SESAR AND THE DIGITAL TRANSFORMATION OF EUROPE'S AIRPORTS

ACI
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AIRPORTS COUNCIL
INTERNATIONAL

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FOREWORD
OLIVIER JANKOVEC

OLIVIER JANKOVEC
Director General
ACI EUROPE

The swift evolution of air transport from perilous luxury service to safe, highly commoditised consumer product is one of the greatest developments of the 20th century.

Yet, when something becomes accessible to all, it loses its exclusivity and some of its mystique. When a service is safe and delivered reasonably smoothly, people become less concerned with how it works, how the system behind it operates, and how it is changing and evolving over time.

This is the place where air transport in Europe finds itself today. The 21st-century emphasis on 'user experience' at all points of business-to-customer (B2C) service delivery means that so much of what we read and hear about is focused on the 'front of house' part of air transport – the visible parts of the passenger experience.

And yet, the passenger experience is primarily conditioned by what happens 'behind the scenes', with operational efficiency at its core. This is where new technology and related processes come into play, in particular the vast miscellany of new metrics that feed analytics, the software, the hardware, the internet of things.

All these developments are now redefining the business-to-business (B2B) part of air transport, and they are putting Europe's airports on the path of digital transformation. This digital transformation enables increased operational integration between airports and their partners, starting with ANSPs and airlines. This is about breaking operations silos, taking predictability to new levels, unleashing latent capacity, reducing costs – and ultimately placing the passenger at the very core of our operations.

But, just like for any other business, digital transformation is not straightforward and can come with a great many uncertainties, challenges and risks. This is why SESAR

is so important not just for airports, but for the entire aviation system.

SESAR is both the test-bed and gateway to the widest collection of proven technological solutions for airport operations in Europe. As such, it has come to play an important role in advancing the business of airports and their competitive edge – alongside the delivery of the Single European Sky technological pillar of ATM modernisation.

This is why ACI EUROPE closely cooperates with the SESAR Joint Undertaking, and is directly involved in the deployment of SESAR. I am extremely pleased that with this publication we now have a comprehensive yet accessible account of SESAR solutions available to airports. Building on our previous guidance on digital transformation, it is designed to help you take stock of the possibilities that the digital revolution presents for your airport. As you can read, digitalisation brings multi-faceted benefits: operational performance, capacity maximisation, environmental protection, improved safety – everything is connected.

Looking forward, exciting times lie ahead. Disruption in the aviation sector will come from further structural market changes, new air connectivity patterns, changing consumer behaviours and societal values. There is no doubt that technology and digitalisation will play a major role in enabling and shaping these disruption factors. The SESAR JU is already gearing up for these future challenges.

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MESSAGE FROM FLORIAN GUILLERMET

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FLORIAN GUILLERMET
Executive Director
SESAR Joint Undertaking

Airports are not only vital nodes in the air traffic management (ATM) system, they are also catalysts for change. We have seen this for ourselves, through the research and development activities carried out at airports big and small across Europe over the last decade.

There is a real appetite to make use of the latest technologies available to improve the efficiency of airport operations and ultimately to provide their customers, both passengers and airlines, with a better service and experience.

Through our collaboration with ACI EUROPE and the direct membership of airports through the SESAR Airport Consortium, we are embracing digital disruption in order to advance the development and uptake of solutions that will transform airside operations in the years to come.

We are grateful to ACI EUROPE for showcasing some of these solutions in this publication and placing them in the context of the broader digital transformation of Europe's airports.

SESAR
JOINT UNDERTAKING

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CHAPTER 1: THE FIRST STEPS

INTRODUCTION: UNDERSTANDING DIGITAL

The speed of innovation has increased markedly in the past two decades. The abundance of powerful portable devices, specialised channels and the vast array of ways and means for us to exchange information have resulted in enormous change in the ways we communicate and share information, both personally and professionally. But in a world of increasing buzzwords, what exactly should we understand from the word 'digital'?

THE MEANING OF DIGITAL

Digital can mean different things to different people – it has connotations of screens, data, coding, gadgetry, security, new forms of access, new genres of communication, innovation and of course, speed.

In pure communications terms – consider the example of how the digital revolution has changed personal, corporate and crisis communications beyond recognition.

In the context of the air travel experience, digital innovation has changed nearly every step of the process – from buying the ticket (online or mobile), travelling to the airport (car-sharing empowered by a smartphone app), automated or self check-in technology, to data-driven security pre-clearance, geotagged airport retail offers, and tailored social media messaging about the status of your flight.

In the past year, Airports Council International (ACI) has published two key manuals designed to help airports to better grasp the opportunities presented by digital innovation, by providing a roadmap to becoming a 'digital airport'.

The first, the *Airport Digital Transformation Best Practice,* published by ACI World, is intended as a decision and implementation aid for airport managers who are responsible for choosing the right digital solutions for their airport operators and companies.

Digital innovation has changed nearly every step of the process – from buying the ticket (online or mobile), travelling to the airport (car-sharing empowered by a smartphone app), automated or self check-in technology, to data-driven security pre-clearance, geotagged airport retail offers and tailored social media messaging about the status of your flight."

Meanwhile, the second edition of ACI EUROPE's *Guidelines on Passenger Services at European Airports* emphasises the importance of using technology to place passengers at the heart of the airport business.

This report notes: "Business success is not just about the deployment of new technologies, simply because IT systems and applications change too quickly. Instead, success is about transforming the airport business, adapting to passengers, staff and stakeholders, and leveraging existing and new technologies to meet objectives and goals.

"Therefore, digital transformation is about evolving processes and services to deliver a better experience to all passengers and users. From a passenger's point of view, a better experience means a personalised and individual experience that offers a seamless flow through the airport. It starts before the passenger even arrives at the terminal."

Reflecting on the importance of the new Guidelines, ACI EUROPE's Director General, Olivier Jankovec, said: "These new Guidelines are not just a reminder but a comprehensive illustration of how the airport business isn't just B2B with the airlines but, now more than ever, B2C. Today, the passenger is at the very heart of the airport business."

ACI has also been looking at assessing the future of air transport in the context of the New Experience Travel Technologies (NEXTT)[1] initiative with IATA. NEXTT highlights the need to focus on the complete journey from home to the end destination and to harness the latest technologies for all airport operations. It focuses on all the elements of the journey (passenger, baggage, aircraft and cargo) to improve the passenger experience and overall efficiency. All the innovations related to aircraft – one of the four key elements of the journey – are the areas covered by SESAR.

[1] https://nextt.iata.org/?page=main&data=aircraft

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BUSINESS IMPLICATIONS

The irrevocable change has occurred so rapidly that industries and sectors have had to strategise and invest in order to exploit the opportunities for better, faster, more efficient communications and operations.

If we compare how and on what basis people and companies make decisions today with the situation two decades ago, the key differences are efficiency and the strategic importance of key performers indicators (KPIs). To put it another way, the two most distinctive factors are: (1) Speed of information (both incoming or outgoing) and (2) Availability of data, in the form of business intelligence or analytics.

These factors are obviously very pertinent for any sector dealing with the logistical complexity of sharing large volumes of information, planning and rapid decision-making between a diverse group of stakeholders.

Aviation is a prime example, and change is already occurring at a very rapid pace, as the timeline below reveals:

TIMELINE SO FAR: A WAVE OF CHANGE IN AVIATION

2004 The European Union (EU) gains competences in air traffic management (ATM) and announces a new vision of ATM reform in order to deliver a Single European Sky (SES).

2007 The SESAR Joint Undertaking (SESAR JU) – the technological pillar of Europe's Single European Sky (SES) initiative – is set up as a €2.1 billion public/private partnership to coordinate and concentrate all EU research and development (R&D) activities in ATM, and speed up market uptake of new technologies.

June 2007 Munich Airport becomes the first airport in Europe to fully implement Airport Collaborative Decision-Making (A-CDM), the process that enables airport stakeholders to share more real-time information, generating new efficiencies and promoting better use of airport capacity.

April 2010 Volcanic ash puts air traffic management in the spotlight. It also prompts more airport brands to start communicating with passenger directly via social media channels – disrupting what was previously an exclusively airline-passenger dialogue.

October 2011 — The first Boeing 787 Dreamliner – an entirely new type of airliner containing a host of digital innovations – enters into service, making medium and long-haul point-to-point connectivity more economically viable.

December 2014 — Recognising its added value to innovation, the SESAR JU is extended until 2024 with a budget of €1.6 billion. The European Commission also announces €3 billion in EU funding for the SESAR Deployment Manager – in order to modernise and enhance the performance of Europe's ATM system, making it safer, smarter, cheaper and greener.

December 2014 — Heathrow Airport establishes its own Airport Operations Centre (APOC) based on the APOC concept developed by SESAR to monitor and oversee airport operations more efficiently.

