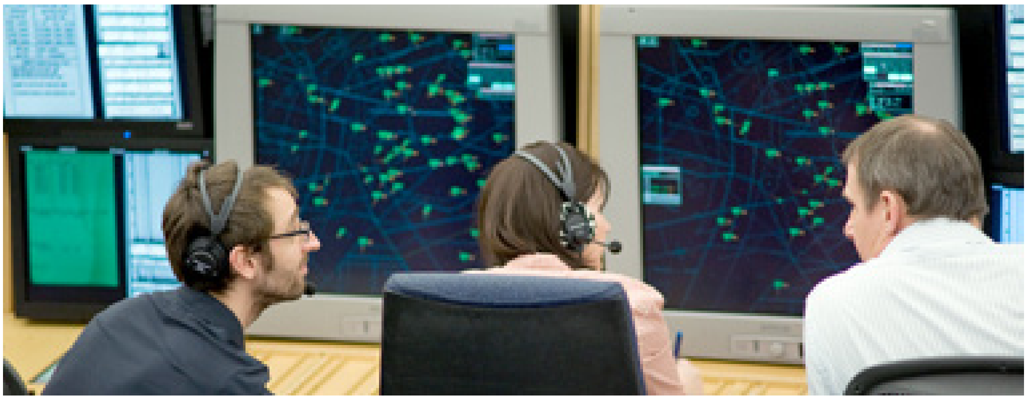
BENEFITS

- **Effective management of team operations**
- **Improved monitoring of traffic as well as information and task sharing**
- **Increased en-route airspace capacity**

USING CONTROLLER RESOURCES EFFECTIVELY

Multi-sector planning

SJU references: #63/Release 2



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Advanced controller tools present an opportunity to look at managing the resources of the air traffic control workforce in new ways, especially when it comes to planning and pre-tactical tasks. With access to electronic flight data, decision-making tools such as what-if or look-see functions, the role of the planning controller has become more flexible. SESAR's multi-sector planning solution reconsiders the usual air traffic control team – composed of a planner for each tactical controller – and proposes a structure whereby a planner can support two tactical controllers, each responsible for a different sector.

The new operating procedures are a direct result of enhancements to the planning tools, such as the aforementioned solution, which improve the efficiency of the planning and decision-making process. They are not expected to be applicable to all sectors at all traffic levels, but a number of sectors can be combined in this way and operate efficiently at reasonably high traffic levels.

A further phase of solution development is extending the new team structure beyond one planner supporting two tactical controllers, to several tactical controllers under the responsibility of a single planner controller. This evolution will require developing the way in which boundaries are defined between planning and tactical control.

The solution is available for industrialisation.

Multi-sector planning improves efficiency and flexibility in manning air traffic control sectors while sectors are only split when required by the level of traffic

While the solution is not expected to be applicable to all sectors at all traffic levels, the SESAR validation exercises showed that a number of sectors can be combined in this way and operate efficiently at reasonably high traffic levels

BENEFITS

- **Improved task sharing**
- **Better distribution of human resources**
- **Improved cost efficiency due to flexibility in sourcing and deployment of human resources**

SJU references:
#27/Release 5

KEEPING AHEAD OF TRAFFIC WITH ADVANCED CONTROLLER TOOLS

Enhanced tactical conflict detection & resolution (CD&R) services and conformance monitoring tools for en-route

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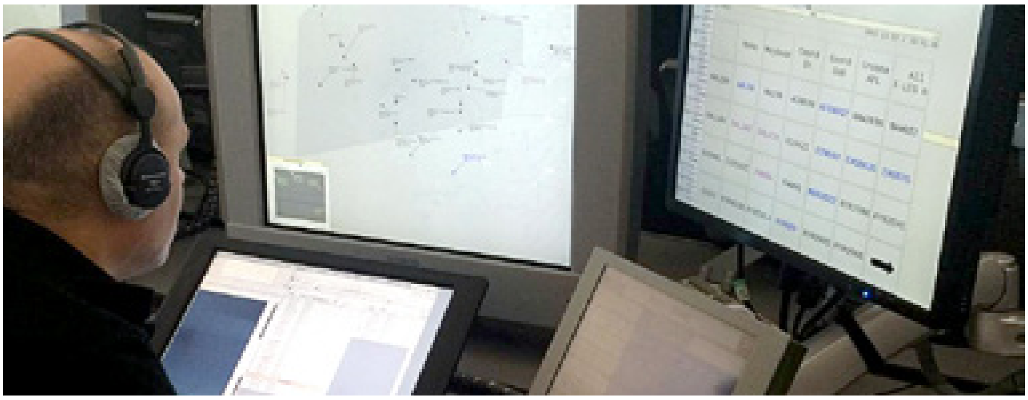


BENEFITS

- **Improved safety**
- **Optimised air navigation service provision**
- **Improved capacity**
- **Increased cost efficiency**

Providing controllers with improved coordination tools is key to meeting Single European Sky performance targets, which aim to triple airspace capacity. SESAR is supporting development of functions to aid capacity and safety.

Reliable and accurate conflict detection and resolution services lead to better decision making and fewer tactical interventions by controllers. This SESAR Solution consists of innovative approaches that provide the en-route controller with two separation provision services:

First, an enhanced monitoring conformance service (MONA) for both tactical and planning controllers. Compared to the existing MONA, this SESAR Solution includes a new alert to take into account lateral deviation and the rate change monitoring in climbing and descending phase to minimize false alerts.

Second, a conflict detection and resolution service fully dedicated and designed for the tactical controller with a conflict detection service down to flight level 100. This service is based on effective clearances and specific ergonomics and use developed for the tactical controller, but also available and usable for the planning controller

New conflict detection tools allow controllers to assess possible conflicts much sooner

This solution is linked to Eurocontrol specifications (STD 61, STD 62)

Where existing tactical controller tools (FASTI baseline) do not fully match with the tactical controller's needs and do not cover all adherence deviations and present false alarms, this SESAR Solution can optimise air navigation service productivity, increases the benefits of such services, and increase the confidence of the en-route controllers in such coordination tools.

This Solution was validated through a series of exercises including several real-time simulations assessing the operational acceptability of automated tools in specific environments such as a free route environment.

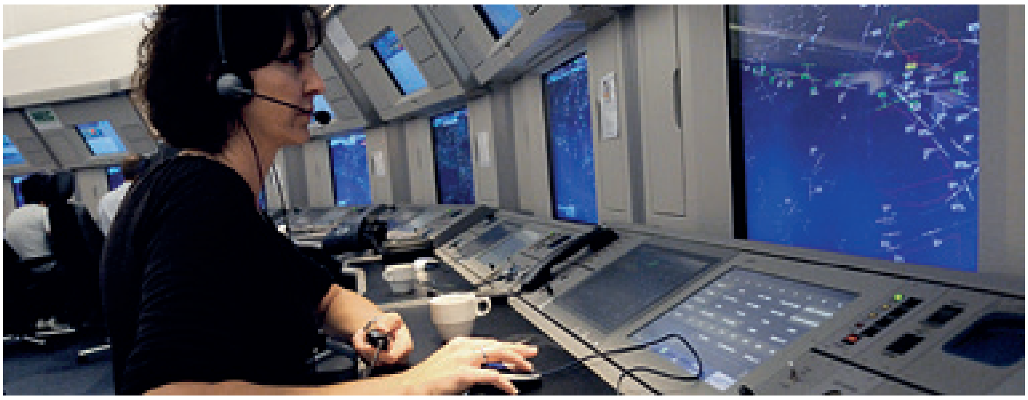
Ultimately, the SESAR work focused on the distribution of tasks between planner and tactical controllers, and how the tools are integrated into the decision-making process.

This SESAR solution is available for industrialisation.

ALLOWING USERS TO CHOOSE THEIR ROUTE

User-preferred routing

SJU references: #65/Release 2



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Many aircraft currently follow fixed routes which are not always the most efficient in terms of time and fuel consumption. There are tactical refinements at an operational level, but SESAR is introducing far more radical change at a design level which ultimately aims to introduce free route airspace across Europe. This enables the operator's flight planning system to calculate the most efficient route taking into consideration wind speed and direction, turbulence, temperature, aircraft type and performance.

This solution is seen as an early iteration of the free route concept due to the potential for this option to mimic established direct route requests from operational airspace users. However, this solution does not take into account cross-border direct routing.

User-preferred routing validation is the result of a number of simulations and flight trials which thoroughly tested the procedures at night, on weekends and weekdays. The validation activities involved air traffic controllers, planners, and supervisors as well as aeronautical information services personnel. Several airlines also participated in the validation activities, learning how to operate the concept correctly, and how the routes are integrated into the wider network.

The results served to identify a list of direct routes within one air traffic service unit that could be implemented. They also showed the maturity of the solution which represents the first step towards the more advanced concept of free route operations. The Maastricht Upper Area Control centre now offers more than 250 user-preferred routes and has recorded an average 7 % reduction in flight distance flown – or two minutes less flight time - by participating aircraft, while lower fuel consumption has seen emissions fall between 6 and 12 %.

The solution is available for industrialisation and is being deployed in accordance withe the Pilot Common Project.

User-preferred routing takes Europe a step closer to the concept of European free route airspace concept

This solution is linked to Eurocontrol specifications (STD 61/STD 62/STD 63/STD 64)

BENEFITS

- **Improved flight efficiency within one air traffic service unit**
- **Reduced average flown distance and reduced flight time**
- **Maintained air navigation service provision, despite capacity increase**
- **Reduced fuel burn and emissions**
- **Maintained levels of safety**

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SJU references:
#32/Release 5

MORE DIRECT ROUTES FOR CROSS-BORDER OPERATIONS

Free route through the use of direct routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and in high complexity environments

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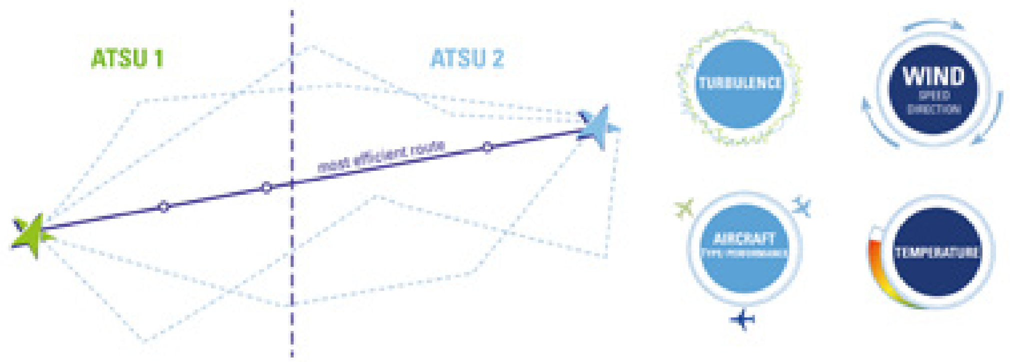

BENEFITS

- **Increased airspace capacity**
- **Improved operational efficiency**
- **Reduced fuel burn and emissions**

Under the current network structure, aircraft fly an average of 20 km further than the most direct route between two points. This SESAR Solution represents a step forward with respect to the user-preferred routing solution. It offers more direct flight planning route options on a large scale, crossing flight information regions and national borders.

Direct routing allows airspace users the possibility to plan a route close to their preferred flight path by selecting a direct route - connecting published waypoints - without the need for the intermediate points to be present in the current fixed-route network.

The extension of direct routes across flight information regions and national boundaries require appropriate airspace changes, as well as new flight data processing systems from airspace users. Advanced flexible use of airspace at the regional scale supports the use of direct routing operations.

Published direct routes are established within local and regional documentation and then made available for flight planning. SESAR continues to support validation activities to assess the operational acceptability of cross-border direct routing operations.

Planned flight distances are reduced in comparison with the fixed route network and follow an optimised flight path

Direct routing is particularly relevant for cross-border operations in high and very high complexity environments

The SESAR Solution is available for industrialisation and is being implemented across the whole of Europe's upper airspace in accordance with the Pilot Common Project.

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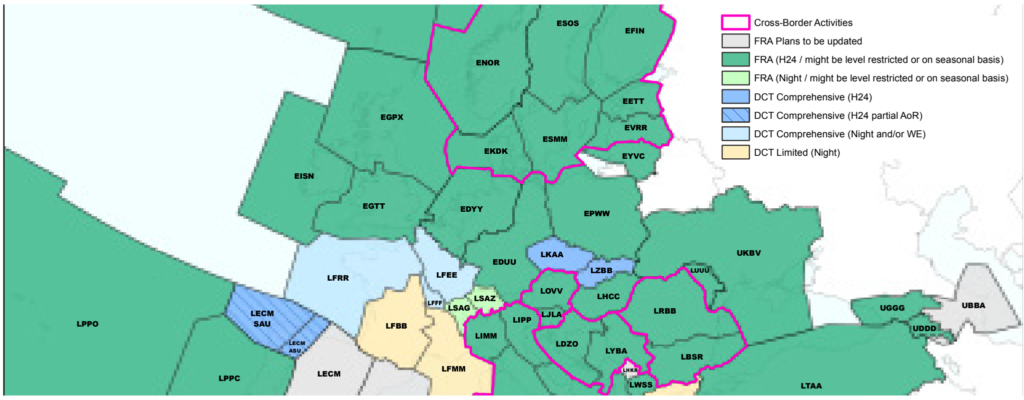
EUROPE-WIDE FREE ROUTING

SJU references: #33/Release 5

Free route through the use of free routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and within permanently low to medium complexity environments



Free routing corresponds to the ability of the airspace user to plan and re-plan a route according to the user-defined segments within free route airspace (FRA), where advanced flexible use of airspace (AFUA) principles provide the necessary airspace flexibility. This solution allows airspace users to plan flight trajectories without reference to a fixed route network or published direct routes within low- to medium-complexity environments.

The solution allows airspace users to plan trajectories, without reference to a fixed route or published direct route network. In doing so, it provides them with significant opportunities to optimise their respective flights in line with individual operator business needs and military requirements.

The validation activities for this solution included real-time simulations to assess the operational acceptability of free routing. The exercises compared service provision when dealing with free routing and direct routing traffic to assess what is required and acceptable and the likely benefits. The work also looked at airspace complexity and considered operational issues related to military airspace zones in a free routing environment.

The SESAR Solution is available for industrialisation.

