SESAR - ACHIEVING ENVIRONMENTAL BENEFITS THROUGH OPERATIONAL EFFICIENCY

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Background on SESAR

The performance of Europe's air traffic management (ATM) system is critically important for the sustainability of aviation and air transport, two sectors which drive European competitiveness, mobility and employment.

SESAR is the technological pillar of the Single European Sky (SES), an EU-wide policy designed to enable ATM to handle a three-fold increase in capacity, improve safety by a factor of 10, enable a 10% reduction in CO_2 emissions per flight and reduce the unit cost of ATM services to the airspace users by 50%. As European traffic is expected to increase from 9.5 million flights in 2012 to nearly 14.4 million in 2035, the challenge for Europe is to meet this expected growth in demand while minimising its environmental impact. SESAR's research and development (R&D) phase is managed by the SESAR Joint Undertaking (SJU) a public-private partnership.

The ATM Master Plan is the strategic plan for ATM improvements in Europe with an outlook period of 20 years, fully aligned with the Global ATM Operational Concept (GATMOC) and the ICAO Global Air Navigation Plan (GANP). Guided by and supporting the European ATM Master Plan, the SESAR Joint Undertaking (SESAR JU) is responsible for concentrating all ATM R&D efforts, and for defining, developing and validating SESAR Solutions in preparation for their deployment. These solutions address all parts of the ATM value chain, from airspace users, airports, air traffic services to the network, as well as the underlying systems architectures, technical systems and infrastructural enablers, validated in real day-to-day operations systems. The early implementation of several of these solutions is already underway, demonstrating SESAR's role in transforming Europe's ATM network into a modern, cohesive and performance-based operational system.

Further proof of the readiness of SESAR R&D is the decision by the European Commission to package a first set of SESAR solutions into a Pilot Common Project (PCP)[1], which are considered mature enough and ready for synchronised deployments across Europe (2015-2020). The SESAR Deployment Programme, which is managed by the SESAR Deployment Manager, aims to ensure that solutions delivered by the SESAR JU are delivered into everyday operations across Europe, delivering significant benefits to airspace users and the environment. Preparations are underway to deploy the solutions contained in the PCP between 2018 and 2025.

In line with the performance-based approach for ICAO's Aviation System Block Upgrades (ASBUs) methodology implementation, the whole SESAR framework stems from a performance-based approach, with the setting up of SESAR performance ambitions, aligned the policy targets of the Single European Sky requiring the design of the European ATM system to be able to handle a three-fold increase in capacity, improve safety by a factor of 10, enable a 10% reduction in CO_2 emissions per flight and reduce the unit cost of ATM services to the airspace users by 50%. Those SESAR performance ambitions have been expressed in terms of Key Performance Indicators (KPIs) in the areas of capacity, cost efficiency (ANS productivity), operational efficiency, environment, safety and security. Those KPI's include e.g. departure delays, fuel burn per flight, CO_2 emission, gate-to-gate ANS cost, as illustrated in the figure below.

SESAR ambitions to enable a 10% reduction in CO_2 emiissions per flight

Figure 1. SESAR's Performance targets

This article presents a summary of the SESAR R&D developments from an environmental perspective (by end-2015). Details of the entire SESAR R&D work programme can be found on the SJU website (www.sesarju.eu).

Delivering 'High-Performing Aviation for Europe'

The specific SESAR contribution to the SES high-level goals are continuously reviewed and kept up to date in the European ATM Master Plan, the main planning tool for defining ATM modernisation priorities and ensuring that the SESAR Target Concept becomes a reality. Built in collaboration with all aviation stakeholders, 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.

Published in December 2015, the latest edition provides a comprehensive vision of the future ATM system, which is built around the notion of 'trajectory-based operations' and the provision of air navigation services (ANS) in support of the execution of the civil business or military mission trajectory — meaning that aircraft can fly their preferred trajectories without being constrained by airspace configurations. This vision is enabled by a progressive increase of the level of automation support, the implementation of virtualisation technologies, as well as the use of standardised and interoperable systems. The system infrastructure will gradually evolve with digitalisation technology, allowing air navigation service providers (ANSPs), irrespective of national borders, to plug in their operations where needed, supported by a range of information services. Airports will be fully integrated into the ATM network level, which will facilitate and optimise airspace user operations.

Deployment synchronisation of critical changes is also reflected in the Plan, ensuring convergence of timelines across stakeholders. Through this collaborative and holistic approach to planning and reporting, European stakeholders continue to demonstrate their commitment to lead the way in the global ATM and aviation market. In this global arena, the plan is instrumental for aligning priorities and planning across world regions to ensure harmonisation and interoperability.