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January 2015 — The Airbus A350, competitor to Boeing's 787, enters service.

April 2015 — The world's first remote tower starts to operate at Örnsköldsvik Airport in northern Sweden.

May-June 2015 — Crowdsourcing innovation, Groupe ADP and Schiphol Group jointly organise the first dedicated airport hackathon, called Hack & Fly.

June 2016 — In its *Airport Industry Connectivity Report,* ACI EUROPE reveals that between 2006 and 2015, 99 % of the growth at Top 10 airports came from low-cost carriers who prioritise turnaround efficiency.

December 2017 — Over 630 Boeing 787s have now entered service.

June 2018 — The European Parliament adopts first ever EU aviation safety rules for the civil use of drones in European airspace.

However, let's not be under any illusions – a 'digital airport' still exists to provide the very real and analogue facility for aircraft to take off and land: to land with one set of passengers and freight and take off with another. It is the possibilities offered by software-led and, in some cases, highly mobile innovative solutions, as well as more effective linkage with ATM advancements, that can transform an airport for the digital age.

What follows in the pages ahead aims to help you assess the technologies and solutions that have been developed by SESAR on the airside front – the stage they are at, the benefits and efficiencies they provide – all with a view to empowering you and your airport with the digital tools to enable your business transformation into a digital airport.

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THE DIGITAL TRANSFORMATION OF AIRPORTS

IT innovation continues to change the way people travel. It will also influence how airports and airlines operate, with the use of biometrics, artificial intelligence, machine learning, robotics, virtual reality and blockchain – to name but a few technologies – that are set to further transform the business over the coming decades.

Indeed, the smart use of technology is expected to help airports better manage the challenge of rising traffic demand by raising the capacity of existing facilities, while at the same time making the airport experience easier, more comfortable, convenient and enjoyable for passengers.

Describing the digital transformation taking place at airports, Barbara Dalibard, CEO of the global technology provider SITA, said in early 2018: "Already biometrics is becoming more commonplace at airports around the world and is delivering secure seamless travel from check-in to boarding.

"By embracing the internet of things and connecting everything across the industry we will produce more data that can be used with artificial intelligence to create valuable insights and expose new ways of working.

"Over the next 20 years, this use of digital technologies to improve service, operations and efficiency will have profound effects on the air transport industry."

SESAR: DELIVERING SOLUTIONS FOR A DIGITAL ERA

The changes taking place at airports reflect the broader changes happening in the world of aviation, starting with aircraft themselves, which are set to become more autonomous, more connected, more intelligent and more diverse.

At the same time, air traffic is projected to grow significantly, from several thousands of conventional aircraft in operation every day to potentially hundreds of thousands of air vehicles (such as drones), operating in all areas, including cities. Services must also evolve, as tomorrow's passengers increasingly expect smart and personalised mobility options that allow them to travel seamlessly and efficiently.

Established as the technological pillar of the Single European Sky, SESAR (Single European Sky Air Traffic Management Research) aims to increase the performance of European aviation through the delivery and deployment of technological and operation solutions fit for purpose for this digital era.

SESAR BUILDING BLOCKS

SESAR has three phases in its lifecycle:

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- **Definition:** The European ATM Master Plan is the European planning tool for defining ATM modernisation priorities and ensuring that SESAR Solutions become a reality. Both pragmatic and ambitious in its design, the plan provides a high-level view of what is needed to deliver the vision of a high-performing aviation system for Europe by 2035 and beyond. The ATM Master Plan is executed by the SESAR Joint Undertaking (SESAR JU), a public-private partnership (PPP) established as a community body in 2007.

- **Development:** SESAR has created an innovation pipeline through which promising ideas are explored and then moved out of the lab into real operations. The pipeline consists of exploratory research, industrial research and validation, as well as very large-scale demonstrations. The end products are operational and technical solutions, known as SESAR Solutions, which are delivered ready for industrialisation. This phase is managed by the SESAR JU.
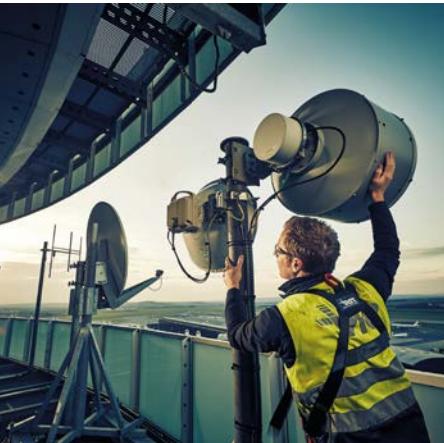
Since 2008, SESAR JU has researched, validated and delivered a catalogue of more than 60 solutions, many of which target airports' operational and business needs.

These solutions are bringing tangible benefits in terms of enhanced safety, increased capacity, increased operational efficiency and resilience, lower running costs and an improved environmental footprint.

Local implementations have already started, together with a number of synchronised deployments – joint initiatives involving more than one location – across 24 airports in Europe. Mindful of this, in 2016, SESAR JU launched SESAR 2020, the next wave of research and innovation, to address new opportunities and challenges.

• **Deployment:** SESAR Solutions are being implemented either to answer local needs, or in a timely, synchronised way under the EU's Pilot Common Project (PCP), to deliver the maximum benefit to Europe's airports.

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As an EU regulation governing the synchronised deployment of the first set of SESAR solutions, and in full accordance with the SESAR deployment programme, the PCP is expected to deliver around €12.1 billion in performance gains, for an investment of €3.8 billion between 2015 and 2024, and potential annual benefits to the aviation sector of up to €15 billion per annum beyond 2035.

From SESAR's perspective, synchronised deployment is managed by the SESAR Deployment Manager, which was established in December 2014 under a framework partnership arrangement with the European Commission.

Airport operators are represented in the SESAR Deployment Manager through the SESAR-Related Deployment Airport Grouping (SDAG), part of ACI EUROPE. SDAG is responsible for ensuring not only that airports implement enhancements that deliver performance improvement, but also that technologies and procedures have proven benefits.

SESAR AND AIRPORTS

It is easy to think that SESAR has little to do with Europe's airports, but that couldn't be further from the truth, as airports are front and central when it comes to accommodating future traffic growth. Every flight begins (and ends) at the airport.

Without doubt, Europe's airports are some of the most modern and best equipped in the world. But with ACI forecasts predicting that passenger numbers across the continent will rise an average of 3.3 % per annum to reach 3.9 billion by 2036, it is vital that airports become more operationally efficient, to ensure that air transport does not become a victim of its own success and run out of capacity on the ground in the next 20 years.

Some of the required capacity will, of course, be met by new infrastructure in the shape of new terminals, runways and even completely new airports, like Istanbul New Airport in Turkey.

However, with land for infrastructure development often at a premium and finding the funds to build new facilities a constant source of difficulty for airports, technology is going to play a pivotal role in enhancing the operational efficiency of airports in the years ahead, as well as ensuring the success of the Single European Sky initiative.

SESAR is working with airports and other stakeholders in the aviation value chain to develop and deliver the technological solutions that will equip the industry for growth, help meet passenger demand for seamless and smart air travel, and also make flying safer and more cost-efficient."

This is why SESAR is working with airports and other stakeholders in the aviation value chain to develop and deliver the technological solutions that will equip the industry for growth, help meet passenger demand for seamless and smart air travel, and also make flying safer and more cost-efficient.

The programme looks at what technologies can be developed for runway throughput, integrated surface management, airport safety nets, total airport management and remote towers. The programme also addresses emerging challenges such as the further integration of drones and cybersecurity.

The size of the airport is irrelevant, as the smart thinking and innovation needed to deliver the technological solutions

to ensure data integration is as relevant to mega-hubs like London Heathrow, Frankfurt, Paris-CDG and Amsterdam Schiphol as it is to regional gateways and tiny airports handling only a dozen flights a day. The benefits include more efficient aircraft movements for larger hubs and improved connectivity, resilience, cost efficiency and environmental sustainability for regional airports.

THE BUSINESS CASE FOR AIRPORTS

Competition between Europe's airports has never been fiercer, and the new operating environment, which offers more choice and flexibility for airlines and passengers across the continent, means that airports need to do all that they can to make maximum use of their facilities.

This means operating an efficient, customer-friendly airport that is safe, secure, proactive on environment and capable of meeting both current and future demand. To put it another way, an airport that effectively manages the expectations and needs of its stakeholders.

It also means embracing new technologies and new ways of doing business.

Better communications and an improved, coordinated exchange of information between aviation's key stakeholders – airports, airlines and the ANSPs – will, ultimately, determine how successful airports are in achieving these goals.