Flights benefit from optimised flight paths when planning flights using free routes, but remain subject to air traffic control during execution

SESAR exercises are reviewing a range of different flight levels for the introduction of free route airspace implementation

This solution is linked to Eurocontrol specifications (STD 61/STD 62/ STD63/STD64)

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BENEFITS

- **Increased airspace capacity**
- **Improved operational efficiency**
- **Reduced fuel burn and emissions**

SJU references: #60/Release 1

IMPROVING CONFLICT ALERT FOR CONTROLLERS

Enhanced short-term conflict alert (STCA) for terminal manoeuvring areas (TMAs)

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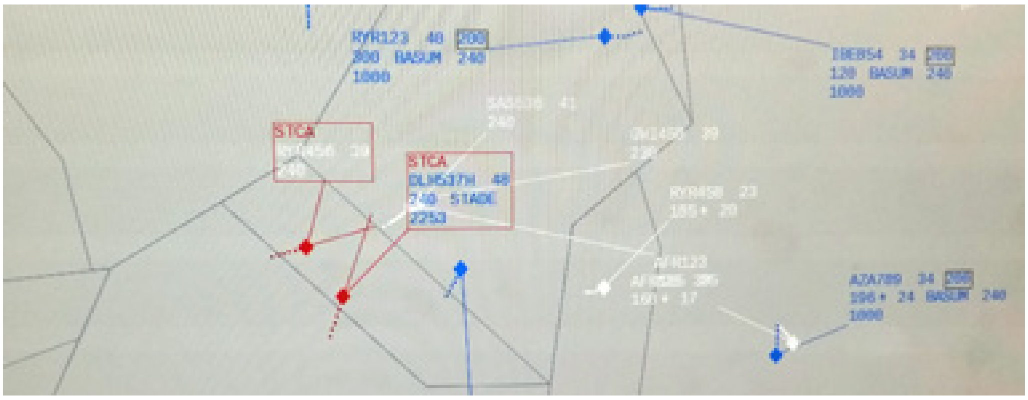

Ground-based safety nets are an integral part of the ATM system. Using primarily ATS surveillance data, they provide warning times of up to two minutes. Upon receiving an alert, air traffic controllers are expected to immediately assess the situation and take appropriate action. A valuable safety net is the automated short-term conflict alert (STCA), a sophisticated algorithm which uses the track data to warn against possible short-term conflicts.

STCAs are challenging to develop since they must minimise false alerts, while at the same time making sure that real conflicts trigger an appropriate and timely warning. Specific tuning is necessary for STCA to be effective especially in the terminal airspace in order to account for lower separation minima, as well as increased frequency of turns, climbs and descents.

Validation exercises looked at enhanced STCA solutions to reduce the number of false and nuisance alerts compared to existing technologies, while maintaining the detection of genuine alerts. This is beneficial for flight safety, as it helps controllers focus on issues such as conflict risks or resolution advisories. The enhanced algorithms developed for the STCA prototype led to more precise warnings and fewer false and nuisance alerts when compared against existing STCA technology.

Tests using real traffic data demonstrated the operational and system feasibility of the prototype for the identification of conflicts between flights. For instance: the false alert rate of the new system was 15 % lower than the existing system. The likelihood of controllers receiving unnecessary resolution advisories during a level-off encounter between two trajectories was shown to be reduced by a factor of between 30 and 70 with the introduction of additional functionalities.

The solution is available for industrialisation.

Human factors and local circumstances have a significant influence on determining what constitutes an operationally relevant conflict which must be alerted by STCA and what is an effective minimum level of nuisance/ false alarms

BENEFITS

- **Identification of conflicts, both en-route and in the terminal area**
- **Reduced false alert rate while maintained genuine alert rate and warning times are maintained**
- **Significant increase in safety of flight especially during complex operations**

BETTER CONFLICT DETECTION TOOLS

Enhanced short-term conflict alerts (STCA) with downlinked parameters

SJU references: #69/Release 3

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Short-term conflict alerts (STCA) provide controllers with a short-term warning of potential conflicts between aircraft in the same airspace. Enhancing the STCA safety net with information down-linked from the aircraft provides more accurate data on which to base warning signals.

Aircraft already transmit enhanced surveillance data using Mode S. In this SESAR solution, two Mode-S derived parameters were incorporated into the STCA logic: selected flight level and track angle rate. The former prompts the system to check if the aircraft intends to climb or descend to a certain flight level even before it begins the manoeuvre. This can detect an unsafe clearance given in error by the controller, or controller-pilot misunderstandings in radio transmissions, such as read back errors or instructions copied by a different aircraft. The latter - track angle rate – gives a better anticipation of how an aircraft will turn, and applies particularly in terminal airspace.

STCA with downlinked parameters was tested for both en-route and terminal airspace environments. The validation results confirmed the benefits in terms of reduction of nuisance alerts, while relevant alert rate was maintained or increased. Thus, controllers' trust in the STCA system increased. There was also evidence of improvements in alert warning time within the en-route environment as well as terminal airspace, chiefly due to the anticipation of the vertical evolution based on the downlink of the selected altitude.

The solution is available for industrialisation.

Controllers reported significant higher trust values with the support of downlinked parameters compared to the current version of short-term conflict alerts

Downlinked information confirming aircraft-selected flight level was the most relevant contribution to improved short-term conflict alerts

BENEFITS

- **Enhanced safety through reduced false alert rates and improved warning times of conflicts between flights**
- **Improved operational efficiency**
- **Increase of controller's situational awareness**

SJU references:
#105/Release 1

AUTOMATED AIRCRAFT COLLISION ALERTS

Enhanced airborne collision avoidance system (ACAS) operations using the autoflight system

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Existing airborne collision avoidance systems (ACAS) triggers resolution advisories when a collision risk is predicted. Unnecessary alerts can be caused by aircraft correctly climbing or descending to a cleared flight level close to the level occupied by another aircraft. This can reduce the system's safety benefits and make air traffic control operations more complex. ICAO has recommended new altitude capture laws that automatically reduce the vertical rate at the approach to the selected flight level, reducing unnecessary resolution advisories.

SESAR partners conducted validation exercises that replicated the environment in which ACAS is being operated, and used different configurations to test the application of the new altitude capture rule compared with existing operations. The scenarios included testing aircraft in close encounters, where there is an actual risk of mid-air collision, and an in day-to-day encounters, in which the aircraft are not necessarily on a close-encounter course but where trajectories may trigger a conflict alert. The tests looked at safety, pilot acceptance, compatibility with air traffic control, and trajectory modification, to see if the new law improved the current situation.

The validation showed the new altitude capture law is very effective in reducing the number of resolution advisories triggered in 1,000 ft level-off encounters. The likelihood of receiving a resolution advisory was reduced by a factor of 30, and even 70 in one particular configuration. SESAR recommends implementing the altitude capture rule to reduce unnecessary ACAS alerts. It also recommends modifying the collision avoidance system to improve protection against multiple alerts.

The solution can bring significant operational benefits. By automatically reducing the vertical rate at the approach to the selected flight level, unnecessary alerts are reduced, increasing faith in the system, while reducing distraction on the flight deck. Compatibility with air traffic control operations has also been positively assessed.

The solution is available for industrialisation.

The solution triggers a safe automated response by the aircraft itself, instead of the current manual response performed by pilots

The new altitude capture laws aim to reduce unnecessary alarms generated by airborne collision avoidance systems

This solution is linked to EUROCAE ED-224 (MASPS for Automatic Flight Guidance and Control System coupled to TCAS)

BENEFITS

- **Safety levels are maintained**
- **ACAS operations are less disturbing for air traffic management and pilots**
- **Increased air navigation service provision**
- **Resolution advisories are more consistent**
- **Shorter response time for resolution advisories in general**

Optimised ATM network services

SJU references:
#20/Release 5

SHARING INFORMATION IN REAL TIME

Initial collaborative network operations plan (NOP)

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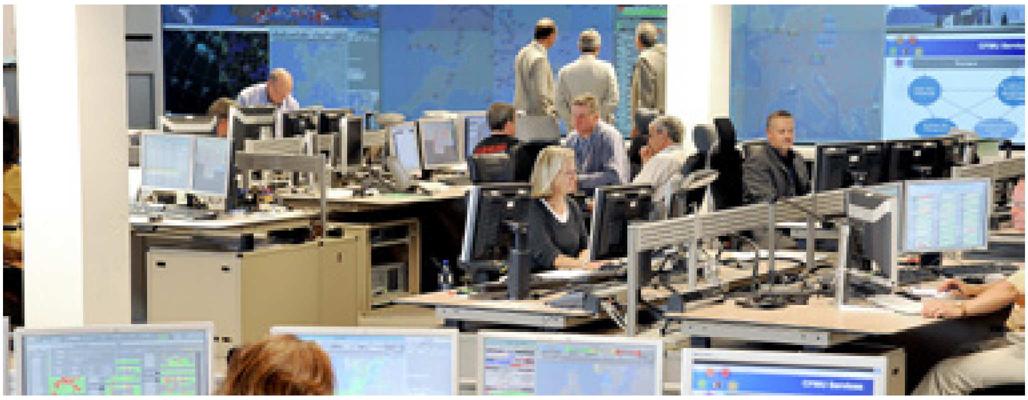
STAKEHOLDERS



The network operations plan (NOP) is a single window showing information in real time about the air traffic situation across the whole of Europe. Through the NOP, air navigation service providers, airlines, ground handlers, meteorological experts and airports can view the current situation and can coordinate their activities. Importantly, it connects the airports with the rest of the system by including capacity and operational data and shows where any likely pinch points might occur.

BENEFITS

- **Increased ATC network capacity**
- **Enhanced predictability**
- **Improved planning allowing for optimised routes**
- **Enhanced safety**

The SESAR Solution extends the collaborative NOP information structure to enable more data exchanges between the Network Manager and other partners in order to deliver greater operational efficiency. Additional automation tools support the process, and assist decision making and performance monitoring. The concept also uses system-wide information management (SWIM) to allow shared operational real-time decision making. The SESAR solution addressed three main aspects: the airport operations plan (AOP)-NOP integration, the meteorological status monitoring and the network performance monitoring.

The solution enables the Network Manager and stakeholders to prepare and share information in real time and supports collaborative decision-making processes.

Live trials in different locations looked at the feasibility and benefits of expanding the collaborative aspects of NOP, and the integration AOP-NOP, specifically by assessing the safety and technical feasibility of automatically updating controller displays when airspace users activate temporary airspace reservations in military airspace. The exercises aimed to identify the interoperability requirements between air traffic control, airspace users and the Network Manager.

Data exchanges between the Network Manager, airports, airspace users and air traffic control carried out in real time contribute to greater operational efficiency

Meanwhile, a series of shadow-mode exercises evaluated the use of the information sharing environment for assessing the impact of advanced short-term air traffic flow capacity management (ATFCM) measures (STAMs) on network performance. The exercises are also validated the integration of weather information into the network - including meteorological forecasts - to improve tactical demand capacity balancing measures.

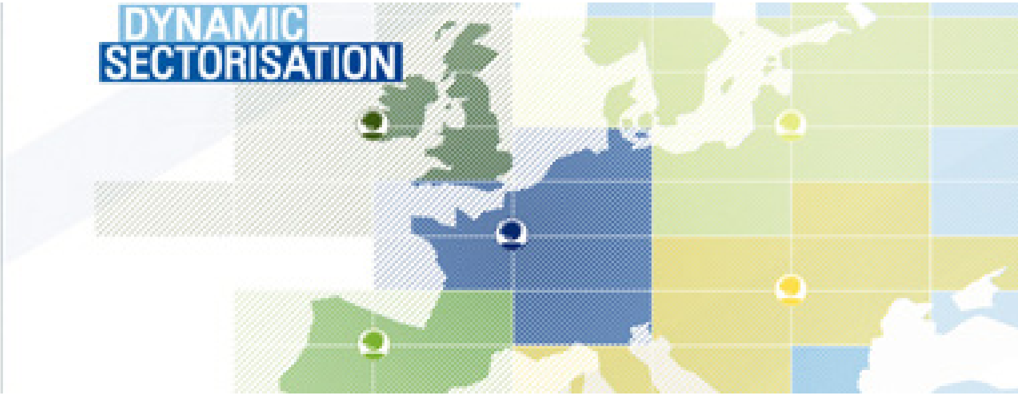
PCP

The SESAR Solution is available for industrialisation. The solution will be deployed across Europe in accordance with the Pilot Common Project.

MORE EFFICIENT AIRSPACE MANAGEMENT

Automated support for dynamic sectorisation

SJU references:
#66/Release 2



Spare airspace capacity can become available even at peak traffic times, but there are few tools available today to take advantage of this. Air traffic management systems can detect high traffic density, but do not – as yet – find alternative solutions to ease congestion. By adapting airspace configurations, this latent capacity can be used to help meet demand at peak times.

This SESAR automated solution considers the traffic needs, and groups or ungroups airspace sectors to match capacity with evolving demand. The support tool is used by the supervisor to determine sector planning on the day of operations and to manage staff resources accordingly. The result is better use of airspace and human resources, improved safety due to early management of constraints, and fewer delays.

During the validation activities, the automated support for dynamic sectorisation tool was used by the supervisor and flow manager to evaluate the most suitable en-route sector configuration and related staffing needs. The tool takes into account several information sources. These include demand data, including actual flight data as well as planned data; local constraints such as staff availability; and unplanned events such as bad weather or changes as a result of actions at other airports.

The validation of dynamic sectorisation showed that traffic capacity increased by 10 % during peak periods, while the number of delayed flights fell by 5 %. In addition, because the tools provided advanced warning, the air traffic management system was better prepared to manage these situations safely. The improved situational awareness avoided demand and capacity imbalances and enabled controllers to handle more flights per sector even during busy periods.

This solution is ready for industrialisation and is due to be deployed across Europe in accordance with the Pilot Common Project.

Shadow-mode trials using the tool for automated support for dynamic sectorisation resulted in better use of available airspace and staff resources

The concept provides support for decision making based on sector configuration in order to optimise use of the controller work force

STAKEHOLDERS

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BENEFITS

- **Improved safety due to increased situational awareness of supervisors**
- **Increased capacity due to better use of available resources, both human and airspace**
- **Reduced saturation periods and flight delays**
- **Increased cost efficiency**

PCP

SJU references:
#31/Release 5

ADVANCED FLEXIBLE USE OF AIRSPACE

Variable profile military reserved areas and enhanced civil-military collaboration

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Traditional airspace classification of certain areas for either 'civil' or 'military' use has been superseded by the concept of flexible airspace use which allows the airspace to be allocated according to user requirements. The concept is achieved through enhanced civil/military coordination and plays a major role in delivering additional airspace capacity. However, its application is still largely confined to national airspace use rather than cross-border implementation, a situation that SESAR is working hard to change.

This solution offers greater flexibility by allowing dynamic airspace management in all phases of ATM operations, from initial planning through to the execution phase, taking into account local traffic characteristics. The solution includes support tools, operational procedures and processes for real-time airspace status data exchange and for managing variable profile areas (VPA). Planning operations can be enhanced by sharing airspace information in real time and supporting the collaborative decision-making process between the Network Manager, civil and military authorities, and airspace users. The aim is to achieve greater dynamic airspace management, accommodating local and network needs.

Live trials demonstrated the feasibility of automatically updating airspace status into the Network Manager system, and assessing the optimum technology solution that can put into an operational environment. The activities helped to refine the interoperability requirements so there is better exchange of data between the different parties. A series of shadow-mode trials validated the benefits of sharing and using aeronautical information for mission-planning purposes.

Flexible use of airspace allows users to have access on the basis of actual need

SESAR has validated the advanced flexible use of airspace in terms of connectivity using basic procedures and systems with limited functionality. SESAR's work is now concentrating on refining those procedures and further developing the functionality of the systems space.

The solution is now available for industrialisation and is being deployed across Europe in accordance with the Pilot Common Project.