The performance targets for environment in the 2015 Master Plan are to reduce fuel burn by between 250 and 500 kg per flight by 2035. The programme first phase (SESAR 1) from 2007 to 2016 aimed to contribute a 2.8% reduction to the SES objective, which amounts to approximately 134kg of fuel per flight.

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Delivering Concrete Solutions Targeting Fuel Efficiency

SESAR defines, develops, validates and delivers to aviation stakeholders innovative technological and operational solutions for managing air traffic in a more efficient manner in the form of yearly Releases. A SESAR Release is a sub-set of the SESAR Programme that focuses on groups of validation projects delivering, in a specific timeframe, R&D results that will support a decision to move related activities to the industrialisation phase. It is expected that the SESAR R&D work programme will result in over 50 solutions by the end of 2016, delivered in five Releases. In order to assess the environmental benefits SESAR has developed a set of tools, *IMPACT*, to measure the environmental impact of each of its solutions for fuel, noise and local air quality impacts.

Each solution consists of a series of simulations and/or live trials with associated validation targets and goals that are assessed in a harmonised and consistent manner. Some examples are provided below of the Solutions that have significant environmental benefits that were assessed using IMPACT.

Integrating Airports and Optimising Operations on the Ground

Taxiing can represent almost one third of total fuel burn for a short haul flight if waiting in queue adds to the time on the ground. SESAR developed solutions which allow aircraft to move more smoothly and efficiently from the terminal to the runway, without unnecessary queuing or stops. The SESAR solution **departure manager (DMAN) baseline to be used for the integration of AMAN and DMAN** validated at Paris Charles de Gaulle airport showed benefits in terms of environment sustainability and cost-effectiveness, with a significant reduction in fuel burn and CO_2 emissions (average reduction of 14.6 kg per flight, corresponding to 46.6 kg drop in CO_2 emissions) due to reduced waiting and taxi times.

Another solution improving ground operations is **pre-departure sequencing supported by route planning** to deliver an optimal traffic flow to the runway. The main objective of this solution is to optimise the traffic flow delivered to the runway supported by a DMAN and the routing and planning function of advanced surface movement guidance and control systems (A-SMGCS). The combination of these two systems allows a reduction in the waiting time at the runway holding point, increased taxi-out accuracy and hence greater take-off time predictability, as well as provides for a more stable pre-departure sequence (target start-up approval time or TSAT).

SESAR is also working on de-icing procedures at airports, which in addition to improving operational efficiency can also allow for better management of wastewater, for example. Validation exercises aiming to integrate de-icing operations into the airport operations plan (AOP) have been carried out in Oslo. The ultimate goal is to see a de-icing management tool (DIMT) shared among all airport stakeholders in the A-CDM so that everybody can plan adequately.

En-route: Flying the Optimum Route

SESAR makes it possible for aircraft to freely plan and fly the most efficient route between departure and destination, both within Europe and on trans-continental flights. The concept of **free routing** provides important fuel savings by reducing flown distance and flight time in all en-route airspace categories and allowing carrying less fuel. Flight-trials in the Maastricht Upper Airspace Control Centre have shown that the free route solution could reduce flight distances by 5% and flight times by 2 minutes, leading to a 12% reduction in fuel burn and emissions.

Extended flight plan is another example of achieving efficiency and reducing fuel in the en-route phase. It makes use of the flight management system and communication capabilities of the aircraft and ground systems in order to share and integrate data, and optimise the aircraft trajectory in all four dimensions. This enables a more efficient and predictable handling of flights.

The SESAR solution enhanced terminal operations with LPV procedures consists of an innovative required navigation performance (RNP) approach procedure to localizer performance with vertical guidance (LPV) minima focusing on the initial and intermediate approach segments. LPV procedures do not require any new equipment at the airport. This 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.

Departures and Arrivals: Creating Fewer Delays, Optimising Descent Paths and Reducing Aircraft Noise

Today, aircraft making their final approach to land are obliged to maintain minimum distances between one another. In strong headwinds, longer gaps inevitably develop between airplanes. The SESAR solution of **time-based separation** replaces current distance separations with time intervals. Exercises at London Heathrow Airport showed that this solution allows up to five more aircraft to land per hour in strong wind conditions, thereby reducing holding times by up to 10 minutes, and fuel consumption by 10% per flight.

Continuous descent operations (CDO) from top of descent to runway in medium to high density/complexity TMAs will bring the largest environment benefits by reducing level-offs in the descent phase. CDO enabled by Point Merge in high density and complex environments have also been proven to be beneficial.

Approach procedures with vertical guidance (APVs) have been shown to provide fuel efficiency benefits in low density areas.