The need to do a better job of sharing information and data is nothing new, of course. Traditionally this is not something that the aviation industry has been very good at, with airports and airlines tending to operate as silos, and even on occasion arguing over who has a more direct connection with passengers.

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FIVE REASONS WHY AIRPORTS SHOULD SIGN UP TO SESAR

Enhanced safety

The SESAR airport-safety related solutions rely not only on improved information sharing and collaboration between stakeholders, but also on sophisticated support tools that help the human operator (ATCO, flight crew, vehicle drivers, etc.) make the right decision at the right time. This will enhance safety on the ground, and allow airports to safely and more efficiently handle more aircraft and ground support vehicles. Initiatives range from "Follow the Greens" and the seamless sharing of meteorological data, to runway status lights.

Optimised capacity

Europe faces a capacity crunch. EUROCONTROL's latest *Challenges of Growth* report [2] has warned that air traffic growth is currently accelerating to the point where it will exceed airport capacity to the tune of 1.5 million flights or 160 million passengers per annum from 2040. Such a scenario would mean missing the opportunity to create two million new jobs and losing nearly €88.1 billion per annum in economic activity.

SESAR solutions, such as flight sequencing for arrivals and departures, optimising traffic in and around the airport, and total airport management, will equip airports to make maximum use of their facilities.

Increased operational efficiency

As traffic grows and airports' physical expansion remains limited, operational efficiency becomes essential. A host of innovative developments, including airport operations centres, and big data for optimising traffic in and around the airport, will certainly help in this regard.

Reduced costs

According to the 2018 version of the Air Transport Action Group (ATAG) report, *Aviation: Benefits Beyond Borders* [3], aviation supports 12.2 million jobs in Europe and 4.2 % of the EU's GDP. Despite this, 46 % of Europe's airports operate at a loss. Of those airports handling less than one million passengers per annum, 71 % are in the red. Reducing costs therefore remains a top priority for airports, and is the reason

[2] European Aviation in 2040 - Challenges of Growth, EUROCONTROL, 2018.
[3] *Aviation Benefits Beyond Borders,* ATAG, 2018.

why automation and digitalisation will prove crucial in helping them drive down costs now and in the future. A number of SESAR initiatives are designed to do just this, and vary from remote towers to the implementation of satellite technologies like ground-based augmentation systems (GBAS).

Environmental mitigation

Gone are the days when aircraft noise was pretty much all airports had to be concerned about when it came to the environment. Today's airports have to be environmental stewards; they need to be seen to be green and committed to reducing their CO_2 emissions, aircraft fuel burn, and a whole host of other environmental targets, in order to retain their licence to grow. Runway management solutions specifically developed under the SESAR umbrella to combat these issues include advanced arrival procedures, enhanced surface operations, and improved flight sequencing for arriving and departing aircraft.

TIMELINE OF INNOVATION

Many of the SESAR solutions for airports to date have been targeted at their operational and business needs, including local and synchronised deployments. You can read more about them and the benefits they are already bringing to airports, the wider aviation industry and the travelling public in the following chapters.

Chapter 2 describes how airport operations today, and up to 2035, will be shaped by SESAR solutions. The chapter has a selection of solutions that are bringing benefits in terms of enhanced safety, increased capacity, improved operational efficiency, reduced costs, and environmental mitigation.

The solutions are clustered according to various operations – runway management, surface management, enhanced airport operations management and safety nets – and the chapter gives information about the suitability of the solution for airports of varying sizes.

Meanwhile, Chapter 3 looks into the crystal ball and considers what airport operations might look like beyond 2035, reflects on some emerging trends such as the development of drone technology, and how the digital transformation of airports and SESAR is already beginning to embrace some of them.

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2 THE STORY SO FAR

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CHAPTER 2:
THE STORY SO FAR

"ENABLING DIGITAL TECHNOLOGIES" KEY

Automated runway operations

- Decision support tools for air traffic controllers and pilots, which anticipate operational situations, analyse their consequences and propose remedial actions to ensure safe, efficient and sustainable runway operations.

- Algorithms fed with accurate and up-to-date data, which sequence the arrival and departure flows on the runway, to optimise its throughput and the predictability of the operations.

Automated surface operations

- Decision support tools for air traffic controllers, pilots and vehicle drivers, which anticipate operational situations, analyse their consequences and propose remedial actions to ensure safe, efficient and sustainable surface operations.

- Algorithms fed with accurate and up-to-date data, which optimise the flow of aircraft on the airport surface, making the operations safer, more efficient and more resilient.

Data-driven airport operations management

- Connected, data-based, intelligent toolbox supporting all the airport stakeholders in steering, monitoring and managing the operations for a highly resilient and efficient airport.

Digital or remote tower

- High-definition, infrared and pan-tilt-zoom cameras augmented by available radar and flight data and meteorological information to deliver cost-efficient and safe air traffic services remotely.

Enhanced vision technologies

- On-board augmented and virtual reality devices helping the pilots navigate on and around the airport, whatever the weather conditions or the equipage level of the airfield.

Satellite-based technologies

- Use of satellite-based navigation as a cost-efficient solution to enhance runway and surface operations performance, facilitate more efficient and greener arrival procedures, and support accessibility of secondary airports.

▼ © Milan Malpensa Airport / MXP

TRIALLING, DEVELOPING AND DEPLOYING

European airports must embrace a turning point in their history. The demand for air travel is on the rise, even as social and environmental constraints hinder the expansion of large airports and the ability of secondary airports to absorb the traffic overflow.

Continuing to offer excellent service to their aviation partners entails adopting new technologies and procedures that will enhance traffic throughput at existing facilities and maintain or improve safety.

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This chapter highlights some of the areas where pioneering new technologies, procedures and ways of working have been introduced, and in some cases deployed during SESAR 1, as well as the difference they have made. It also outlines what is in the pipeline for SESAR 2020.

The projects focus on optimising airport capacity while taking account of different traffic demands, future aircraft capability and airport configurations. They also improve access to regional airports, making the areas they serve economically attractive with the potential for new jobs.

Moreover, the solutions address and alleviate such environmental concerns as noise and aircraft carbon emissions.

RUNWAY MANAGEMENT

SATELLITE TECHNOLOGIES ALLOW NEW APPROACHES

Satellite-based navigation systems, such as the ground-based augmentation system (GBAS), are the natural successors to instrument landing systems (ILS).

Pilots have used ILS for approach and landing guidance in low-visibility conditions, such as heavy rain and low cloud, for more than 50 years. GBAS has already proved to be more reliable, cost-effective and dynamic, as it can guide aircraft through different approaches to different touchdown points on the runway.

Using global navigation satellite systems (GNSS) signals makes positioning even more accurate, with position errors of less than one metre in both the horizontal and vertical planes.

GBAS CAT I operations have been implemented at several European airports, including Bremen, Málaga-Costa del Sol, Frankfurt and Zurich. In collaboration with Lufthansa and German air navigation service provider, DFS, Frankfurt

▲ © Fraport

BENEFITS

Operational efficiency:
Improved resilience and reduced delays and disruptions are key GBAS advantages.

Reduced costs: *GBAS has lower installation and maintenance costs than ILS.*

Environmental mitigation:
Improved environmental mitigation results from shorter routes and noise abatement.

" *With the launch of this new landing procedure on the airport's existing runways, we are also evaluating possibilities for further active noise-protection measures."*

Anke Giesen
Executive Director of Operations, Fraport AG.

Airport introduced GBAS for CAT I approaches in 2014, and it has allowed for the adoption of approaches that have reduced noise levels in surrounding communities.

"Frankfurt Airport was the first hub worldwide to enable GBAS landings with a 3.2 degree angle of approach in the final approach," said Fraport AG's Executive Director of Operations, Anke Giesen.

"With the launch of this new landing procedure on the airport's existing runways, we are also evaluating possibilities for further active noise-protection measures."

SESAR R&D has focused on precision approaches using GBAS CAT II/III, and the solution is now ready for deployment. The next step for Frankfurt will be to introduce GBAS for CAT II/III operations.

GBAS is supplemented by the satellite-based augmentation system (SBAS), which uses GNSS data provided by geostationary satellites to cover wider areas.

Research is ongoing to investigate the use of satellite navigation and augmentation capabilities, such as GBAS and SBAS, to enhance landing performance and to facilitate advanced arrival procedures, such as curved approaches, glide slope increase, and 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.

TIME-BASED SEPARATION INCREASES EFFICIENCY

BENEFITS

Airfield safety: *Increased situational awareness improves safety.*

Optimised capacity: *As a result of increased aircraft landing rates in strong headwind conditions, capacity is optimised.*

Operational efficiency: *A reduction in holding times, as well as stack entry to touchdown times, improves operations.*

> *Time-based separation addresses the biggest single cause of arrival delays at the airport. Heathrow has been operating at 98 % capacity for over a decade so technology like this is essential, providing the best service possible to our passengers."*

Derek Provan
Heathrow's former Chief Operating Officer & Chief Executive Officer AGS Airports Limited.