BENEFITS

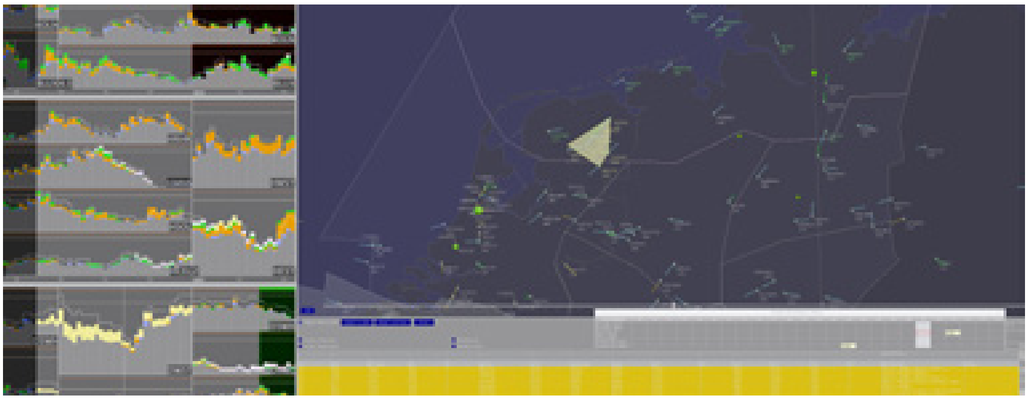
- **Increased airspace capacity**
- **Optimised trajectories, thereby reducing track miles**
- **Improved safety**

PCP

BETTER TOOLS FOR COMPLEXITY RESOLUTION

Automated support for traffic complexity detection and resolution

SJU references: #19/Release 5



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Air traffic control uses flight plan data filed by airlines - indicating the routes they intend to fly - to safely and efficiently manage the airspace. Reality, however, can vary from planned operations, as aircraft encounter unexpected delays, weather disruption or can be re-routed to avoid bottlenecks. Providing local flow management positions (FMP) with more accurate information about traffic flow, as well as tools to predict complexity and traffic peaks, offers a more efficient way to reduce airspace complexity.

SESAR is replacing today's non-integrated tools with advanced software that can assess traffic demand and complexity based on continuously updated information from multiple sources. By applying predefined complexity metrics, FMPs at local level can take timely action to adjust capacity in collaboration with the Network Manager and airspace users. The result is more predictable traffic flow, fewer delays and enhanced safety.

The complexity assessment and resolution (CAR) tool operates in short-term and medium-term time horizons to balance workload across different sectors to maximise throughput without overloading or leaving airspace capacity unused. CAR is supported by automated tools which take into account the availability of airspace (due to weather, reservation, etc), sector capacity, operator preferences and overall network operations. Resolution of complexity problems requires the combination of automated detection tools and flexible deployment of human resources to ensure high levels of efficiency are sustained. It supports FMPs and supervisors in better tactical decision making, and delivers more predictable traffic flow.

Dynamic management of airspace structure helps to de-conflict traffic ahead of time, and optimises the use of controller resources

This solution enables flight management positions and supervisors to identify, assess and resolve local complexity situations, thereby reducing traffic peaks

Real-time simulations tested the automation tools in the en-route environment, and the extended arrival manager time horizon. Further real-time simulations assessed the concept of complexity measurement in a free route environment. The aim is to simplify the air traffic situation and enable controllers to optimise throughput with very little intervention.

This solution is available for industrialisation and is being deployed across Europe in accordance with the Pilot Common Project.

BENEFITS

- **Increased ATC capacity**
- **Improved punctuality**
- **Increased cost efficiency**
- **Enhanced safety**
- **Reduced fuel and emissions**

SJU references
#17/Release 5

LESS WAITING AND FEWER DELAYS

Advanced short-term ATFCM measures (STAMs)

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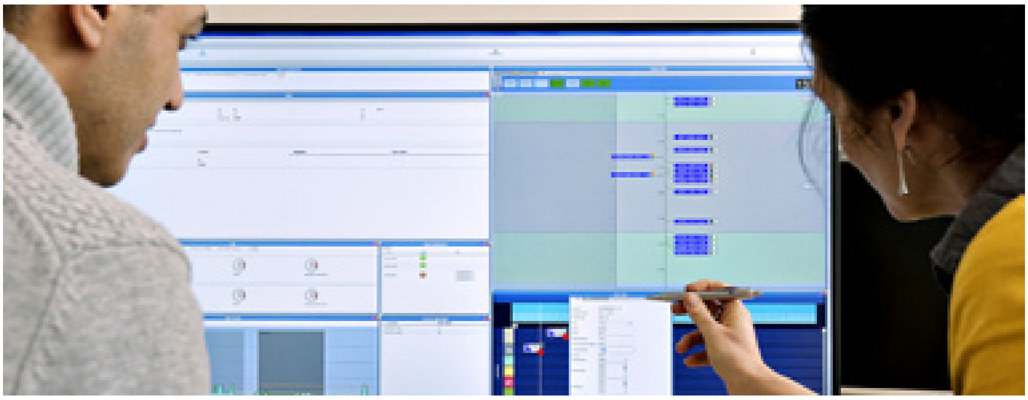

To avoid traffic overload, flights are typically held on the ground rather than added to congested flight paths. These precautionary measures can be imposed hours in advance and are based on flight plans. Short-term air traffic flow capacity management (ATFCM) measures (STAMs) have more flexibility to handle traffic overload since control measures are applied at a later stage and align more closely with actual demand. They also allow additional measures, such as temporarily constraining a flight or group of flights at a lower altitude, or imposing minimum re-routings, to prevent sector overload.

SESAR has developed advanced STAMs through sharing information between the Network Manager and area control centres which only impose a wider range of measures as and when necessary.

Through close cooperation between different actors, it is possible to target individual flights with a STAM measure, such as a minor ground delay, flight level cap, or minor re-routing, to take into account local preferred solutions, rather than apply a regulation to a group of flights as a whole.

Advanced STAMs include a set of automated support tools at the network level which detect hotspots and disseminate the information to flow management positions in the area control centres. The toolset also includes 'what-if' functionalities to evaluate what the effect of STAMs will be before effectively applying them. The information takes account of an expanded information set including weather, airport operations, runway occupancy and traffic complexity. The data is shared electronically with the possibility to use business-to-business (B2B) system-wide information management (SWIM) in the future.

STAMs not only improve visibility and predictability during operations, but also allow detailed post-operations analysis

SESAR's automated STAM tools allow a shared situational awareness of the STAMs applied across the network for flow management staff, and makes all STAM-related data available for detailed post-operational analysis.

This solution is available for industrialisation and is due to be deployed across Europe in accordance with the Pilot Common Project.

BENEFITS

- **Better use of airspace capacity in terminal and en-route airspace**
- **Increased cost efficiency**
- **Improved situational awareness of the European network**

PCP

MOVING TO TIME-BASED OPERATIONS

Calculated take-off time (CTOT) and target time of arrival (TTA)

SJU references: #18/Release 5

STAKEHOLDERS

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As the airspace network and the airports become more connected, opportunities open up to smooth traffic flow and prevent imbalances between demand and capacity. This SESAR solution allows more intelligent demand and capacity balancing when traffic demand for landing into an airport exceeds the airport capacity (hotspot), by allowing the arrival airport to participate in the decision-making process of how to resolve the situation.

The solution aims at complementing departure regulations, such as the calculated take-off time (CTOT), with the dissemination of locally-generated target times, over the hotspot. Each airport collaborates with terminal area control to develop its own strategy to allocate the available landing capacity. Strategies are likely to take into account airspace users' input, the consistency of flight plans with seasonally-allocated airport slots, arrival route and runway allocation, or gate and connection management. This collaborative process contributes to a more coherent approach to demand regulation, which is expected to result in a reduced number of knock-on delays thereby benefitting passengers and airlines, as well as the network.

Another aspect of this SESAR solution is based on a greater level of information sharing between the Network Manager and flight operators. Whenever a flight is issued with a regulated take-off time, the airline also receives from the Network Manager the corresponding target time to arrive at the capacity-constrained area that motivated the regulation of its departure time. While target times are hard constraints, it is expected that the shared awareness will increase the effectiveness of air traffic flow management regulations. During the flight, any deviations between the agreed targets and the actual flight may be used by the different partners (flight crew, aircraft operator, local traffic managers) to support adherence to the time of entry in the congested area(s) and/or to assess and monitor the effects of deviations.

This solution involves the timely exchange of relevant airport and network information, resulting in common situational awareness which leads to improved network and airport planning activities, as well as improving operational performance

Live trials validated its feasibility with input from all actors involved. The trials included communicating planned measures (such as take-off and arrival time) as well as tactical measures imposed to maintain planned performance. The trials are also testing the use of sharing the same network view of the situation.

This solution is available for industrialisation and is due to be deployed across Europe in accordance with the Pilot Common Project.

BENEFITS

- **Improved information sharing**
- **Enhanced predictability**
- **Improved situational awareness**
- **Increased capacity**

PCP

SJU references: #56/Release 4

WORKING IN PARTNERSHIP WITH AIRLINES

Enhanced air traffic flow management (ATFM) slot swapping

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Slot swapping is a means to reduce the impact of delays which may be caused by late inbound flights, weather conditions, airport congestion, among others. Slot exchanges within a single airline are agreed in a cooperative process with the Network Manager to smooth the traffic flow.

BENEFITS

- **Improved network performance (management and capacity)**
- **Improved environmental performance**

The SESAR solution enhances slot swapping functionalities by making it possible to swap pre-allocated slots with allocated slots or carry out multiple swaps for a single flight. These functionalities allow airlines to swap between long-haul and short-haul flights, or split the delay assigned to one flight between a maximum of three flights.

In current operations, when a flight is cancelled the Network Manager assigns its slot to another flight, usually operated by a different airline. This situation does not encourage flight cancellation, which results in the slots of cancelled flights being made available too late for them to be used by another flight. This solution allows airlines to promote one of their own flights in instances where they have to cancel a flight. This feature is expected to encourage cancellation of flights in the system, which would ultimately benefit all airspace users, particularly in capacity constrained situations.

Exercises simulating European city pairs validated this swapping tool which supported multiple swaps for a single flight, as well as substituting slots in case of cancellation. Over a seven-week time period, 199 swap requests were made using the tool with only 5 % rejected. The Network Manager reported that the response time to requests was not affected. Airspace users reported estimated savings of EUR 1 000 per flight.

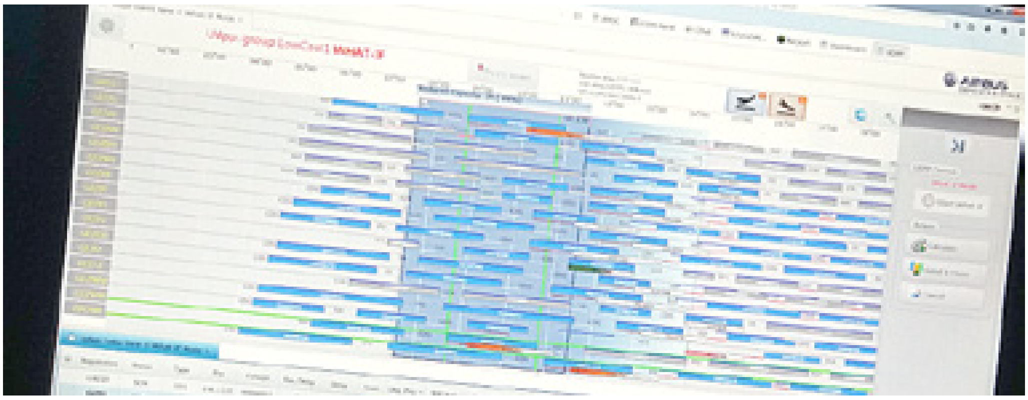
It is not always easy to identify which flights would benefit from a swap. SESAR's enhanced slot swapping tool provides system support for the process, and makes it possible to carry out multiple swaps

The solution is available for industrialisation.

AIRLINE INPUT IMPROVES DEPARTURE OUTPUT

User-driven prioritisation process (UDPP) departure

SJU references:
#57/Release 4



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The user-driven prioritisation process allows airlines to change the priority order of unregulated flights among themselves and in collaboration with the airport authorities. Airlines are given this flexibility in the pre-departure sequence (PDS) for last-minute disruptions, which usually lead to departure delays or cancelled flights.

A full-scale demonstration at a major European hub introduced the SESAR tool as part of the airport's existing pre-departure sequencing process. The Departure Flexibility (DFlex) project allowed airlines to re-order departures based on their operational requirements while still early in the planning stages. It also included a 'ready-to-depart' functionality to support an immediate swap for a flight that is ready for start-up. Participating airlines were given the opportunity to agree to a new target start-up approval time (TSAT) with air traffic control to optimise their schedules. Among benefits, the tool helped to manage a runway closure which otherwise would have prevented passengers making flight connections, and delays were selectively kept to a minimum for long-haul flights.

Offers a local solution for airlines at a collaborative decision-making airport to identify slot swapping opportunities in an easy and user-friendly way

The solution creates more opportunities for departure flexibility within a group of airlines, with benefits increasing as more airlines join. It requires a pre-departure planning process to function, for example using information already shared between operators about planned push-back, start-up and target take-off times. It is especially beneficial in case of disruption with significant financial benefits for the airlines.

This solution is available for industrialisation.

BENEFITS

- **Reduced airline delay costs in case of disrupted situations, without jeopardising airport and network performance**
- **Increased flexibility for airlines**
- **Improved environmental performance**

Enabling aviation infrastructure

SJU references:
#28/Release 5

SHARED DATA FOR IMPROVED FLIGHT EFFICIENCY

Initial ground-ground interoperability

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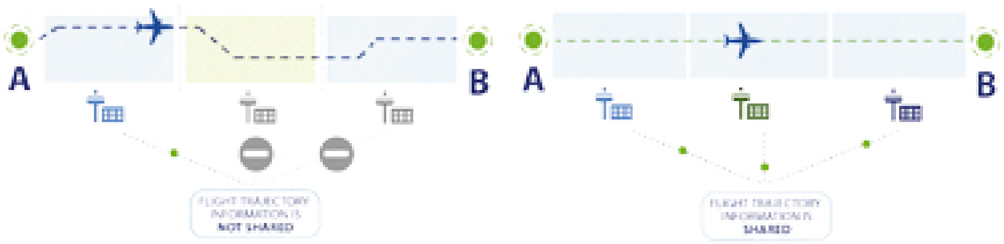

BENEFITS

- **Increased and easier access to information sharing**
- **Support standards update in preparation for deployment**

Today, when an aircraft leaves one national airspace and enters another, the adjacent centres exchange a basic or minimum set of flight information through an on-line data interchange mechanism known as OLDI. Centres further downstream however, do not get access to this information straight away and must rely on the originally filed flight plan in order to organise their airspace. To address this, SESAR is developing Europe's first system for continuous exchange of flight information between all actors managing an aircraft at all stages of its journey.

The solution is based on a secure system-wide information management (SWIM) technical infrastructure (known as the SWIM blue profile) supporting the concept of the 'flight object' which is a single entity holding the most up-to-date information about a flight. The system allows controllers to conduct silent coordination between adjacent units. In this way, all air traffic control facilities hold a consistent view of the flight at all times, which supports seamless cross-border operations, including cross-border free route operations.

This solution represents a key enabler to support all ATM solutions that require an interface between different ground control centres (e.g. Free route operations).

Requirements are being scoped for the technical feasibility of flight data trajectory sharing between air traffic service units through the use of flight object. The information is used for the coordination of tasks and controller assistance services between different ground control centers. Requirements and use cases specify how the flight object can be used by air traffic control to provide the optimum flight profile for an aircraft, also known as the reference business trajectory.