Another example is **extended arrival management** (E-AMAN). Today, arriving airport 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. E-AMAN allows for the sequencing of arrival traffic much earlier than is currently the case, by extending the AMAN horizon from the airspace around the airport to further upstream. Controllers in the upstream and cross border sectors, including those in neighbouring FABs, can instruct pilots to adjust aircraft speed before beginning descent, thereby reducing the need for holding. The results from SESAR flight trials show that this solution offers valuable reductions in fuel consumption and CO_2 emissions.

SESAR solutions also aim to improve the measurement and management of noise. At Brussels airport, a SESAR-enabled **optimised descent operations** allowed aircraft to reduce its noise impact on the ground of up to 6dB, at between 7.5 to 30 nautical miles from the airport runway.

Already implemented!
The solutions below are currently being used in live operations by airspace users:

- Time-based separation at Heathrow Airport;
- Cross-border arrival management (XMAN) for London Heathrow, managed by NATS, is the world's first implementation of the SESAR Extended Arrival Management solution with multi-ANSP partners;
- Point Merge procedures implemented in Paris Charles de Gaulle and Oslo.

Seeing is Believing

In addition to its R&D activities, the SJU co-finances demonstration projects run by consortia, including an even wider range of different types of stakeholders, and mandatorily an airline. Since 2009, 33 Atlantic Interoperability Initiative to Reduce Emissions (AIRE) projects were co-financed, demonstrating SESAR solutions in real operational conditions with commercial flights. A total of 15,483 flight trials were conducted involving 17 ANSPs, 26 airlines, and 9 airports. These projects demonstrated savings ranging from 60 to 3,100 kg of CO_2 per flight. The solutions demonstrated often resulted in improved day-to-day operations. Furthermore, important findings on ATM capabilities and data assessment needed were highlighted during these demonstrations.

Since 2009, a total of 15,483 flight trials were conducted as part of the AIRE projects, demonstrating savings ranging from 60 to 3,100 kg of CO_2 per flight

These trials have almost entirely used technology which is already in place, but until the relevant AIRE project came along, air traffic controllers and other users had not necessarily thought deeply about how to make the best use operationally of that technology. The following improvement areas/solutions have now been implemented to a large extent thanks to these trials:

- **Lateral [separation] optimisation** for any flight that requests it in Santa Maria and New York oceanic airspace;
- **Continuous descent operations** procedures published for Madrid, Gothenburg, Prague, Toulouse, and Riga airports;
- Development of **required navigation performance authorisation required (RNP AR) procedures** in Sweden and Latvia;
- Development of required **navigation performance standard terminal arrival route (RNP STAR)** and **authorisation required approach (RNP AR)** procedures in Lanzarote and La Palma airports.

AIRE has been a pioneer programme and helped other regions to follow the same path. For example, the ENGAGE project led by NAV CANADA capitalising on trials carried out in Santa Maria and New York oceanic airspace has successfully demonstrated the viability and safety of aircraft varying speeds (Mach) and altitudes while transiting the unsurveilled airspace also over the North Atlantic, and the TOPFLIGHT project demonstrated multiple elements of the SESAR concept in the gate-to-gate optimisation of transatlantic flights between North America and Europe. TOPFLIGHT demonstrated the feasibility and benefits of the SESAR concept and reinforced commitment regarding the early transition of some of those elements into sustainable operations in complex TMA, high-density en-route and oceanic environments.

Future Activities

In 2014, the European Union adopted legislation extending the legal mandate of the SJU until December 2024. In addition, the amending regulation entrusted the SJU with executing and delivering the SESAR Research & Innovation 2020 Programme (SESAR 2020) to contribute towards achieving the Single European Sky and more specifically, the European ATM Master Plan.

SESAR 2020 activities have already started with the launching of exploratory research activities, and will continue in 2016 with new R&D projects to deliver solutions in response to the evolving needs of Europe's aviation and air transport industries captured in the European ATM Master Plan. More solutions bringing environmental benefits will be developed and will aim to contribute to achieving high performance aviation in Europe.

Conclusions

Consistent with the ASBUs methodology, Europe's approach to the GANP implementation is based on the SES institutional/regulatory framework and the SESAR programme. The ATM Master Plan is Europe's strategic plan in fully alignment with the GATMOC and the GANP.

With 25 delivered solutions to date and over 30 more to be delivered during its first phase, the SESAR R&D programme is undeniably meeting its environmental objectives and providing concrete options and ways to help reduce the environmental impact of aviation.

References

1. European Commission Implementing Regulation (EU) No 716/2014 of 27 June 2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan Text with EEA relevance.