Replacing fixed, minimum separation distances between flights with time-based separation (TBS) that is adjusted to wind conditions on approach, means more efficient use of the skies, and a consistent and reliable flow of traffic to airports.

Traditional distance-based separation minima often lead to delays in arrivals, as the gap between flights becomes bigger in strong headwind conditions. Having a precise knowledge of exactly when an aircraft will touch down means that airports can guarantee how many flights they will handle per hour and, just as importantly, have the resources ready on the ground to accommodate them.

At London Heathrow Airport, TBS has reduced aircraft holding times by 115,000 minutes per annum since it went live in March 2015, and it allows up to 2.6 extra landings per hour in strong winds [4].

"Time-based separation addresses the biggest single cause of arrival delays at the airport. Heathrow has been operating at 98 % capacity for over a decade so technology like this is essential, providing the best service possible to our passengers," said Derek Provan, Heathrow's former Chief Operating Officer and new Chief Executive Officer of AGS Airports Limited.

The solution will be deployed across Europe under the EU's Pilot Common Project.

The end product of TBS is increased safety, fewer delays and an improved environmental performance, not least by avoiding unnecessary fuel burn for the airlines. With TBS, air traffic controllers have real-time separation indicators, improving their situational awareness to manage aircraft.

The solution is primarily targeted at intercontinental and major European hubs. It is part of a suite of separation standards, including re-categorisation, that will provide greater efficiency in airport approaches.

[4] Customer Report, NATS, 2017.

SEPARATION OPTIMISATION

Lack of new runways, weather, wind and environmental issues, together with the wake turbulence formed behind an aircraft on departure and arrival, are the challenges to delivering additional capacity at Europe's airports.

Traditionally, international regulations require that three aircraft wake separation categories – light, medium and heavy – determine the wake vortex generated by an aircraft.

However, this is changing, and the European wake vortex re-categorisation scheme (RECAT-EU) means six categories now provide greater runway capacity in Europe. First deployed at Paris-CDG in late 2015, RECAT-EU has increased runway throughput at the airport by more than 10 % per hour during peak periods. Leipzig-Halle is also using this re-categorisation to optimise its freight movements, and London Heathrow, Vienna and Toulouse have also begun using the new separation standards.

The plan is to move this re-categorisation into an even more granular matrix, with every possible combination of commercial aircraft being defined in a pair-wise separation system. Deployment will be from 2022 onwards for ground-based solutions and beyond for airborne systems if interoperability with the ground has to be ensured.

These separation minima will be incorporated into time-based separation or TBS, which is another SESAR solution, deployed at London Heathrow and planned to be rolled out at 16 European airports by 2024.

Not only do airports benefit from an increase in arrival and departure runway capacity with RECAT and TBS, but also operational efficiency, predictability, resilience and safety are enhanced.

SESAR is exploring how to build on this work through separation support tools for air traffic controllers, ensuring their workload is not amplified. Research and development is also

BENEFITS

Airfield safety: *New separation standards will improve resilience while maintaining or increasing safety.*

Optimised capacity: *Improved wake turbulence separation will increase arrival and departure runway capacity, efficiency and predictability.*

Operational efficiency: *Improved productivity and performance.*

focusing on wake risk monitoring and awareness functions, both ground and airborne, and wake vortex decay enhancing devices.

When wake turbulence is not a consideration for air traffic control, reduced minimum radar separation can come into play to ensure that airports both large and small maximise their runway throughput. This reduction in radar separation is thanks to a better surveillance performance.

New technology will ensure that necessary separation is safely adhered to – and that accurate separation can be systematically achieved through enhanced positional accuracy.

EUROCONTROL's Head of Airport Research, Bob Graham, said: "The safety and throughput challenges are many, but the good news is that under SESAR we are making progress. We are safely reducing wake separation distances, which is significant, and are now preparing to deploy tools such as RECAT at Paris CDG and time-based separation standards at Heathrow and at many other airports.

"From our perspective, the work being done in SESAR is critical to optimising the existing real estate and creating more capacity, at an acceptable cost, to allow Europe's airports to meet future demand. This summer we saw the first indications of delays increasing significantly and, with new runways often taking years to win approval, new capacity-enhancing solutions are needed to avoid the huge shortfall in capacity predicted by 2040 in *EUROCONTROL's Challenges of Growth* report published earlier this year.

"Put in perspective, if we take the report's average prediction and not enough is done to make the current system more efficient, Europe will have 16 capacity-constrained airports by 2040, meaning that 160 million people per annum won't be able to fly."

Whilst the solutions are primarily targeted at intercontinental and major European hubs, there is increasing global interest, and this is encouraged through SESAR's international outreach and European policy.
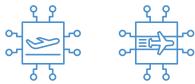
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From our perspective, the work being done in SESAR is critical to optimising the existing real estate and creating more capacity, at an acceptable cost, to allow Europe's airports to meet future demand."

Bob Graham
Head of Airport Research, EUROCONTROL.

► © Paris-Charles De Gaulle Airport / CDG

FLIGHT SEQUENCING FOR ARRIVALS AND DEPARTURES

Few things are more frustrating for passengers than sitting on board an aircraft as it is stuck in a queue on the tarmac waiting to take off. Airports and airlines are no happier as delays and unnecessary fuel burn mount up.

For many airports this kind of unpredictability is not an option, which is why some have adopted the departure manager (DMAN), a planning tool that is helping transform the departure management process from an informed estimate into a fine art.

Using information from different sources – airlines, ground handlers and air traffic controllers – courtesy of airport collaborative decision making (A-CDM) and the airport operations plan (AOP), DMAN calculates the optimal start-up, off-block and take-off times to ensure the quickest, most efficient and safest departure sequence.

Since its deployment at Paris-CDG, DMAN has shaved 8 % off of taxi times, saves 4,000 tonnes of fuel annually and reduces CO_2 emissions by 13,000 tonnes [5]– the equivalent of saving 170,000 trees per year.

Paris-CDG's Managing Director, Marc Houalla, says: "It has transformed the way we coordinate airport operations, especially airside, where we make a better use of ATM capacity. We are already much more efficient during crisis times, like huge operational disruptions events such as snowfalls. We are now looking at going further to provide real-time landside and airside performance monitoring to achieve total airport management."

As part of the EU's Pilot Common Project, DMAN can be further enhanced if it uses data provided by an advanced surface movement guidance and control system (A-SMGCS), as this will allow it to see where an aircraft is parked, its taxi route length, and any required adjustments if temporary restrictions are in place.

DMAN can also be integrated with its arrival equivalent, AMAN – which provides sequencing support based on trajectory predictions – to enable even more dynamic scheduling and runway configurations, that will help airports increase their overall throughput.

Exercises at Stockholm Arlanda and London Gatwick validated the use of route planning information provided by A-SMGCS and airborne trajectories to improve AMAN and DMAN integration and the calculation of an integrated runway sequence.

BENEFITS

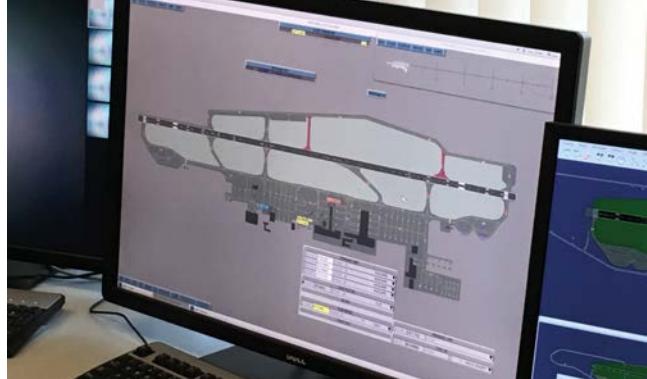**Optimised capacity:** *More efficient use of the runway means optimised capacity.*

Operational efficiency: *Efficiency gains are generated through improved predictability; enhanced tactical runway scheduling; and reduced waiting and taxi times and runway delays.*

Reduced costs: *Reduced aircraft fuel burn will reduce cost.*

Environmental mitigation: *Reduced CO_2 emissions.*

[5] Airport-CDM, DGAC-DSNA, 2014.

> **" It has transformed the way we coordinate airport operations, especially airside, where we make a better use of ATM capacity. We are already much more efficient during crisis times."**
>
> **Marc Houalla**
> *Managing Director, Paris-Charles De Gaulle Airport.*

The results showed increased predictability in terms of synchronised arrival and departure planning, and enhanced target take-off time (TTOT) and target landing times (TLDT), resulting in increased runway throughput and reduced fuel burn.