Access to common flight data can result in more effective and better optimised coordination between adjacent ATC centres (or ANSPs)

Initial ground-ground interoperability represents a complete paradigm shift in how flight data information is shared between actors

This solution is linked to EUROCAE ED-133A

The aim of this initial solution is to ensure the industry standards for the exchange of flight information through the flight object will be in place to support its planned deployment in accordance with the Pilot Common Project. This solution will be consolidated with R&D activities in SESAR 2020 on the integration of trajectory management processes (See PJ.18-02).

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GETTING CONNECTED

Extended projected profile (EPP) availability on the ground

SJU references: #115/Release 5

STAKEHOLDERS

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Modern aircraft feature advanced computerised flight management systems (FMS) to guide their navigation, which can exchange relevant data with the airline operations centres (AOC). Air traffic control centres, in turn, have sophisticated flight data processing systems (FDPS) to manage flight data on the ground, but there is limited data connection between the FMS and air traffic control ground systems.

The initial trajectory information sharing solution is based on the aircraft downlinking trajectory information directly from the FMS to the ground systems via an updated standard for the automatic dependent surveillance contract (ADS-C) that is used today exclusively for oceanic and remote operations. The newly developed standard is called ATN Baseline 2 and targets all operations. It allows the i4D FMS to downlink the extended projected profile (EPP), which contains an updated FMS route prediction. The data in the new standard is much more detailed than in the current ADS-C reports used in oceanic airspace; it includes, for example, the predicted aircraft weight, as well as the predicted horizontal and vertical speeds on up to 128 future waypoints along the route.

In this initial solution, the ground systems will enable controllers to display the downlinked route on the radar screen and will also automatically cross-check whether the downlinked route is consistent with what was expected on the ground; controllers will receive a warning in case a discrepancy is identified.

This solution is ready for industrialisation. It will be deployed in a synchronised way across 22 air traffic control centres and 18 terminal manoeuvring areas and airports across Europe in accordance with the Pilot Common Project.

Increased data connectivity between on-board systems and ground air traffic control systems is a key enabler for the modernisation of the ATM system

This solution is linked to EUROCAE standards ED-228A and ED-229A

BENEFITS

- **Increased ground situational awareness resulting in increased predictability**

PCP

SJU references:
#67/Release 2

PLANNING IMPROVES WITH ACCURATE FLIGHT DATA

AOC data increasing trajectory prediction accuracy

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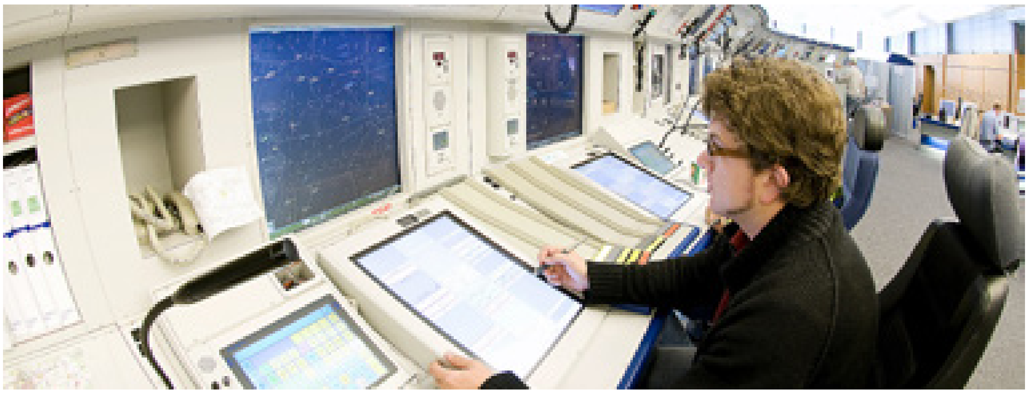


Europe's vision to achieve high-performing aviation by 2035 builds on the idea of trajectory-based operations – meaning that aircraft can fly their preferred trajectory while minimising constraints due to airspace and service configurations. SESAR has introduced an early version which makes use of flight planning data sourced from airline operational control (AOC) to help controllers optimise aircraft flight paths. This solution represents an initial step towards the extended flight plan solution and flight and flow information for a collaborative environment (FF-ICE).

BENEFITS

- **Increased predictability**
- **Increased safety**

Access to flight planning data enables air traffic control to create more accurate trajectory predictors (TP) based on the intentions of the aircraft. The TP are used by advanced controller tools to detect potential conflicts and to develop efficient arrival and departure streams. Eventually, when new datalink communications are universally applied, trajectory information will be exchanged directly between the aircraft and the ground, anticipated from 2025 onwards.

The flight data provides information about aircraft climb and descent speed, and take-off mass, and can be used to help create trajectory profiles to meet five-minute up to two-hour time horizons. The data is particularly helpful when creating climbing and descending flight profiles, where current tools can encounter limited controller acceptance due to high false alerts and re-sequencing rates which result from the poor accuracy of trajectory predictions.

A real-time simulation in a complex terminal airspace resulted in a 10 % reduction in medium-term conflict-detection false alerts when the underlying technical profile is supported by AOC data. Air navigation service provision was improved since fewer false alerts meant controllers had to perform fewer unnecessary actions, and airlines consumed less fuel as a result of fewer level-offs.

The solution is available for industrialisation.

Trajectory information provides air traffic control with the degree of accuracy it needs to build sequencing or conflict-detection and resolution tools which support controllers' tasks

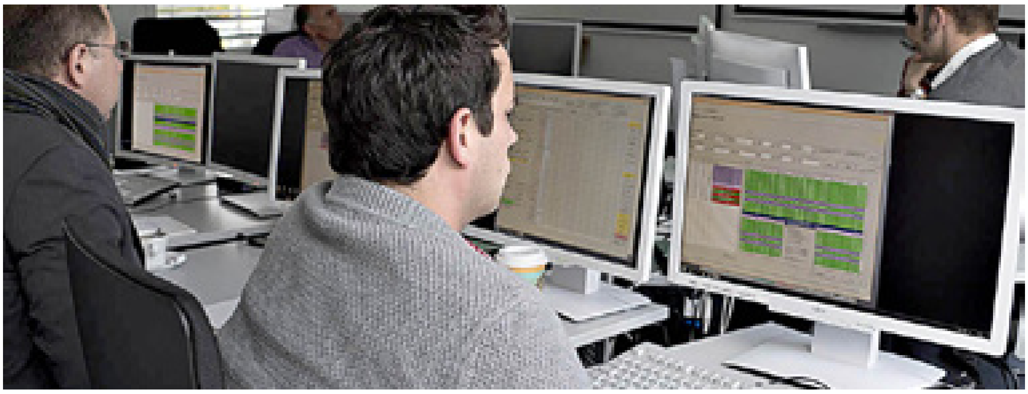
Most of the benefits expected from this concept occur in flight segments with strong ascending and descending profiles such as terminal airspace

This solution is linked to the FIXM standard (v4) included in the ICAO Flight Plan 2012

IMPROVED PLANNING THANKS TO ENRICHED DATA

Extended flight plan

SJU references: #37/Release 5



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Air navigation service providers use aircraft flight plan data to plan and schedule air traffic in order to balance airspace supply and demand. In Europe's future trajectory-based flight environment, where aircraft can fly their preferred flight paths without being constrained by airspace configurations, flight plan data will include additional information, which will allow both the Network Manager and the air traffic control units to have a more precise plan of how the aircraft will fly.

The extended flight plan (EFPL) goes beyond the ICAO minimum requirements for aircraft flight plans, which were updated in 2012, with yet more operational data. In addition to trajectory data and aircraft performance data (compared to the ICAO flight plan), a key part of the concept allows for applied airspace management constraints and accepted trajectories to be sent from the Network Manager to the airspace users.

The EFPL includes further information relevant to each point of the aircraft's trajectory, for example speed and aircraft mass, as well as other performance data such as planned climb and descent profiles. This allows both air traffic control and the Network Manager to improve their prediction of the trajectory. This is especially relevant in complex airspace, because it allows better flow management, and also improves the performance of the conflict detection and resolution tools used by controllers.

The EFPL aims to reduce flight plan rejections by the Network Manager and increase traffic predictability. Concerning the flight plan rejections, the use of 15 data fields in the ICAO flight plan is open to different interpretations resulting in unwarranted flight plan rejections. The validation of this SESAR solution has included the refinement of the data exchange processes and shows that EFPL significantly reduces flight plan rejections compared to those associated with the ICAO 2012 flight plan validation process.

The solution is available for industrialisation. The extended flight plan is being deployed in Europe in accordance with the Pilot Common Project.

The extended flight plan includes additional information in relation to an aircraft's planned four-dimensional trajectory which supports an airspace environment where aircraft can fly their preferred flight paths

This solution sees the integration of four – dimensional flight plan data into the Network Manager flight planning acceptance and distribution system

BENEFITS

- **Improved network predictability**
- **Enhanced safety**
- **Improved performance of conflict detection and resolution tools**

PCP

SJU references:
#34/Release 5

THE BENEFITS OF DIGITAL DATA
Digital integrated briefing

ANSP

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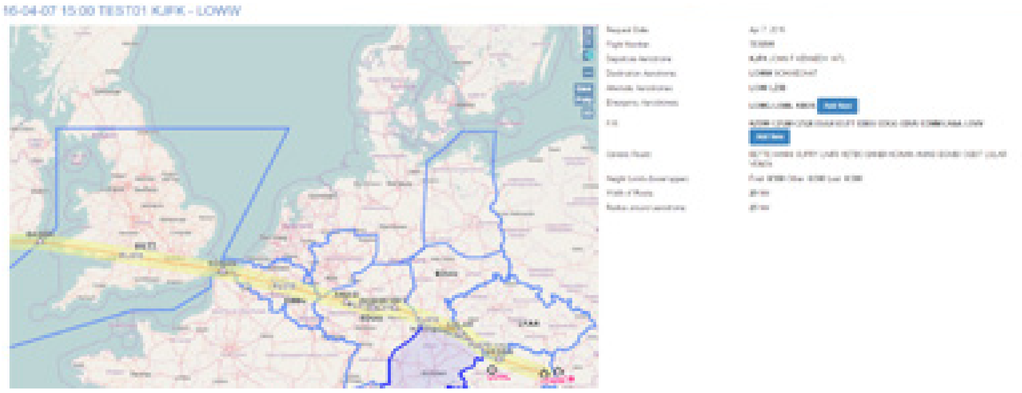
STAKEHOLDERS

BENEFITS

- **Enhanced information sharing**
- **Increased cost efficiency through improved service provision**
- **Improved situational awareness**



The current pre-flight briefing for the pilot includes pages of information, called notice to airmen (NOTAM), recent weather reports and forecasts (MET), which have to be integrated into a consolidated operational picture. The documents can be difficult for pilots to use, and no longer satisfy today's air traffic needs for timely and accurate aeronautical and meteorological information updates. By introducing digital NOTAM and MET data, the briefing could be radically improved.

Aircraft are increasingly equipped with electronic flight bag (EFB) devices which support pre-flight briefing to the pilot and on the ground through provision of flight documentation. The pre-flight briefing could take place directly on the EFB, receiving digital briefings from the ground and updated over a datalink during the flight. Retrieval of the digital aeronautical data, including NOTAM and MET data, is enabled by means of system-wide information management (SWIM) and digital NOTAM.

SWIM information exchange and digital NOTAMs can support the graphical representation of data such as meteorological charts, as well as increase the usability of briefing material by making it searchable and interactive. The digitised information can also be validated and cross-checked automatically (unlike today's pre-briefing documents) to ensure adherence to ICAO standards and to reduce risk of error. In addition, relevant information can be selected more easily from digital data compared with briefing notes which may include between 10 and 50 pages for a cross-European flight.

This solution aims to improve pre-flight information sharing between pilot, flight dispatchers and air traffic controllers through the exchange of easier to understand, better filtered digital aeronautical data

Real-time simulations assessed enhancements in pilot briefing applications based on digital NOTAMs, digital MET, and air traffic flow management data, with the aim of improving situational awareness for pilots and reducing briefing times.

The SESAR solution is aligned with the ICAO roadmap for the provision of digital aeronautical information on a global scale and mirrors parallel development in the US

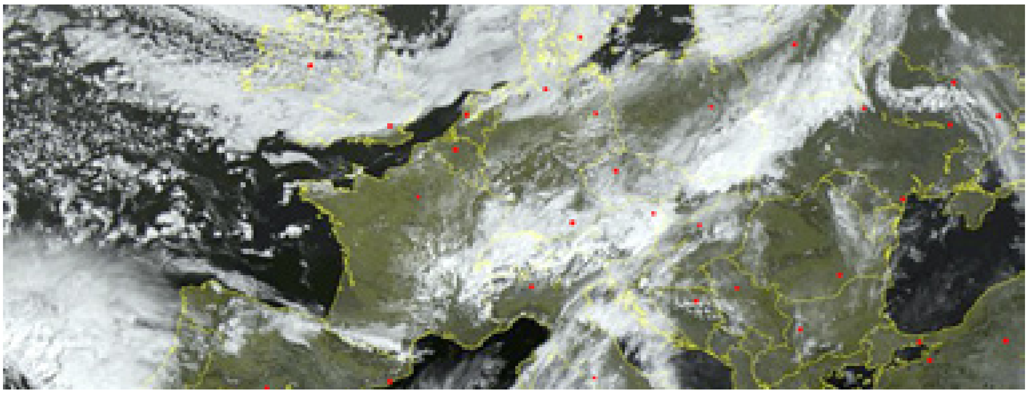
In terms of benefits, the graphical presentation of digital information, better filtering automatic notification of relevant changes and a more logical organisation of the pre-flight information bulletins can improve pilot and dispatcher awareness, reduce briefing times and reduce the risk of information being misunderstood or missed.

This solution is available for industrialisation.

STAYING AHEAD OF THE WEATHER

Meteorological information exchange

SJU references: #35/Release 5



STAKEHOLDERS

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Bad weather brings unwelcome disruption to flight schedules and is the cause of approximately 13 % of Europe's primary delays. Yet the impact can be mitigated by the timely sharing of information so that effective recovery strategies can be put in place.

Meteorological information is currently available in several message formats and also in the form of maps or charts and plain text. Although end users are accustomed to these formats, they limit the opportunity to use the data effectively, for example to prioritise key information, or highlight relevant weather phenomena. Access to more precise weather data can assist decision making when it comes to flight planning, resource planning, and route planning, and can help to avoid unnecessary delay.

SESAR developed a mechanism by which meteorological data generated by European meteorological agencies can be seamlessly integrated into aeronautical information service provision; this is known as the four-dimensional (4D) weather cube. The 4DWxCube is a (virtual) repository of shared consistent and translated meteorological information, produced by multiple meteorological service providers (METSPs) and made available to airspace management stakeholders via its system-wide information management (SWIM) compliant MET-GATE.

The SESAR 4D weather cube makes use of actual and forecast MET information from different air and ground sources for providing adverse weather alerts

This solution builds on ICAO Annex 3 standards and recommendations, and contributes to the definition of MET standards

Sharing this weather information and its integration within the air traffic management decision-making process enables airspace users, airports and air navigation service providers to stay up to date with the latest weather situation, and to plan accordingly and effectively. Weather conditions influence all aspects of air traffic operations, for example by increasing or decreasing tailwind, by changing pressure or temperature or by introducing low-visibility conditions.