Talking about the benefits of integrating AMAN/DMAN at Arlanda, LFV's Jan-Olof Roos, says: "In SESAR 2020, we are working with a sequence-based coupled AMAN/DMAN that is dynamically updated. This means setting the combined sequence between arrivals and departures before the top of an aircraft's descent, so around 40 minutes from touchdown.

"This sequence is further refined around 10 minutes from the runway after departures start moving. The main benefits are improved predictability, punctuality and fuel efficiency, along with a positive impact on capacity.

"Airport and airline staff will also benefit from the increased accuracy of estimated landing and block times."

Anders Östlings, Head of Airside and Landside Operations at Stockholm Arlanda Airport, says: "We have seen an increase in the ability to predict our daily operations since the integration of AMAN/DMAN.

"Predictability is a key factor when several different actors need to cooperate to complete the turnaround of an aircraft. If all are given the best possibility to predict what and when actions are required, it enables them to be more proactive and to better manage their resources in a more operationally efficient manner."

He adds: "Stockholm Arlanda Airport is growing, and our capacity does not always match the rising demand of our customers. Therefore, the ability to more accurately predict on-the-day-demand, and identify critical time intervals where, for example, gate and stand capacity is at a premium, has been crucial for us in planning our daily operations.

"Increased predictability means that we are also able to better plan our arrival flows from touchdown to in-block, reducing the need to hold up aircraft on taxiways. This benefits both our strict environmental policies and minimises airline fuel burn at Stockholm Arlanda."
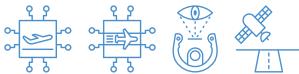
The solutions are primarily aimed at intercontinental and European hub airports.

ENHANCED ACCESSIBILITY TO SMALLER AIRPORTS

With the main airport hubs becoming busier, secondary gateways will come to the fore, dealing not only in an increasing number of scheduled flights, but also acting as an important alternative for diverted flights.

It is therefore crucial that smaller airports are accessible no matter what the weather conditions and that their ground operations are predictable. However, these airports have limited resources to invest in advanced ground infrastructure.

One option is to invest in emerging visual-based technologies that are located on board the aircraft and can be used by all aircraft types. Already delivered by SESAR, the enhanced flight vision system can be displayed to the pilot using a coloured helmet-mounted display. The solution offers the advantage of operating independently of ground infrastructure at most runway ends with precision or non-precision landing procedures.

These benefits of the solution offer a useful capability for airspace users in the business aviation community, which typically consists of small and medium operators with limited resources, operating at smaller airfields.

Research continues on combining enhanced vision systems (EVS) and synthetic vision systems (SVS) to enable not only landing but also taxi and take-off in low-visibility conditions. In doing so, the systems enhance the positional awareness of the pilot during taxiing and can help to maintain standard taxi speeds safely in low-visibility conditions.

Beyond operations, enhanced visibility solutions will boost situational awareness in all weather conditions for all operators, contributing to increased safety. Increased positional information during taxi, take-off and landing promotes stabilised approaches: for example, decreasing the risk of hard landings, tail strikes and runway excursions.

A second complementary option from the ground perspective is a solution that evaluates different options for aircraft and vehicle tracking, using camera-based systems as an affordable alternative surveillance source, or in combination with other available surveillance sources such as multilateration and automatic dependent surveillance – broadcast (ADS-B) sensors. The video data can be used by all airport stakeholders as a tool to enhance safety and operational performance. This solution can also trigger controller alerts for conflicting situations and incursions on the runways, taxiways and apron areas.

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BENEFITS

Airfield safety: *Enhanced visual operations facilitate greater situational awareness and predictability.*

Optimised capacity: *There will be improved accessibility to all airports without additional ground infrastructure.*

> *Beyond operations, enhanced visibility solutions will boost situational awareness in all weather conditions for all operators, contributing to increased safety."*

△ © Fraport on behalf of SEAC

SURFACE MANAGEMENT

SURFACE MOVEMENT ENHANCEMENTS

BENEFITS

Airfield safety: *Improved predictability and situational awareness – routes are known and potentially shared – makes airfield operations safer.*

Operational efficiency: *Allows for the optimum use of available capacity.*

Reduced costs: *Shorter taxi times lead to reduced fuel burn.*

Environmental mitigation: *A reduction in CO_2 emissions thanks to more efficient surface movements.*

" *Trials at Barcelona, Hamburg, Madrid Barajas, Milan Malpensa and Paris-CDG revealed more accurate taxi times compared with current operating methods, overall improvements in surface operations and enhanced safety, particularly in low-visibility conditions."*

Selecting the most suitable route from the departure gate to the runway or from the runway to the gate just got a little easier, following the successful validation of a solution that delivers automated assistance to controllers for surface movement planning and routing.

The solution improves the predictability of surface operations, increases safety and reduces emissions by reducing taxi times; it is also part of the EU's PCP.

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 electronic format of the route plan means that the information can be shared by the airline operations centre, air traffic control and other operators on the airfield, as well as the cockpit. It is less prone to error than route plans agreed solely based on controller/pilot communication, and 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 at Barcelona, Hamburg, Madrid-Barajas, Milan Malpensa and Paris-CDG revealed more accurate taxi times compared with current operating methods, overall improvements in surface operations and enhanced safety, particularly in low-visibility conditions.

Surface movements have also been enhanced by the delivery of another SESAR solution, D-taxi, which utilises datalink exchanges between pilots and controllers during the aircraft taxiing phase as an alternative to radio.

Tests of different scenarios at Milan-Malpensa Airport proved that datalink provides an efficient, less error-prone way to relay such non-safety critical messages as departure clearance, expected routing information, start-up and push-back.

Work is ongoing to improve route generation by monitoring the progress of mobiles along their routes, and taking into account potential conflicting situations with other mobiles, in order to regularly update the remaining taxi times of aircraft and to perform short-term trajectory predictions.

The solution is primarily aimed at intercontinental and European hubs.

FOLLOW THE GREENS

Follow the Greens is an innovative guidance system that makes smart use of taxiway centre lights to direct aircraft to gates, runways or wherever they need to be on the airfield.

Enabled by linking the airfield lighting infrastructure with the taxi route management system, it provides a clear route for flight crews and vehicle drivers to follow, reducing route deviations. The solution is particularly effective at night, in reduced visibility, and at airports with complex layouts.

The lights are automatically and progressively switched on in segments or individually as the vehicle moves along its assigned route, while pilots and vehicle drivers receive a single instruction to "follow the greens" from air traffic control. Red lights can be turned on at intersections to stop an aircraft.

Simulation trials were held at Frankfurt Airport as part of the SESAR validation process, and showed that the technology could shorten taxiing times by 38 % and reduce fuel burn and CO_2 emissions by 41 %.

Hamburg Airport has announced that an ongoing upgrade to Apron 1 means that it will become the first European airport to permanently introduce Follow the Greens operations in 2021.

BENEFITS

Airfield safety: *Safety advantages include reduced runway incursions, taxi-route deviations and holding position overruns in low-visibility conditions.*

Operational efficiency: *Apron throughput is increased.*

Reduced costs: *Aircraft burn less fuel.*

Environmental mitigation: *A reduction in CO_2 emissions thanks to smoother aircraft taxi operations.*

> *Hamburg Airport has announced that an ongoing upgrade to Apron 1 means that it will become the first European airport to permanently introduce Follow the Greens operations in 2021."*

The airport's Aviation Director, Johannes Scharnberg, explained: "A dynamic light strip has a decisive advantage over static light blocks, meaning aircraft can taxi more efficiently and require less space. This is particularly important in view of the spatial restrictions of Hamburg Airport's apron."

While the focus of research has been on the apron area, SESAR is further designing the solution to address the entire airport movement area. It assesses all aircraft traffic on the ground and identifies the best route for pilots/drivers to take. Instead of dealing with maps and waiting for guidance from the control tower, the pilots/drivers can simply follow a set of green lights, which will lead them to their destination.

The solution is principally targeted at intercontinental and European hubs.

VIRTUAL STOP BARS

SESAR has championed the development of a virtual stop bar solution that allows controllers to reduce the size of the control blocks used in low-visibility conditions, in order to maintain safe separation distances between taxiing aircraft and reduce the risk of runway incursions.

Validation tests on various scenarios at Milan-Malpensa Airport showed that the solution – which complements the existing stop bar lights already used on the airfield – improves the predictability of surface movements due to smoother traffic flows and more consistent taxi times. The efficiencies mitigate the loss of airport capacity during low-visibility conditions.

Talking about the benefits of Virtual Block Control, Fabio Donello at ENAV, the Italian ANSP, said: "It improved taxi time efficiency by roughly 10-15 %, with related improvements in terms of aircraft fuel burn and CO_2 emissions. Further research activities focusing on the usability as well as on the benefits associated with predictability and efficiency are planned in the context of SESAR 2020."

BENEFITS

Airfield safety: *Safety is improved, especially in low-visibility conditions.*

Operational efficiency: *Increased resilience when visibility is poor.*

The solution is primarily aimed at intercontinental and European hubs.

ENHANCED AIRPORT OPERATIONS MANAGEMENT

TOTAL AIRPORT MANAGEMENT

The need to do a better job of sharing information and data between different aviation stakeholders is key to the successful management, operation and development of today's airports.

The more information that is shared between airports, airlines, air traffic controllers, ground handlers and countless other stakeholders – ranging from inflight catering companies and car park operators to retail and food and beverage providers in the terminal – the more an airport is prepared for different eventualities and can respond accordingly.

Airport collaborative decision making (A-CDM) is arguably the industry's first step towards achieving this goal, as it has introduced new levels of efficiency to ground handling operations at airports, thanks to the exchange of real-time data about flight arrivals and departures between airports, airlines, ground handlers and air traffic controllers.

Today, A-CDM is used by 28 airports across Europe and, according to EUROCONTROL, one of the early adopters, Helsinki Airport, has revealed that its introduction has saved it and its airlines up to €4 million per annum in operating costs, and also provided significant environmental benefits.

Specifically, A-CDM has reduced aircraft taxiing times by 60,000 minutes or 42 days; saved 86,000 minutes or 60 days of flight delays, and saved 800 tonnes or €650,000 of fuel; this is due to the shorter taxiing times and having more detailed information about when each aircraft will depart from the gate [6].

But A-CDM – which actually pre-dates the SESAR programme – is just the start as SESAR and the industry will develop the airport management concept and move towards total airport management (TAM).

The aim of the SESAR airport operations management concept is to achieve more efficient local operations and, crucially, the better integration of all airports – regional and hub – into the air traffic management network.

Achieving this goal requires a number of factors, such as the seamless integration of the airport operations plan (AOP) – a single rolling plan of performance-based indicators agreed on by all stakeholders – into the network operations plan (NOP) for the whole of Europe.

> *The aim of the SESAR airport operations management concept is to achieve more efficient local operations and, crucially, the better integration of all airports – regional and hub – into the air traffic management network."*

[6] A-CDM Impact Assessment - Final Report, EUROCONTROL, 2016.

> *We've proved we can use big data to predict the likely passenger transfer times and how to allocate resources."*

Bob Graham
Head of Airport Research, EUROCONTROL.

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When this is achieved, airports can consider setting up an airport operations centre (APOC), which is effectively the nerve centre in this concept, allowing an unparalleled overview of operations and facilitating effective, fast decisions on how the airport can function most efficiently, especially under challenging circumstances.

AIRPORT OPERATIONS CENTRES

A nerve centre that is 100 % focused on ensuring that airports are as operationally efficient as possible, whatever happens on any given day, is now a reality, following the development of the APOC.

Already in place at London Heathrow, Brussels, Paris CDG and Geneva airports, and partially developed on the SESAR APOC concept, APOCs are staffed by airport operations experts who sit alongside representatives from the airlines, ground handlers, security, border control and others, to monitor real-time data being fed to them from a number of different sources. It means that, when necessary, the team responds quickly and efficiently to any unexpected changes, in order to avoid potential disruptions.

APOCs make use of information from the AOP, which is linked to the NOP, when making decisions.

A study published in 2016 within the framework of SESAR, followed by a live trial at Heathrow, illustrated how integrating big data techniques into the APOC provides accurate forecasts, so that airports better understand the key factors that influence passengers' connection time. This reduces the risk of missed flights.

This is good news for the industry and the travelling public, as disruption at any airport, but particularly major hubs, can have a significant knock-on effect on the rest of the network.

Talking about EUROCONTROL's APOC *Business Process Reengineering Big Data Study* (7), which looked at how machine learning techniques are being used to forecast transfer passengers' connection times at London Heathrow, EUROCONTROL's Head of Airport Research, Bob Graham, said: "We've proved we can use big data to predict the likely passenger transfer times and how to allocate resources.

"With such predictions, airports and airlines can take informed strategic decisions on whether or not to hold an aircraft and what the consequences of such decisions will be. If we can predict the status of aircraft at the gate and where delays

▼ © Alicante Airport / ALC

(7) APOC Business Process Re-engineering Big Data Study, SESAR-EUROCONTROL, 2016.

BENEFITS

Airfield safety: *Increased predictability enhances runway and airfield safety.*

Optimised capacity: *Improved airport resilience will limit capacity reduction in degraded situations.*

Operational efficiency: *Empowered airports will be the ground coordinators of local operations and the network at large.*

> *Better collaboration and communication allows us to make best use of our capacity. This means fewer aircraft downtime, less disruptions and happier passengers."*

Thomas Romig
Head of Airport Operation Control Center, Geneva Airport.

are likely to occur with confidence, then we will be able to forecast with greater accuracy traffic loads half an hour to an hour in advance, even considering different environmental and meteorological conditions – and develop a much better collaborative plan to handle the demand."

Paris-CDG notes that the creation of a study-level APOC as a part of the collaborative decision-making (CDM) approach has improved the coordination and communication between different stakeholders.

It adds that the CDM approach linked to the APOC has improved crisis management performance both airside and landside; it has also ensured that it is better equipped to anticipate and respond to events.

The airport and fellow Groupe ADP-operated gateway, Paris-Orly, is now looking to extend the APOC concept to airside and landside operations and go further to provide real-time performance monitoring to reach total airport management.

Geneva Airport was so convinced of the value of an APOC that it invested €1.8 million and two years of its time in creating its own high-tech nerve centre, which it opened on 1 May 2017, and Thomas Romig, Head of the Geneva APOC, said that it has not looked back since.

Geneva uses its APOC to monitor and manage its landside and airside processes and procedures, covering everything from access to the terminal to the flow of support vehicles on the airfield, the ground movement of all aircraft and the runway and airspace capacity.

Romig said: "Better collaboration and communication allows us to make best use of our capacity. This means less aircraft downtime, fewer disruptions and happier passengers."

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> **"** *Paris-CDG and Paris-Orly are now looking to extend the APOC concept to airside and landside operations and go further to provide real-time performance monitoring to reach total airport management."*

Geneva Airport's APOC shares commonalities with the SESAR solution that is being finalised in SESAR 2020.

Researchers are now looking at new ways to enhance airport performance monitoring by developing a single APOC performance dashboard concept, fed with landside and airside key performance indicators (KPIs) and covering total airport management processes.

"SESAR work to date shows that we can harmonise the KPIs and create basic 'what if?' functions," added Graham. "Common standards for KPI are important if you want to have APOC staff planning and coordinating in a clear and unambiguous language. One of our roles in this work will be to support the partners in developing the standards."

Improved weather forecasting for de-icing and a meteorological information exchange are just two of the SESAR solutions that can be integrated into the airport operations centre.

The solution is targeted at intercontinental, European hubs and major regional airports.

IMPROVED WEATHER FORECASTING FOR DE-ICING

Validated during a series of exercises in Helsinki, Oslo and Stockholm, the SESAR de-icing management tool uses data from meteorological service providers to more accurately predict when aircraft de-icing needs 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 are no longer in the dark about the progress of de-icing activities, nor do they need to make their own estimates of when aircraft are ready for departure.

The solution envisages that de-icing operations are considered part of normal operations at an airport during the winter period, which in some parts of Europe can last for many months,

instead of being characterised as unusual or something that only happens in adverse conditions and needs a collaborative approach to resolve.

The de-icing management tool (DIMT), which can be as light as an internet browser-based tool, 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.

- 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 solution is targeted at all airports that have to deal with icing conditions in the winter season.

METEOROLOGICAL INFORMATION EXCHANGE

Bad weather brings unwelcome disruption to flight schedules and is a notable cause of delays. Yet the impact of bad weather can be mitigated by the timely sharing of information, so that effective recovery strategies can be put in place.

SESAR has 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.

BENEFITS

Airfield safety: Increased predictability enhances runway and airfield safety.

Operational efficiency: More flights get to operate on time.

Optimised capacity: Improved airport resilience will limit capacity reduction in degraded situations.

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.

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

The solution is targeted at all airports.

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REMOTE TOWERS: SAFETY AND COST EFFECTIVENESS

Remote control towers are transforming the way small to medium-sized gateways handle flights and, in some cases, even ensure that they stay open for business.

SESAR members and partners have shown the feasibility of physically separating the control tower and controllers, while still enabling the safe provision of ATC services at an airport.