The meteorological information exchange uses SWIM to enable seamless interchange of meteorological data with different partners, and involves SWIM-compliant services such as legacy forecasts (METAR/TAF/SIGMET) and new ones such as hazardous weather (convection, turbulence, icing) developed under the scope of this solution.

This solution is available for industrialisation. MET information exchange will be deployed as part of initial SWIM, in accordance with the Pilot Common Project.

BENEFITS

- **Improved safety**
- **Improved planning, leading to fuel reduction**
- **Increased cost efficiency through improved service provision**

PCP

SJU references:
#46/Release 5

LEARNING TO SWIM

Initial system-wide information management (SWIM) technology solution

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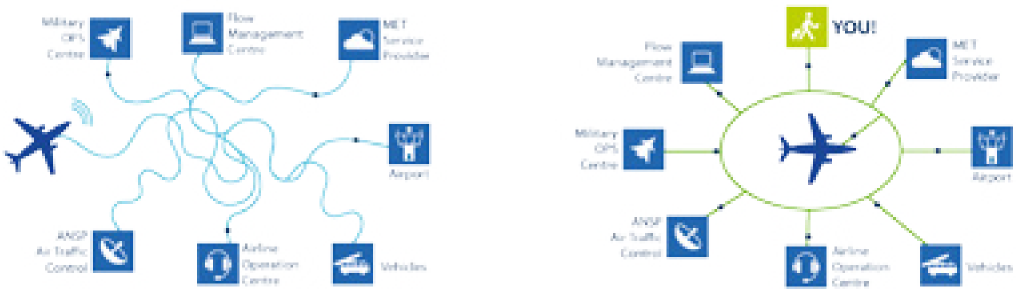


SESAR is introducing a new approach to sharing information, called system-wide information management (SWIM). SWIM enables seamless information data access and interchange between all providers and users of air traffic management data and services.

The aim of SWIM is to provide information users with relevant and commonly understandable information. It does not refer to a single solution or technology, but rather a global level of interoperability and standardisation that enables users and providers to exchange data without having to use different interfaces or protocols. It is based on service-oriented architecture and open and standard technologies. It introduces a totally new way of working that sits comfortably in a cloud environment.

This SWIM technological solution provides a coherent set of specifications to support standardisation in the context of SWIM deployment. These are the key elements in steering SWIM-enabled systems for ensuring interoperability are the following:

- Aeronautical information reference model (AIRM) to ensure semantic interoperability;
- Information service reference model (ISRM) to ensure organisational interoperability;
- SWIM technical infrastructure (SWIM TI) profiles and architecture to enable technical interoperability;
- SWIM registry to improve the visibility and accessibility of ATM information and services available through SWIM. It enables service providers, consumers, and the swim governance to share a common view on SWIM providing consolidated information on services that have been implemented based on SWIM standards.

SWIM represents a complete paradigm shift in how information is managed along its full lifecycle and across the whole European ATM system

The SWIM solution and services are developed in accordance with the ICAO SWIM manual

This solution is available for industrialisation and is due to be deployed in Europe, in accordance with the Pilot Common Project. The first SWIM-enabled solution was introduced in 2014 to support the exchange of data between neighbouring airspace sectors.

BENEFITS

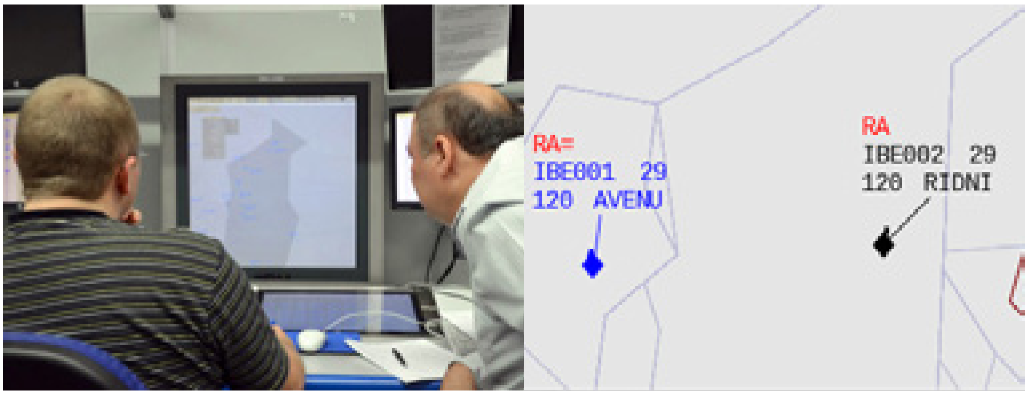
- **Increased cost efficiency and easily accessible information sharing**
- **Improved contextual awareness**
- **Improved collaborative decision making**

PCP

VISUALISING AIRBORNE ALERTS FROM THE GROUND

ACAS ground monitoring and presentation system

SJU references: #100/Release 5



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The airborne collision avoidance system (ACAS) provides resolution advisories (RAs) to pilots in order to avoid collisions. Controllers rely on pilots to report RAs by radio as they occur in accordance with ICAO regulations. However these reports can come late, incomplete or are absent in some instances. This solution consists of a set of monitoring stations and a server system, which enable the continuous monitoring and analysis of ACAS RAs and coordination messages between airborne units from the ground.

The system includes the potential to provide real-time airborne data to ground-based safety nets. For ACAS RA monitoring, the ground station is extended to be able to receive 1030 MHz messages exchanged between ACAS equipped aircraft and the RA broadcast that can provide information on the presence of an RA.

A test platform was used to monitor the entire upper airspace during a period of more than three years to collect data and evaluate the concept. The system was able to process and deliver valid resolution advisories within two seconds, and was able to filter out false advisories.

The SESAR validation work also showed that the fusion and the use of surveillance sensor data from Mode-S radar, wide area multilateration (WAM), multilateration (MLAT) and ADS-B, when combined with ACAS ground sensor RA data provide practical and beneficial safety enhancements.

SESAR exercises show that ACAS monitoring on the ground is feasible and can be integrated into an overall air traffic management system

This solution is available for industrialisation but further work is expected to address the operational use by controllers.

BENEFITS

- **Enhanced safety**

SJU references:
#101/Release 5

SPECTRUM EFFICIENT SURVEILLANCE

Extended hybrid surveillance

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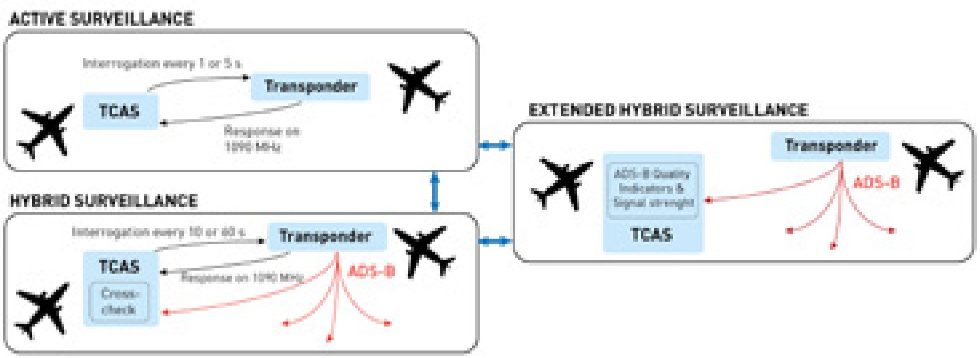

The traffic alert and collision avoidance system (TCAS) is an airborne collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. Currently, TCAS II is dependent upon 1090 MHz replies that are elicited by 1030 MHz interrogations. These provide the pilot with information about the relative distance, bearing and aircraft altitude and are used to build active tracks. However, the process uses precious frequency bandwidth that is also needed for surveillance purposes.

The technical solution consists of an enhanced TCAS capability, adding passive surveillance methods and reducing the need for active Mode-S interrogations. By making fewer active interrogations, this solution allows the aircraft to significantly reduce the usage of the 1090 MHz frequency.

Validations carried out using roof-top antennae in the proximity of an airport showed the basic functionality of the system. The concept was also flight-tested and this data was used in simulation activity to assess the results and overall impact on 1090 MHz load. The technology met the minimum operating requirements developed for the solution and resulted in no operational differences for pilots and controllers. When the 1090 MHz usage was compared with TCAS II, the assessment showed a reduction of Mode-S interrogations of at least 70 %.

This solution is available for industrialisation.

Minimum operational performance standards (MOPS) for improved hybrid surveillance has been already published both by EUROCAE (ED-221) and RTCA (DO-300A)

In addition to changes required for ADS-B-in capability, improved hybrid surveillance would also require a TCAS II unit software update

BENEFITS

- **Reduced risk of radar information loss due to overloaded frequency band**

ENTERING THE NEW DIGITAL ENVIRONMENT

Aeronautical mobile airport communication system (AeroMACS)

SJU references: #102/Release 5

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ATM communications capacity is reaching saturation in Europe due to increasing air traffic volumes and density. The situation is particularly acute on the airport surface where a large concentration of aircraft combined with pre-flight and post-flight operations increasingly rely on data communications.

The aeronautical mobile airport communication system (AeroMACS) offers a solution to offload the saturated VHF datalink communications in the airport environment and support new services. The technical solution AeroMACS is based on commercial 4G technology and uses the IEEE 802.16 (WiMAX) standard. Designed to operate in reserved (aeronautical) frequency bands, AeroMACS can be used for air navigation service providers (ANSPs), airspace users and airport authority communications, in compliance with SESAR's future communication infrastructure (FCI) concept. AeroMACS is an international standard and supports globally harmonised and available capabilities according to ICAO Global Air Navigation Plan (GANP).

SESAR validated the system concept and usage of the airport surface datalink system. This has been done through simulations, developing prototypes and testing in lab conditions as well as on-site at airports and on aircraft. In addition, SESAR led the development of standards in ICAO, EUROCAE/RTCA and the Airlines Electronic Engineering Committee (AEEC). Together with other FCI solutions, AeroMACS will support the multilink FCI concept, offering increased robustness of datalink operations and thereby supporting the move towards the use of datalink communications as the primary means of communications in airspace management.

This solution is linked to EUROCAE standards ED223 and ED227 and the AeroMACS Manual (ICAO Doc10044)

This solution is available for industrialisation. Implementation will be subject to the demonstration of a viable business case.

BENEFITS

- **Increased capacity for information and communications exchanges**
- **More efficient airport surface operations with increased safety and security levels**
- **Increased cost efficiency, thanks to synergies and sharing of infrastructure between actors, thereby lowering costs**

SJU references:
#109/Release 5

A NEW GENERATION OF SATELLITE-BASED DATALINK COMMUNICATIONS

Air traffic services (ATS) datalink using Iris Precursor

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The Iris Precursor offers a viable option for air traffic services (ATS) datalink using existing satellite technology systems to support initial four-dimensional (i4D) datalink capability. The technology can be used to provide end-to-end air–ground communications for i4D operations, connecting aircraft and air traffic management ground systems.

The Iris Precursor is designed to exploit an opportunity to deploy an aviation communications service based on the existing SwiftBroadband (SBB) satellite network from Inmarsat. The aim is to augment the existing VHF datalink (VDL) capability in Europe in order to increase reliability and capacity, and help establish satellite communications as a key component in the future ATM communications landscape. This solution also offers an alternative datalink option for aircraft already equipped with SATCOM systems.

A SESAR flight trial demonstrated that the Iris Precursor service could provide the communication performance required for datalink exchanges to fly i4D operations. Specifically, it showed how i4D automatic dependent surveillance-contract (ADS-C) could be successfully maintained with two air traffic control centres for over two hours. During this time, i4D ADS-C reports were generated on events resulting in downlinking trajectory updates approximatively every 20 seconds with 20 waypoints - an update rate which is well above the rate needed for i4D trajectory exchanges. In addition to the i4D trajectory exchanges, various controller-pilot datalink communications (CPDLC) messages were exchanged along the flight with a remarkable performance round trip time of below two seconds throughout the flight's duration.

This solution is available for industrialisation. The transition roadmap from Iris Precursor to the future communication infrastructure is currently being addressed by SESAR 2020 - the next wave of research and innovation activities by the SESAR JU - as well as by the European Space Agency (ESA) and Inmarsat (Iris Service Evolution).

BENEFITS

- **Enabler for initial i4D operations**

IMPROVING SURVEILLANCE SECURITY AND INTEGRITY

ADS-B surveillance of aircraft in flight and on the surface

SJU References:
#110

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Automatic dependent surveillance-broadcast (ADS-B) is a technique which allows the tracking of aircraft in flight and on the surface. Enhancements of the functionality and interfaces are required to the ground surveillance system, in order to make it compliant with the new applications of ADS-B in radar airspace, ADS-B for airport surveillance and other emerging requirements, such as security.

The SESAR solution consists of ADS-B ground station and surveillance data processing and distribution (SDPD) functionality. The solution also offers detection and mitigation techniques against deliberate spoofing of the ground system by outside agents. These techniques can also be used to cope with malfunctioning of avionics equipment. SESAR has contributed to the relevant standards, such as EUROCAE technical specifications, incorporating new functionalities developed for the ADS-B ground station, ASTERIX interface specifications as well as to the SDPD specifications.

Shadow-mode exercises showed how the solution can be used in different types of airspace (airports, TMA, en-route) under nominal and non-nominal conditions and can be used to improve flight conformance monitoring. The solution is seen as a key enabler for surveillance infrastructure rationalisation thanks to the efficiency gains it brings in terms of costs and spectrum usage. The solution is also fully interoperable with other surveillance means.

The SESAR solution is available for industrialisation.

SESAR has contributed to the relevant standards, such as EUROCAE technical specifications, incorporating new functionalities developed for the ADS-B ground station, ASTERIX interface specifications as well as to the SDPD specifications

BENEFITS:

- **Enabler for surveillance infrastructure rationalisation**

SJU References:
#114/Release 5

COMBINING SURVEILLANCE SYSTEMS FOR GREATER EFFICIENCY

Composite cooperative surveillance automatic dependent surveillance – broadcast/Wide area multilateration (ADS-B/WAM)

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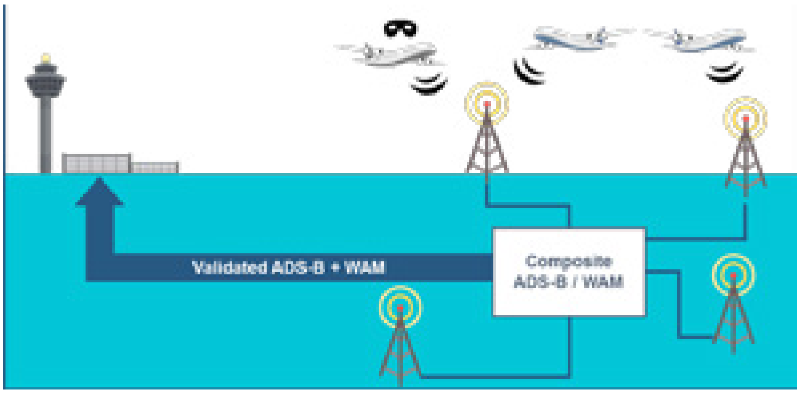


Composite cooperative surveillance ADS-B/WAM is a system that exploits the similarities between the two surveillance techniques and combines them into a single system. ADS-B information received by WAM system is evaluated and if matching with WAM information extracted by others methods, then it is used in the WAM output. Information is then periodically re-evaluated.