In 2015, this R&D led to the first single remote tower deployment at Sweden's Örnsköldsvik Airport, allowing air traffic controllers 150 km away in Sundsvall to handle flights landing and taking off at the airport. With just 80,000 passengers annually, Örnsköldsvik could not justify the cost of full-time control staff.

▼ © SAAB

BENEFITS

Operational efficiency: *Remote towers will deliver greater service flexibility to the network.*

Connectivity: *Increased accessibility to and support for regional economies.*

Reduced costs: *As there is no need to build a bricks-and-mortar tower, enhanced cost-efficiency results.*

" *Constantly striving to improve and make operations more efficient and effective using new technology and digitisation is the best way to secure the successful development and survival of these airports."*

Jonas Abrahamsson
President and CEO, Swedavia.

"Constantly striving to improve and make operations more efficient and effective using new technology and digitisation is the best way to secure the successful development and survival of these airports," said Swedavia president and CEO, Jonas Abrahamsson.

The next logical step was to see if the single remote tower set-up could be used for regional airports with medium-sized traffic volumes. This category of airport is faced with similar challenges as their smaller counterparts in ensuring service continuity, since conventional towers can become too costly to run over time and traffic volumes can fall.

This second SESAR solution was tested at an installation at Saarbrücken Airport in southwest Germany near its border with France. Validation work was complemented by large-scale demonstrations in Germany, Italy and Ireland.

This R&D work and the first deployment have encouraged similar implementation plans. Budapest Airport's remote ATC tower, for example, is ready for take-off after being given the green light by the Hungarian Civil Aviation Authority.

And the smaller physical footprint of remote towers has prompted airport planners and architects to rethink how valuable airport space can be exploited for other operational and business purposes.

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The smaller physical footprint of remote towers has prompted airport planners and architects to rethink how valuable airport space can be exploited for other operational and business purposes."

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▼ © Prague Airport / PRG

Working closely with the UK ANSP, NATS, London City Airport has approved plans for a new remote tower to open in 2019, at the top of which will be 14 high-definition cameras and two pan-tilt-zoom cameras. The cameras will provide a full 360-degree view of the airfield in a level of detail greater than the human eye, and with new viewing tools that will modernise and improve air traffic management.

The images of the airfield and data will be sent via independent and secure super-fast fibre networks to a new operations room at the NATS control centre in Swanwick in Hampshire. From Swanwick, air traffic controllers will perform their operational role, using the live footage displayed on 14 HD screens that form a seamless panoramic moving image, alongside the audio feed from the airfield, and radar readings from the skies above London.

Mike Stoller, Director of Airports at NATS, predicted: "Digital towers are going to transform the way air traffic services are provided at airports by providing real safety, operational and efficiency benefits, and we are delighted that London City Airport has chosen to work with us to deliver what will be the first of its kind in the UK."

SESAR members also looked at how remote towers could serve larger airports as a contingency for outages, providing resilience and safety assurance.

But the story of remote towers does not end there. With the next wave of R&D, the plan is to take the technology even further to respond to the operational performance needs articulated by stakeholders.

One area currently undergoing intense analysis is the remote tower centre (RTC), where a number of modules can be deployed to cover multiple airports on a "one module to one airport" basis.

In November 2017, LFV and the airport operator, Swedavia, signed an agreement to establish remote towers for Kiruna, Umeå, Åre Österund and Malmö airports from a remote tower centre (RTC) at Stockholm Arlanda Airport.

It will be operational by 2019/2020, with the capability to remotely operate over 20 digitally connected airports. A similar installation is planned in Norway, where 15 airports will be operated by a tower centre in Bodø by the end of 2020. The centre will house the same staff who used to sit in the individual towers.

The other possible evolution of the concept is multiple remote tower services. This refers to the provision of air traffic control tower services to more than one airport simultaneously, from

> *Digital towers are going to transform the way air traffic services are provided at airports by providing real safety, operational and efficiency benefits."*

Mike Stoller
Director of Airports at NATS.

a single module that can switch between incoming remote tower camera and communication feeds from different airports.

The research builds on tests at Bodø, where controllers provided aeronautical flight information services simultaneously to locations at Røst and Værøy (the latter technically a heliport).

Large-scale demonstrations in Ireland and the Netherlands also provided complementary input regarding the feasibility of the concept, with the simultaneous management, in low-traffic conditions, of two airports. This concept is undergoing further rigorous R&D in Germany, Hungary, Italy, Lithuania, Norway and Sweden to ascertain all the potential issues and to ensure that it satisfies the most stringent safety requirements.

It is coupled with research on advanced remotely controlled automated weather systems for airports. On validation, it is anticipated that the concept and related systems will bring significant operational and cost-efficiency benefits.

This solution is aimed at regional and smaller airports, with the exception of the SESAR 1 contingency solution, which targets intercontinental, European hubs and major regional airports.
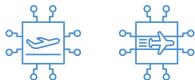
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▼ © DLR

▲ © DSNA

SAFETY NETS

PROTECTING THE RUNWAY

BENEFITS

Airfield safety: *Runway safety is greatly improved.*

> ❝ *It is impressive to observe that RWSL (runway status lights) at CDG have already succeeded in preventing aircraft from operating on unsafe runways.*❞

Nicolas Leon
Senior Project Manager, DSNA.

Not to be confused with Follow the Greens, which guide aircraft between the gate and the runway, runway status lights (RWSL) effectively ensure the safe passage of all traffic surrounding the runway protection area.

This SESAR solution is a fully automated safety system using ground surveillance radar, which provides crews and airside vehicle drivers with an immediate, accurate and clear indication of the runway occupancy status via red warning stop lights.

Introduced at Paris-CDG as part of an ambitious strategy to improve safety, while at the same time maximising the capacity of an airfield handling an average of 650 runway crossings and 1,300 flights a day across its two sets of parallel runways, RWSL have led to a tangible reduction in runway incursions.

Nicolas Leon, Senior Project Manager at France's air navigation service provider, DSNA, said: "It is impressive to observe that RWSL at CDG have already succeeded in preventing aircraft from operating on unsafe runways. Investing in safety is always rewarding for all stakeholders."

The solution is principally aimed at intercontinental and European hubs.

SAFETY SUPPORT TOOLS FOR RUNWAY EXCURSIONS

Runway excursions are one of the most common causes of accidents. They can occur when an aircraft is taking off or landing and can be attributed to multiple factors. Unstable approaches, failure to go around, objects on the runway and the condition of the runway can all play a part.

Runway excursion can result in fatalities and injuries on board the aircraft or on the ground. It can lead to aircraft damage, as well as damage to the airfield or airfield equipment.

BENEFITS

Airfield safety: *Runway excursions will be reduced. Additionally, inspections are better managed.*

Optimised capacity: *Safety support tools can improve runway capacity through greater resilience in adverse conditions.*

Operational efficiency: *Flight diversions are reduced.*

> *Our validation exercise involved the use of built-in runway and weather sensors to enhance awareness of the runway conditions to optimise the operational management of the airport."*

Ondrej Priboj
Slovak air navigation service provider, LPS SR.

Airports – Gdansk, Paris CDG and Poprad-Tatry in Slovakia – are taking part in SESAR work that will focus on how the risk of runway excursion can be mitigated by on-board and ground systems that could warn pilots, controllers or both when appropriate.

This important safety solution necessitates a better knowledge of runway braking conditions as well as the elimination of factors contributing to unstable approaches, for example. It obviously involves close cooperation among all stakeholders.

It is not only safety that will be improved by the successful validation of the project, but also operational resilience, especially in adverse conditions. Better management of runway inspections, and fewer flight diversions due to bad runway conditions, will also have a positive impact.

Talking about lessons learned from the SESAR work at Poprad-Tatry Airport, Ondrej Priboj from the Slovak air navigation service provider, LPS SR, said: "Our validation exercise involved the use of built-in runway and weather sensors to enhance awareness of the runway conditions to optimise the operational management of the airport through improved decision-making for runway treatment, increasing resilience and safety in adverse weather situations.

"Together with our industrial partner MicroStep-MIS, we chose Poprad-Tatry Airport for validation purposes due to its specific location in the foothills of the High Tatra Mountains. Thanks to its high altitude, we experienced different weather conditions, even during a short validation period.

"Overall, we have received positive feedback from the airport operator and air traffic controllers who participated in the validation. The main benefits for users are the integration of different data into one system, clear presentation on a human-machine interface and the implementation of short-term prediction of runway conditions as well. The disadvantage of sensor measurement is that data are limited to the location of the sensor instead of the whole runway surface."
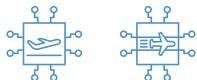
The SESAR solution is aimed at all airport categories.