BENEFITS:

- **Improved cost efficiency**
- **Improved security**

By allowing the use of ADS-B data that has been validated against data derived in parallel by a WAM system, the system can help to reduce the number of interrogations and number of replies and therefore reduce the 1030/1090 MHz radio frequency (RF) load and improve spectrum efficiency. It achieves this through the integration of validated data items into the WAM channel, thereby preventing a need to re-interrogate the data item.

Since the two surveillance layers share hardware components, the system offers improved cost efficiency. Furthermore, the use of the system contributes to an improved security by successfully mitigating associated ADS-B threats.

SESAR has contributed to the relevant standards, such as EUROCAE technical specifications for WAM and ADS-B that are implementing this 'composite' concept

Shadow-mode exercises demonstrated that use of ADS-B data in the WAM output helps to reduce the RF pollution generated by the system. Platforms were used to collect a large dataset of overlapping CAT021 ADS-B and CAT020 WAM messages and assessed to compare WAM & ADS-B values.

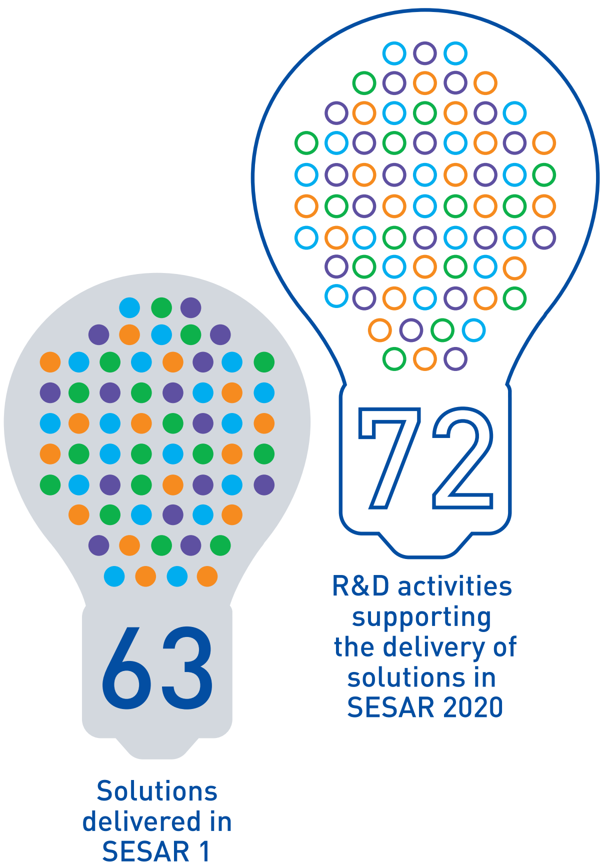
This solution is available for industrialisation.

Conclusion

The SESAR JU will build on the solutions included in this catalogue in SESAR 2020, the next wave of air traffic management research and innovation for Europe. The next edition of this catalogue will detail further progress in the development, validation and delivery of solutions in line with the European ATM Master Plan to contribute to the SES High Level Goals.

In SESAR 2020 the focus will be on further integration of airports into the air traffic network; the implementation of advanced air traffic services such as satellite-based navigational aids; integrated arrival and departure management tools, and free route airspace; and optimising network services through increased dynamic data sharing between airlines and air traffic control. New technical and operational solutions as well as other important evolving challenges, such as the integration of remotely piloted air systems into controlled airspace and cyber security, will also be covered.

The combined resources of SESAR members and industry partners will continue to bring benefits in key performance areas of safety, operational efficiency, security, capacity and the environment, fast-tracking solutions to meet individual stakeholder challenges or more strategic long-term infrastructure improvements.



NOTE: the number of solutions to be delivered in 2020 will be confirmed during the research and innovation activities.

ANNEX 1

Reaching research maturity

SESAR researches and delivers solutions according to a set of agreed business needs and strict performance requirements and with a view to industrialisation readiness. During the course of developments and when assessing the results of SESAR validation, it may become apparent that these solutions do not fully match the completeness criteria for reaching the level of expected maturity and performance which in itself is the very purpose and value of R&D. This is the case for the solutions in this annex, for which further refinements in their development by stakeholders will be required if and when decisions for industrialisation are taken.

A COORDINATED DEPARTURE ROUTE

Departure management integrating surface management constraints

SJU references: #14/Release 5

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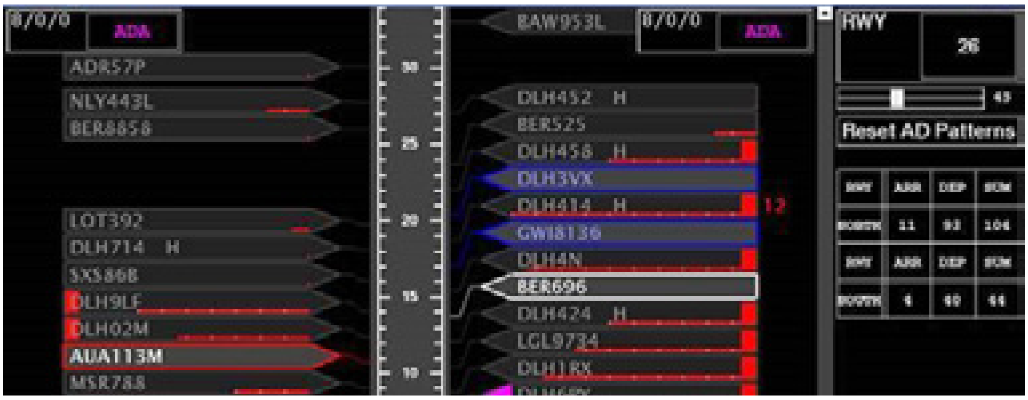

The departure manager (DMAN) takes inputs from a number of different sources to calculate the optimum sequence for aircraft to push back from the gate and taxi to the runway. The process may begin hours before a flight is due to depart, when flight plan data, flow management slots, and aircraft schedules provide a reasonable guide to departure time.

The calculation becomes a lot more precise if tactical information is added into the equation. For example, the taxi out time from the gate to the runway may change by several minutes depending upon the route available; arriving aircraft can slow down the rate of departure; and busy taxiways will also affect route planning by the tower controller. Taking account of these variables, the DMAN is able to estimate more precise departure times, and calculate a more accurate pre-departure sequence for aircraft at the gate.

The solution integrates surface planning and routing functions to build a very accurate departure sequence, taking the tactical changes into account. The solution includes procedures and technical specifications to support the addition of dynamic data from the control tower, in particular to take account of taxi-out times. Integrating surface management constraints with departure management delivers a more predictable departure sequence, and improving the use of available capacity on the airfield. Safety is also enhanced by reducing the risk of unplanned events.

The solution includes procedures and technical specifications supporting departure management that takes into account route planning and route monitoring information

While the solution reached operational and technical feasibility, the expected reduced fuel consumption and increased operational predictability could not be validated. SESAR 2020 PJ.02-08 will build on the valuable results to analyse the balance between sequence updates and planning stability.

BENEFITS

- **Increased predictability**
- **Enhanced safety**
- **Reduces fuel burn and emissions**

SJU references:
#15/Release 5

OPTIMISED ARRIVALS AND DEPARTURES

Integrated and throughput-optimised sequence of arrivals and departures

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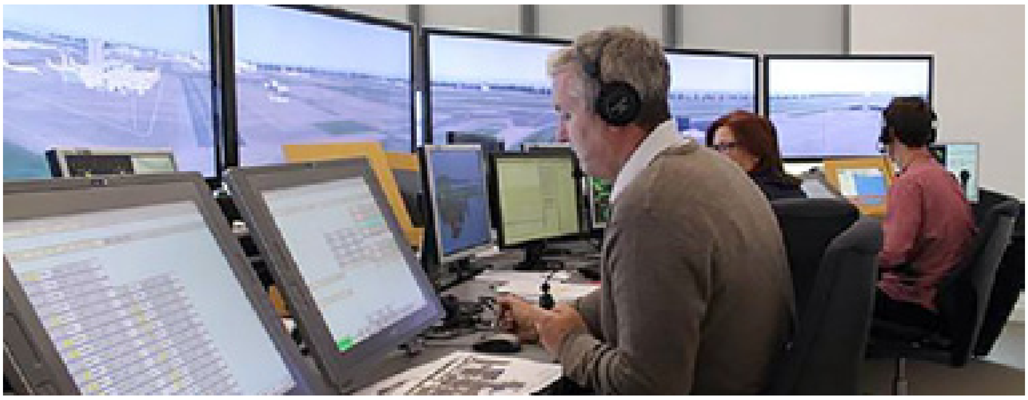

It is common for arriving aircraft to take priority at an airport, but with careful planning, traffic flow can be optimised for both arrivals and departures. By integrating the sequence of arrivals and departures, and adjusting the traffic flows to minimise delays, overall efficiency can be improved.

BENEFITS

- **Keeps delays to a minimum**
- **More predictable arrival and departure times enhances safety**

The solution requires the departure manager (DMAN) to be coupled with the arrival manager (AMAN). An algorithm ensures minimum separations are maintained, and up-to-date information regarding the pre-departure sequence and the arrival metering sequence is used to calculate the optimum traffic flow. Controllers play an important part in working towards establishing the plan, for example by following target take-off times and target landing times as closely as possible. Planners create gaps in the arrival sequence to allow for departure flights. The process is particularly useful at busy single runway airports, or with dependent runways, where both capacity and efficiency can improve as a result of using integrated systems.

Real-time simulations assessed the feasibility of integrating AMAN-DMAN, and its impact on runway throughput, airport operations and service provision. Operational and human factor issues that can affect performance were also looked at. Controller tools such as route planning, surface conflict alerts, and flight data were included in the sequence planning.

Integrated AMAN-DMAN is characterised by high planning stability, and all controllers working towards establishing and delivering a common plan

While the solution reached operational and technical feasibility, the expected performance benefits could not be fully operationally validated. SESAR 2020 PJ.02-08 will focus on the flow-based operations to enable optimised spacing of arrivals and departures reflecting benefits from reduced and predicted runway occupancy.

AIRCRAFT SPACING TOOLS TO STABILISE ARRIVAL MANAGEMENT

ASAS spacing applications 'remain behind' and 'merge behind'

SJU references: #16/Release 5

ANSP

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The management of traffic flows in almost all European terminal manoeuvering areas (TMAs) requires complex traffic patterns and tactical intervention e.g. open-loop vectoring. This impacts the overall ATM system performance (capacity, predictability, efficiency).

By using the aircraft's on-board airborne separation assistance system (ASAS) to monitor distances between aircraft, the flight deck can maintain the spacing requested by air traffic control. Separation provision is still the controller's responsibility, but the pilot would only need one instruction – for example "remain 90 seconds behind" – rather than several speed commands by the controller. On-board automation would automatically generate and execute the appropriate speed commands.

SESAR is assessed the application of airborne interval management sequencing and merging during the arrival phase for ADS-B-in-equipped aircraft.

While the solution was shown to be operationally and technically feasible, the expected operational benefits of decreased fuel consumption and efficient service provision could not be fully validated. SESAR 2020 PJ.01-05 will start from these results, but focusing on different environments and assessing various possibilities of communicating between aircraft.

To carry out airborne sequencing and merging, an aircraft has to be equipped with ADS-B-in, a traffic situational awareness tool, interval management capability, and advanced required navigation performance capabilities

BENEFITS

- **Enhanced safety**
- **Increased capacity in the TMA**

SJU reference:
#112

LIGHTENING THE LOAD
Flexible communication avionics

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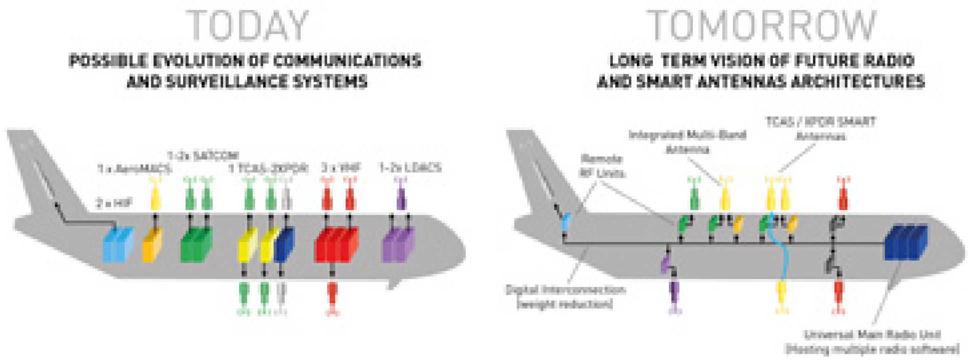


BENEFITS

- **Lower airborne equipment costs**
- **Weight savings in terms of wiring and overall equipment**
- **Increased equipment flexibility, reusability and reconfigurability**
- **Improved reliability and performance thanks to software reconfigurability**

Today, civil aircraft are typically fitted with several radios. This is standalone equipment, which is not only costly but also adds to the weight and the energy consumption of the aircraft. At the same time new technologies are expected to be implemented on board to meet the communication capacity and performance requirements of air traffic management in the future.

SESAR's flexible communication avionics aims to overcome this equipment challenge with the introduction of multi-purpose communications equipment capable of fulfilling conventional radio transceiver functions using generic computing platforms and software. The solution has the potential to reduce the cost, weight, size, and power penalties of multiple radio systems on board aircraft, and to provide flexibility for adding, removing, replacing, or upgrading these systems. In doing so, the solution facilitates the transition from current to future technologies and is a key enabler to realising efficiently multi-link operations.

Since not all aircraft radios are used simultaneously in all airspaces, the solution brings the opportunity to build new dynamically reconfigurable radio systems to operate a specific radio link only when required. Such flexibility can allow a further reduction in the number of separate hardware components carried on board and can also improve availability of the aircraft communication functions and aircraft interactions with the ground.

The feasibility of the solution has been validated through the development of two prototypes and laboratory testing, as well as complementary assessments on the benefits and challenges, for instance, related to security and certification. The solution has the potential to reduce the cost, weight, size, and power penalties of multiple radio systems on board aircraft, and to provide flexibility for adding, removing, replacing, or upgrading these systems. In doing so, the solution facilitates the transition from current to future technologies and is a key enabler to realising efficiently multi-link operations.

Having reached V2/TRL4 maturity (technical feasibility), the technology will be demonstrated by industry within the Clean Sky II research programme.

ANNEX 2

Supporting the delivery of future SESAR Solutions (SESAR 2020)

Guided by the European ATM Master Plan, SESAR 2020 aims to transform European ATM into a more modular, automated system that takes advantage of advances in digital and virtualisation technologies. The planned SESAR R&D activities listed in this annex illustrate this transformation and the ambition of the programme between now and 2024. Covering all key areas of air traffic management, these activities will support the delivery of new solutions to enable a more flight-centric approach to ATM as well as the integration of all vehicles, including remotely-piloted aircrafts or drones, in addition to important established users such as business aviation, general aviation and rotorcraft. As solutions become mature, they will be introduced into the main body of the catalogue.

High-performing airport operations

Wake turbulence separation optimisation

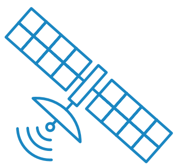
SJU reference: Wake turbulence separation optimisation (PJ.02-01)

The work refers to the use of downlinked information from aircraft to predict wake vortex and determine appropriate wake-vortex minima dynamically, thereby optimising runway delivery.

Enhanced arrival procedures enabled by satellite technologies

SJU reference: Enhanced arrival procedures (PJ.02-02)

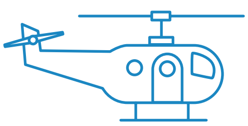
The work makes use of satellite navigation and augmentation capabilities, such as GBAS and satellite-based augmentation systems (SBAS), to enhance landing performance and to facilitate advanced arrival procedures (e.g. curved approaches, glide slope increase, displaced runway threshold). By doing so, noise is reduced while runway occupancy time (ROT) is optimised. The aim is to also reduce the need for separation for wake vortex avoidance.



Minimum-pair separations based on required surveillance performance (RSP)

SJU reference: Minimum-pair separations based on required surveillance performance (RSP) (PJ.02-03)

The work refers to the application (by air traffic control) of non-wake turbulence pair wise separation (PWS) of 2 nautical miles for arrivals on final approach (at the point that the leading aircraft in the pair crosses the runway threshold), based upon RSP.



Independent rotorcraft operations at airports

SJU reference: Independent rotorcraft operations at airports (PJ.02-05)

The work refers to RC specific approach procedures and SBAS-based point-in-space (PinS), which aim to improve access to secondary airports in low-visibility conditions.

Improved access into secondary airports in low-visibility conditions

SJU reference: Improved access into secondary airports in low-visibility conditions (PJ.02-06)

Improved access into secondary airports in low-visibility conditions will be possible thanks to the introduction of new airborne capabilities, such as RNP and global navigation satellite system (GNSS)-based landing systems.

Traffic optimisation on single and multiple runway airports

SJU reference: Traffic optimisation on single and multiple runway airports (PJ.02-08)

This work refers to a system that enables tower and approach controllers to optimise runway operations arrival and/or departure spacing and make the best use of minimum separations, runway occupancy, runway capacity and airport capacity.

Enhanced terminal area for efficient curved operations

SJU reference: Enhanced terminal area for efficient curved operations (PJ.02-11)

The work refers to curved segment approaches as close to the runway as possible to optimise procedures in terms of fuel consumption or noise abatement. Using geometric vertical navigation guidance in the TMA will facilitate a more efficient transition from barometric to geometric vertical navigation.

Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing

SJU reference: Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing (PJ.03a-01)

The work sees the extension of the A-SMGCS routing function to avoid potential traffic conflicts, an improved use of AMAN and DMAN information and integration with total airport management procedures. It includes the exchange of virtual stop bar identifiers and status between air traffic controllers and flight crews to improve safety in low-visibility conditions. The exchange of information between air traffic control and vehicles/aircrafts will be improved with the use of airport datalink and other guidance means.

Enhanced navigation accuracy in low-visibility conditions on airport surfaces

SJU reference: Enhanced navigation and accuracy in low-visibility conditions on the airport surface (PJ.03a-03)

The work refers to improved accuracy of aircraft navigation during both take-off and landing operations, as well as improved accuracy for surface movement navigation and service vehicle positioning (using GBAS or SBAS corrections).

Enhanced visual operations

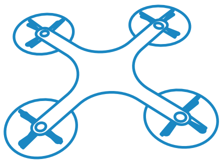
SJU reference: Enhanced visual operations (PJ.03a-04)

The work refers to enhanced vision systems (EVS) and synthetic vision systems (SVS), which will be developed to enable more efficient taxi, take-off and landing operations in low-visibility conditions. This is applicable to all platforms — even if main airline platforms have autoland capabilities to facilitate approaches in low-visibility conditions, they have no capability to facilitate taxi and take-off in order to maintain airport capacity.

Integration of drone operations at airports

SJU reference: Surface operations by remotely-piloted aircraft systems (RPAS) (PJ.03a-09)

The work facilitates the operation of drones at airports and their integration into an environment, which is currently dominated by manned aviation. To the maximum extent possible, drones will have to comply with the existing rules and regulations. The solution includes the particular requirements of remotely-piloted operations, and will describe their specificities with respect to manned operations, providing operational requirements for technological developments that could mitigate them.



Enhanced airport safety nets for controllers
SJU reference: Enhanced airport safety nets for controllers (PJ.03b-01)
These safety alerts for controllers detect potential and actual conflicting situations, incursions and non-conformance to procedures or air traffic control clearances, involving mobiles (and stationary traffic) on runways, taxiways and in the apron, stand and gates area, as well as unauthorised and unidentified traffic. Controllers are provided in all cases with the appropriate alerts.

Conformance monitoring safety nets for pilots
SJU reference: Conformance monitoring safety nets for pilots (PJ.03b-03)
The work provides conformance monitoring safety alerts for the flight crew (either generated by the on-board system or uplinked from the controller alerting system) when the system detects a non-compliance with airport configuration (e.g. closed runway, non-compliant taxiway, restricted area, etc) as well as non-conformance to procedures or clearances.

Traffic alerts for pilots for airport operations
SJU reference: Traffic alerts for pilots for airport operations (PJ.03b-05)
Traffic alerts for pilots for airport operations refer to enhancing on-board systems in order to detect potential and actual risks of collision with other traffic during runway and taxiway operations, non-compliance with airport configuration (e.g. closed runway, non-compliant taxiway, and restricted areas). In all cases the flight crew are provided with appropriate alerts.

Safety support tools for runway excursions
SJU reference: Safety support tools for runway excursions (PJ.03b-06)
This work provides controllers and/or pilots with the appropriate alerts where there is a risk of runway excursion (take-off and landing).

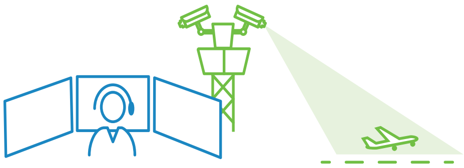
Enhanced collaborative airport performance planning and monitoring
SJU reference: Enhanced collaborative airport performance planning and monitoring (PJ.04-01)
The work extends the airport performance monitoring process to the airport landside and ground access processes with a view to improving the planning and timely execution of airside operations. Specifically, the work sees the development of rationalised dashboard(s) fed with all landside and airside key performance indicators and covering total airport management processes.

Enhanced collaborative airport performance management
SJU reference: Enhanced collaborative airport performance management (PJ.04-02)
This work sees the full integration of the AOP into the NOP, moving towards a total airport DCB process. This involves, among other things, a proactive assessment of the total airport capacity available, including terminal, stand, manoeuvring area, taxiway and runway capacities, and taking into account the prevailing and/or forecast weather and other operational conditions.

Remotely-provided air traffic services for multiple airports
SJU reference: Remotely-provided air traffic services for multiple aerodromes (PJ.05-02)
This work refers to the provision of airport control services or airport flight information services for more than one airport by a single controller from a remote location. It includes further development of the CWP and MET information from multiple airports. This work goes beyond the scope of solution #52 (two small aerodromes).

Flexible and dynamic allocation of remote tower modules

SJU reference: Remotely provided air traffic services from a remote tower centre with a flexible allocation of aerodromes to remote tower modules (PJ.05-03)

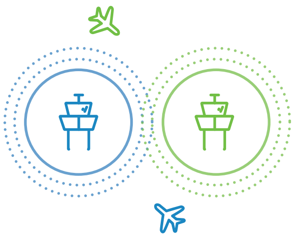


This work will enable the provision of remote tower services to a large number of airports with a flexible and dynamic allocation of airports connected to different remote tower facilities over time depending on needs. It includes the development of remote tower control supervisor and support systems, and advanced and more cost efficient automation functions. It also sees connecting flow management between remotely connected airports and the development of tools and features for a flexible planning of all aerodromes connected to remote tower services.

Advanced air traffic services

Extended arrival management across overlapping AMAN operations

SJU reference: Extended arrival management with overlapping AMAN operations and interaction with DCB and CTA (PJ.01-01)



This work integrates information from multiple arrival management systems, enabled by SWIM, operating out to extended ranges into en-route sectors using local traffic/sector information and balancing the needs of each AMAN. The work addresses the interaction between traffic synchronisation and DCB, including the identification of integration needs, and CTA in high density/complexity TMAs.

Improving traffic flow around airports using arrival and departure management information

SJU reference: Use of arrival and departure management information for traffic optimisation within the TMA (PJ.01-02)

The work sees TMA traffic managed in near real time, taking advantage of predicted demand information provided by arrival and departure management systems from one or multiple airports. This allows the identification and resolution of complex interacting traffic flows in the TMA and on the runway, through the use of AMAN and DMAN flow adjustments and ground holdings.

Dynamic and enhanced routes and airspace

SJU reference: Dynamic and enhanced routes and airspace (PJ.01-03)

This work brings together vertical and lateral profile issues in both the en-route and TMA phases of flight, with a view to creating an end-to-end optimised profile and ensuring transition between free route and fixed route airspace. The solution will be supported by new controller tools and enhanced airborne functionalities.

Airborne spacing flight deck interval management

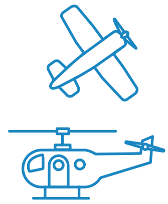
SJU reference: Airborne spacing flight deck interval management (PJ.01-05)

This work refers to new ASAS spacing interval management sequencing and merging (ASPA IM S&M) manoeuvres encompassing the potential use of lateral manoeuvres and involving more complex geometries where a designated target aircraft may not be flying direct to the merge point.

Enhanced rotorcraft and general aviation operations around airports

SJU reference: Enhanced rotorcraft and general aviation operations in the TMA (PJ.01-06)

This work further develops the simultaneous non-interfering (SNI) concept of operations to allow RC and GA to operate to and from airports without conflicting with fixed-wing traffic or requiring runway slots.



Assisted visual separation

SJU reference: Approach improvement through assisted visual separation (PJ.01-07)

This work refers to cockpit display of traffic information (CDTI) assisted visual separation (CAVS) and CDTI assisted pilot procedure (CAPP) applications that enable aircraft to separate each other visually in marginal visual conditions and that facilitate transitions from IFR operations to CAVS during approach.

Optimised traffic management to enable free routing in high and very high complexity environments

SJU reference: Optimised traffic management to enable free routing in high and very high complexity environments (PJ.06-01)

This work enables airspace users to plan flight trajectories without reference to a fixed route network or published directs within high and very high-complexity environments so they can optimise their associated flights in line with their individual operator business needs or military requirements.

Performance-based free routing in lower airspace

SJU reference: Management of performance-based free routing in lower airspace (PJ.06-02)

Management of performance-based free routing in lower airspace sees the application of free route for airspace users beyond what is prescribed in the Pilot Common Project (below FL310), improving predictability, efficiency and flexibility for a wider range of different airspace users.

Improved controller team configuration

SJU reference: High productivity controller team organisation (PJ.10-01a)

This work sees the extension of sector team operations beyond team structures of one planning controller and two tactical controllers both in en-route and TMA in order to optimise flight profiles, minimise delays and improve ANSP cost efficiencies while taking into account intrinsic uncertainty in the trajectory.

Flight-centric air traffic control

SJU reference: Flight-centric air traffic control (PJ.10-01b)

The work sees the provision of ground-based automated support for managing separation provision across several sectors in order to optimise the use of larger sectors. Rather than managing the entire traffic within a given sector, with this solution air traffic control is responsible for a certain number of aircraft throughout their flight segment within a larger airspace or along flows of traffic.

Collaborative control

SJU reference: Collaborative control (PJ.10-01c)

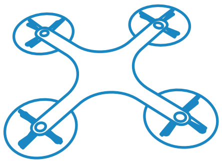
This work refers to coordination by exception rather than coordination by procedure and is facilitated by advanced controller tools, reducing the need for coordination agreements, fewer boundary constraints and the ability to combine sectors into multi-sector planner teams.

Improved performance in the provision of separation

SJU reference: Improved performance in the provision of separation (PJ.10-02a)

The work aims to improve the separation (tactical layer) in the en-route and TMA operational environments through improved ground trajectory prediction. This is achieved using existing information on lateral and vertical clearances that are known by the ground system, airborne information and data derived from meteorological services.

Advanced separation management
SJU reference: Advanced separation management (PJ.10-02b)
This work aims to further improve the quality of services of separation management in the en-route and TMA operational environments by introducing automation mechanisms and integrating additional information (ATC intent, aircraft intent).



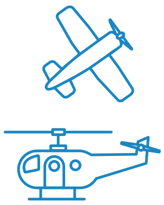
Enabling drones to comply with air traffic control
SJU reference: Integration of RPAS under instrument flight rules (IFR) (PJ.10-05)
This work provides the technical capability or procedural means to allow drones to comply with air traffic control instructions.

Tooling controllers for the future
SJU reference: Generic (non-geographical) controller validations (PJ.10-06)
This work refers to the development of advanced tools and concepts that will help to remove the qualification constraints imposed on controllers for controlling a single volume of airspace. This approach would allow controllers to operate in any airspace classified as a particular type.

Enhanced airborne collision avoidance for standard commercial air transport operations
SJU reference: Enhanced airborne collision avoidance for commercial air transport normal operations - ACAS Xa (PJ.11-A1)
This work refers to the use of ACAS Xa, an airborne collision avoidance system which takes advantage of optimised resolution advisories and of additional surveillance data, without changing the cockpit interface (i.e. same alerts and presentation in the current TCAS).

Enhanced airborne collision avoidance for drone operations
SJU reference: Enhanced airborne collision avoidance for RPAS – ACAS Xu (PJ.11-A2)
This work aims to provide airborne collision avoidance to drones, building on optimised resolution advisories and additional surveillance data, while taking into account the operational specificities of drones (the additional surveillance sources could be ADS-B but also any other sensor installed on the drones).

Enhanced airborne collision avoidance for specific commercial air transport operations
SJU reference: Enhanced airborne collision avoidance for commercial air transport specific operations – ACAS Xo (PJ.11-A3)
This work builds on optimised resolution advisories and additional surveillance data, while avoiding unnecessary triggering of resolution advisories (RAs) in new separation modes (e.g. ASAS), in particular if lower separation minima are considered.



Enhanced airborne collision avoidance for general aviation and rotorcraft
SJU reference: Enhanced airborne collision avoidance for general aviation and rotorcraft – ACAS Xp (PJ.11-A4)
This work takes into account their limited capability to carry equipment and their operational specificities.

Enhanced ground-based safety nets adapted to future operations
SJU reference: Enhanced ground-based safety nets adapted to future operations (PJ.11-G1)
This work refers to ground-based safety nets for SESAR future trajectory management and new separation modes through the use of wider more widespread information sharing and new surveillance means.

Optimised ATM network services

Addressing airspace users' needs within the Network

SJU reference: Airspace user processes for trajectory definition (PJ.07-01)

This work refers to the development of processes related to the flight operation centre (FOC) aimed at managing and updating the shared business trajectory, and fully integrating FOCs in the ATM Network processes. The processes respond to the need to accommodate individual airspace users' business needs and priorities without compromising the performance of the overall ATM system nor the performance of all stakeholders.

Airspace user fleet prioritisation and preferences

SJU reference: Airspace user fleet prioritisation and preferences (PJ.07-02)

The work sees the extension of airspace user capabilities, through the UDPP, allowing them to recommend a priority order request to the Network Manager and appropriate airport authorities for flights affected by delays on departure, arrival and en-route, and to share preferences with other ATM stakeholders in capacity-constrained situations.

Addressing military user needs within the Network

SJU reference: Mission trajectory-driven processes (PJ.07-03)

This work refers to the full integration of the wing operations centre (WOC) within the ATM system and the updating of WOC processes for the management of the shared and reference mission trajectory (SMT/RMT). These processes respond to the need to accommodate individual military airspace user needs and priorities without compromising the overall ATM system and the performance of all stakeholders.

Management of dynamic airspace configurations

SJU reference: Management of dynamic airspace configurations (PJ.08-01)

This work refers to the development of the process, procedures and tools related to dynamic airspace configuration (DAC), supporting dynamic mobile areas of Type 1 and Type 2. It consists of activating airspace configurations through an integrated collaborative decision making process, at national, sub-regional and regional levels; a seamless and coordinated approach to airspace configuration, from planning to execution phases. In doing so, the work allows the Network to continuously adapt to demand pattern changes in a free route environment and air traffic control sectors configurations adapted to dynamic TMA boundaries and both fixed and dynamic elements.

Dynamic airspace configuration supporting moving areas

SJU reference: Dynamic airspace configuration supporting moving areas (PJ.08-02)

This work extends the management of DAV to support dynamic mobile areas (DMA Type 3). This includes an impact assessment and the integration in the DAC process of areas that are potentially unsafe due to weather phenomena that can evolve in four dimensions.

Network prediction and performance

SJU reference: Network prediction and performance (PJ.09-01)

This work consists of improved traffic and demand forecasts based on a shared business trajectory and the computation of confidence indexes. Prediction of DCB constraints and complexity issues are based on the definition of metrics and algorithms for prediction, detection and assessment of traffic complexity, thus improving the accuracy and credibility of the diagnosis and awareness of hotspots.

Integrated local DCB processes

SJU reference: Integrated local DCB processes (PJ.09-02)

This work sees the seamless integration of local network management with extended air traffic control planning and arrival management activities in short-term and execution phases. The work will improve the efficiency of ATM resource management, as well as the effectiveness of complexity resolutions by closing the gap between local network management and extended ATC planning.

Collaborative network management

SJU reference: Collaborative network management functions (PJ.09-03)

This work allows for network management based on transparency, performance targets and agreed control mechanisms. The work enables a real-time visualisation of the evolving AOP/NOP planning environment (such as demand pattern and capacity bottlenecks) to support airspace user and local planning activities.

Enabling aviation infrastructure

CNS environment evolution

SJU reference: CNS environment evolution (PJ.14-01-01)

This work aims at identifying potential technological/functional synergies across the CNS domains to benefit from common system/infrastructure capabilities for both ground and airborne segments. The goal is to evaluate and define evolutionary steps towards an efficient and reliable integrated CNS provision.

Future communication infrastructure (FCI) terrestrial datalink

SJU reference: Future communication infrastructure (FCI) terrestrial datalink (PJ.14-02-01)

The work covers L-band digital aeronautical communications system (L-DACS) and digital voice communications.

FCI datalink

SJU reference: FCI datalink (PJ.14-02-02)

This work enables data communications in oceanic and remote regions and is complementary to terrestrial systems. The work will be carried out in cooperation with the European Space Agency Iris programme.

FCI network technologies

SJU reference: FCI network technologies (PJ.14-02-04)

This work sees the migration towards Internet protocol, enabling network-centric SWIM architectures and military interfacing.

New ADS-B services for general aviation

SJU reference: Development of new services similar to FIS-B to support ADS-B solutions for general aviation (PJ.14-02-05)

Development of new services similar to flight information system-broadcast (FIS-B) to support ADS-B solutions for general aviation.

AeroMACS integration in to the ground ATM infrastructure

SJU reference: Operationally validated AeroMACS development (PJ.14-02-06)

This work trials the deployment of AeroMACS at airport(s) with multiple mobile users, integrating AeroMACS on vehicles and EFB equipped aircraft. The aim is to support validation of other potential usages of the AeroMACS data link to support especially digital voice communication and multilink and to prepare/support the consideration of the AeroMACS enabler in demonstrating the AeroMACS capabilities with involving airport(s) and airlines.

GBAS for complex runway environments
SJU reference: GBAS (PJ.14-03-01)
The work sees the application of GBAS CAT III L1 (GBAS approach service type (GAST-D)) in order to maximise the benefits of GBAS technology down to CAT II/III minima.

Multi-constellation/Multi-frequency (MC/MF) GNSS
SJU reference: Multi-constellation/Multi-frequency (MC/MF) GNSS (PJ.14-03-02)
Multi-constellation/Multi-frequency (MC/MF) GNSS refers to standardisation developments for multi-constellation GNSS.

Alternative position, navigation and timing (A-PNT)
SJU reference: Alternative position, navigation and timing (A-PNT) (PJ.14-03-04)
This work covers fall-back capabilities in case of GNSS unavailability. A-PNT options could include distance measuring equipment (DME)/inertial reference system (IRS) hybridisation, multilateration and L-DACS mode N.

Surveillance performance monitoring
SJU reference: Surveillance performance monitoring (PJ.14-04-01)
This work refers to the development of a new surveillance system-wide area multilateration (WAM), multi-static primary surveillance radar (MSPSR), integrated CNS (ICNS) and space-based ADS-B.

Cooperative and non-cooperative surveillance
SJU reference: Cooperative and non-cooperative surveillance (PJ.14-04-03)
This sees the new use and evolution of cooperative and non-cooperative surveillance for ATM and A-SMGCS purposes.

Sub-regional demand capacity balancing service
SJU reference: Sub-regional demand capacity balancing service (PJ.15-01)
This service aims at facilitating an improved usage of the airspace at sub-regional level and facilitate tactical interventions when necessary, ensuring that any potential disruptions could be correctly managed. The scope also includes an AOP common service to facilitate the integration of AOP information into the NOP.

Delay sharing service
SJU reference: Delay sharing service (PJ.15-02)
This work aims to enable AMAN functionalities to operate within an extended horizon to provide local and overall arrival sequences for planning and tactical operational purposes in a cross-border environment.

Trajectory prediction service
SJU reference: Trajectory prediction service (PJ.15-08)
This work aims at computing and distributing an accurate and consistent 4D trajectory and update as the flight progresses. The output could be used during different flight phases, such as an initial reference trajectory in the planning phase, as input for DCM during the tactical phase or to facilitate transfers during the operations phase.

Static aeronautical data service
SJU reference: Static aeronautical data service (PJ.15-10)
This work provides static aeronautical data in digital form to be used by different ATM systems (e.g. safety nets). The output is an AIXM-compliant dataset whose subsets can be retrieved by individual requests demanding specific geographical areas, attributes or functional features.

Aeronautical digital map service
SJU reference: Aeronautical digital map service (PJ.15-11)
The work provides digital maps ready to be used by different ATM systems (e.g. safety nets) when performing separation functions. The output is highly customisable in order to meet the different requirements from the consumers and easily convertible among different digital formats, as AIXM, GML, XML, etc.

Towards virtualisation
SJU reference: Work station, service interface definition and virtual centre concept (PJ.16-03)
The work provides an operating environment in which different air traffic service units, even across different ANSPs, can appear as a single unit and can be subject to operational and technical interoperability. Based on the virtual centre concept, the CWP/HMI needs to interface with one or more information service providers or consumers.

Data centre services for virtual centres
SJU reference: Data centre services for virtual centres (PJ.15-09)
The work aims to provide air traffic services using standardised operating methods, procedures and technical equipment. The service would be seen as a unique system from the consumer's perspective, rather than the current fragmented situation.

Advanced human machine interface (HMI) technologies
SJU reference: Workstation, Controller productivity (PJ.16-04)
This work aims to increase the efficiency of service provision through the development of new human machine interface (HMI) interaction modes in relation to other SESAR Solutions (including new user interface technologies, such as speech recognition, multi-touch and gaze detection).

Air-ground advisory information sharing (SWIM TI purple profile)
SJU reference: Air-ground advisory information sharing (SWIM TI purple profile) (PJ.17-01)
This work supports ATM operational improvements that depend on A/G information exchanges to enable better situational awareness and collaborative decision-making. This includes the specification of technical architecture and functions that are required to achieve full interoperability between air and ground SWIM segments and meet the safety and performance requirements required by airborne operations.

Ground-ground civil-military information sharing (SWIM TI green profile)
SJU reference: Ground-ground civil-military information sharing (SWIM TI green profile) (PJ.17-03)
This work ensures that protocols and data models used in military systems can be interfaced with SWIM with adequate quality of service levels maintained. It will complement the air-ground advisory information sharing (SWIM TI purple profile) for advisory services.

Improved mission trajectories
SJU reference: Mission trajectories (PJ.18-01)
The work sees the integration of mission trajectories into the TBO environment throughout all phases of trajectory planning and execution (SMT/RMT). Enhanced mission trajectory will be subject to trajectory management processes and contain 4D targets and ATM constraints.

Integration of trajectory management processes in planning and execution
SJU reference: Integration of trajectory management processes in planning and execution (PJ.18-02)
This work refers to the management, negotiation and sharing of the SBT/SMT, as well as the management, updating, revision and sharing of the RBT/RMT, and finally the transition from the SBT/SMT to the RBT/RMT. The solution consolidates the extension of the trajectory and flight plan information exchange and delivers the technical solution to provide the infrastructure enabling seamless operation and trajectory sharing in response to the need of the SESAR Solutions.

Improved trajectory management through data sharing
SJU reference: Management and sharing of data used in trajectory (AIM, METEO) (PJ.18-04)
This work will allow greater flexibility to meet the full 4D trajectory management requirements and is expected to come with further proposals on operational, technical and institutional aspects of how aeronautical data should be identified and exchanged.

Performance-based trajectory prediction
SJU reference: Performance-based trajectory prediction (PJ.18-06)
This refers to data exchange between air and ground and the use of other sources in order to support all advanced operational processes required in SESAR 2020. The work looks at how the trajectory predictions for ATC, FOC and NM can be improved, taking into account all possible data sources (legacy or not).

ANNEX 3

Glossary

ACAS	Airborne collision avoidance system
A-CDM	Airport collaborative decision making
ADDEP	Airport departure data entry panel
ADS-B	Automatic dependent surveillance – broadcast
AEEC	Airlines Electronic Engineering Committee
AFIS	Aerodrome flight information services
AFUA	Advanced flexible use of airspace
AIRM	Aeronautical information reference model
AIXM	Aeronautical information exchange model
ANSP	Airspace navigation service provider
AO	Airport operators
AOC	Airline operational control
AOP	Airport operations plan
AMAN	Arrival manager
A-PNT	Alternative position, navigation and timing
APOC	Airport operations centre
ASAS	Airborne separation assistance system
A-SMGCS	Advanced surface movement guidance and control systems
ATC	Air traffic control
ATFCM	Advanced short-term air traffic flow capacity management
ATM	Air traffic management
ATV	Air transit view
AU	Airspace user
CAPP	CDTI assisted pilot procedure
CAR	Complexity assessment and resolution
CBA	Cost-benefit analysis
CDA	Continuous descent approach
CDM	Collaborative decision making
CDO	Continuous descent operations
CDTI	Cockpit display of traffic information
CNS	Communications, navigation and surveillance
CONOPS	Concept of Operations
COS	Conflict organiser and signaller
CPDLC	Controller-pilot datalink communications
CTA	Controlled time of arrival
CTOT	Calculated take-off times
DAC	Dynamic airspace configuration
DCB	Dynamic capacity balancing
DMAN	Departure manager
DME	Distance measuring equipment
D-TAXI	Datalink taxi
DMIT	De-icing management tool
E-AMAN	Extended AMAN
EASA	European Aviation Safety Agency
EATMA	European ATM architecture
EDIT	Estimated de-icing time
EEZT	Estimated end of de-icing Time
EFB	Electronic flight bag
EFPL	Extended flight plan
eFDP	Electronic flight data processing
EGNOS	European Geostationary Navigation Overlay Service
EOCVM	European operational concept validation methodology

EPP	Extended projected profile
ERM	Environment reference material
ESA	European Space Agency
EVS	Enhanced vision systems
EU	European Union
FAB	Functional Airspace Block
FABEC	Functional Airspace Block Europe Central
FASTI	First ATC support tools implementation
FCI	Future communication infrastructure
FF-ICE	Flight and flow information for the collaborative environment concept
FIS-B	Flight information system-broadcast
FMP	Flow management position
FOC	Flight operation centre
FRA	Free route airspace
FRT	Fixed radius transition
GBAS	Ground-based augmentation system
GLS	GBAS landing system
GNSS	Global navigation satellite system
GPS	Global positioning system
HMI	Human machine interface
i4D	Initial four dimensional trajectory management
ICAO	International Civil Aviation Organization
ICT	Information and communications technology
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ILS	Instrument landing system
IRS	Inertial reference system
ISRM	Information service reference model
ITF	In-trail follow
ITM	In-trail merge
JU	Joint Undertaking
LPV	Localiser performance with vertical guidance
MC/MF	Multi-constellation/Multi-frequency
METSPs	Meteorological service providers
MLAT	Multilateration
MONA	Monitoring aids
MOPS	Minimum operational performance standards
MSPSR	Multi-static primary surveillance radar
MTCD	Medium-term conflict detection
NM	Nautical mile
NM	Network Manager
NOP	Network operations plan
NOTAM	Notice to airmen
OLDI	On-line data interchange
PCP	Pilot Common Project
PBN	Performance-based navigation
PinS	Point-in-space
P-RNAV	Precision area navigation
PWS	Pair wise separation
RA	Resolution advisory
REL	Runway entrance lights
RF	Radius-to-fix
RIL	Runway intersection lights
RNP	Required navigation performance
ROT	Runway occupancy time
RSP	Required surveillance performance
RTA	Required time of arrival
RTS	Remote tower services
RWSL	Runway status light
SATCOM	Satellite communications
SDPD	Surveillance data processing and distribution
SecRAM	SESAR ATM security risk assessment methodology
SES	Single European Sky
SESAR	Single European Sky ATM Research

SIGMET	Significant meteorological information
SMGCS	Surface movement guidance and control system
SMR	Surface movement radar
SRM	Safety reference material
STAM	Short-term ATFM measures
STCA	Short-term conflict alert
SVS	Synthetic vision systems
SWIM	System-wide information management
SWIM TI	SWIM technical infrastructure
TBS	Time-based separation
TCAS	Traffic alert and collision avoidance system
THL	Take-off hold lights
TMA	Terminal manoeuvering area
TOBT	Target off-block time
TP	Trajectory predictors
TSAT	Target start-up approval time
TTL	Time-to-lose
TTOT	Target take-off time
UDPP	User-driven prioritisation process
VPA	Variable profile areas
V-PAT	Vertical flight path analysis
WAM	Wide area multilateration
WeP	What-else probing
WiMAX	Aviation airport surface datalink system
WOC	Wing operations centre

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