AIRPORT SAFETY NETS FOR PILOTS

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Airfield safety: Alerts for flight crew highlighting non-compliance with the airport configuration, such as a closed runway, and warning the pilots about other aircraft in their vicinity, significantly improve safety on the airport surface.

Worldwide, near-misses due to runway incursions occur regularly. Given that airports are busy places and getting busier by the day, traffic management on the ground must at least keep pace with the problem, and reduce the near-miss rate to zero.

A project looking at traffic alerts for pilots during airport operations is exploring the enhancement of on-board systems to detect potential and actual risks of aircraft collisions with other traffic during runway and taxiway operations. The project also includes non-compliance with the airport configuration, such as a closed runway or taxiway and other restricted areas. In all cases, the flight crew are provided with appropriate alerts to allow them to take corrective action.

The reaction time to any potential risk can be shorter if the flight crew receives an alert as well as the air traffic controller.

The solution is particularly applicable at airports where no safety net is provided to controllers. The flight crew gets a warning when operating at an airport where the ATC is not equipped with appropriate alerting systems.

To further optimise measures, a corresponding solution addresses the operational interoperability of alerts triggered by aircraft and ground safety nets in identical risk situations.

Automatic dependent surveillance – broadcast (ADS-B) underpins this additional project. ADS-B uses a combination of satellites, transmitters and receivers to provide flight crews

▼ © EUROCONTROL

and ground control personnel with specific information about the location and speed of aircraft. Because it works at low altitudes and on the ground, ADS-B provides a significant advantage over traditional radar. It means that ADS-B can be used to monitor traffic on the taxiways and runways of an airport, thereby significantly improving safety on the airport surface.

"ADS-B is a key enabler for improving airport safety," agrees Pierre Nieradka of Airbus. "Within SESAR R&D, Airbus is working on SURF-A or SURFACE-ALERT. This is an alerting system for pilots in case of a risk of collision on the runway."

This solution is aimed at all airport categories.

ADVANCED AIRPORT SAFETY NETS FOR AIR TRAFFIC CONTROLLERS

BENEFITS

Airfield safety: Safety nets will allow an improved situational awareness for all stakeholders; a reduction of airport surface incidents at main airports with A-SMGCS; fewer runway incursions at secondary airports with no A-SMGCS; and a reduction of weather-related incidents at all airports.

> *The advanced version of the solution, under development in SESAR 2020, extends to all mobiles and beyond the runways and taxiways to cover the entire airport surface."*

Enhanced airport safety nets for air traffic controllers will prevent conflicting clearances being issued and detect non-conformance to clearances across the entire airport. These safety nets are part of the Pilot Common Project.

Already deployment-ready is a system that detects conflicting ATC clearances during runway operations, and non-conformance to procedures or clearances for traffic on runways, taxiways and in the apron/stand/gate area. The system will provide the appropriate indications and alerts to controllers.

In the near future, larger airports with an advanced-surface movement guidance and control System (A-SMGCS) will be able to further reduce the number of airport surface incidents, while the number and severity of runway incursions at the secondary airports with no A-SMGCS will also be reduced, as will the number of weather-related incidents at all airports.

When traffic does not comply with procedure or specific instructions, an alert is sounded and displayed. Having alerts for both controller and pilot reduces reaction time should a potential risk be identified. This can be especially crucial in low-visibility conditions.

The advanced version of the solution, under development in SESAR 2020, extends to all mobiles and beyond the runways and taxiways to cover the entire airport surface.

This solution is targeted at all airport categories.

A MOVING MAP OF TRAFFIC

BENEFITS

Airfield safety: Increased situational awareness of vehicle drivers on and around the runway.

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Drivers of airside vehicles are now safer than ever following the delivery of a SESAR solution that is designed to improve their situational awareness, and which issues alerts when there is a perceived risk of collision or potential entry into a restricted or closed area.

The system can be installed as a separate physical display in the vehicle or as an integrated application with several innovative functionalities, one of which is a moving map that shows drivers their exact position on the airfield, and the location of all aircraft and other vehicles. The system can distinguish between arriving and departing flights through the use of different colours or symbols.

▼ *© Groupe ADP*

> ❝ *One of the IAA's values is efficiency. To date, the results of the SESAR solution have shown increases in efficiency and performance."*
>
> **Paul McCann**
> *Acting General Manager for Terminal Services, Irish Aviation Authority.*

Trials at Dublin Airport – where vehicle drivers are often obliged to cross runways in foggy and low-visibility conditions – showed an increase in safety levels because of the reduced risk of Stop Bar violations, runway incursions and collision/interference with aircraft and other vehicles.

Paul McCann, the Irish Aviation Authority's acting general manager for terminal services, said: "One of the IAA's values is efficiency. To date, the results of the SESAR solution have shown increases in efficiency and performance."

The solution is primarily targeted at intercontinental, European hubs and major regional airports.

3 ON THE DRAWING BOARD

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CHAPTER 3:
ON THE DRAWING BOARD

ON THE HORIZON: MORE DISRUPTION

Disruptive innovation is intensifying, with airports continuing to face dynamic influences from all sides.

For example, airport retail previously only had to worry about the high street. But now its revenues are being eroded by competition from online retail, combined with dwindling passenger dwell time, because smartphone apps allow passengers to judge their airport time more efficiently.

Car rentals at airports are being affected by improved intermodal connectivity, by city driving solutions and, in the case of the cost-conscious passenger, by car-pooling services. The imminent arrival of autonomous cars spells trouble for parking revenues. And this is all just on the airport landside.

RESPONDING WITH INNOVATION

European airports are becoming mindful of these threats, and a growing trend of engagement and innovation is now under way across the board – with a lot of media coverage being generated by solutions that can have a direct impact on the passenger experience.

Like some other industries, the seeds of much of this digital innovation were sown by the hackathon culture that earlier this decade began to look at cutting-edge passenger-related solutions.

The Schiphol Group and Groupe ADP were among the first to host a joint-hackathon several years ago, with the objective of crowdsourcing innovative ideas from outsiders who could potentially bring disruptive insights. Schiphol continues to pursue innovation through hackathons. It was the key organiser of "Recoding Aviation" – a massive European airports' hackathon last year, in which Gatwick, Frankfurt Airport, Geneva Airport, Copenhagen Airports, Munich Airport and Swedavia all participated.

> *Disruptive innovation is intensifying, with airports continuing to face dynamic influences from all sides."*

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Moving to bigger, more full-time investments in innovation, Munich Airport created its InnovationPilot in 2015. Through it, the airport essentially crowdsources to reach innovators outside the airport business, seeking external ideas that can help it identify and develop new ideas to improve specific aspects of its business.

France's Groupe ADP has gone one step further, establishing its Innovation Hub in March last year, which supports airport business-related start-ups by investing in them, and provides an array of support services such as experimentation, testing and export/roll-out options through the Groupe ADP Management subsidiary.

All these enterprises expect to unleash new innovations for passengers in the short to medium term. In parallel to that, research into the new wave of innovations for the business-to-business side of airport operations continues – focused on better coordination and service to airlines, ANSPs and ground handlers.

Airport innovation hubs are just one way to go to foster new ideas. In the light of SESAR, airports are also looking for new airside solutions to enhance their operations. This chapter looks at the innovative ideas being explored by SESAR for airport operations. Although still very much on the drawing board, the promise of these research activities is such that ATM procedures could be transformed, with beneficial implications for airports and ground coordinators.

Crystal-ball gazing is not an exact science, of course, and history is replete with idiosyncratic predictions of the future. But these activities have firmer foundations, based on the needs of aviation stakeholders and the development of existing technologies.

With cutting-edge solutions appearing regularly, airports seeking out innovation look set to benefit from SESAR's innovative excellence and real-world understanding.

PIONEERING RESEARCH

Through its exploratory research, the SESAR JU looks beyond the horizon of current R&D and what is already identified in the European ATM Master Plan, which is the commonly-agreed ATM modernisation roadmap for Europe.

The aim is to investigate new ideas, concepts and technologies, and to challenge preconceived notions about air traffic management and the aviation value chain.

By advancing promising research ideas and embedding them in a broader programme of work, the SESAR JU is helping to future-proof Europe's aviation industry and to maintain its global competitive edge.

To achieve this, SESAR has created an innovation pipeline, bringing on board the academic community and young scientists, as well as SMEs, research centres, airlines, manufacturers and ANSPs from across the European Union and beyond, to inject fresh thinking and new ideas into the system.

Indeed, researchers throughout Europe are contributing to SESAR-coordinated exploratory research into potential new technologies that could make air travel safer, quicker and more efficient in the future.

A range of research themes have been investigated to date, including automation, robotics and autonomy; complexity, data science and information management; environment and meteorology; economics and legal and regulatory frameworks. Research activities have also looked at specific airport operations, and some of the enabling technologies and system architecture.

Here is just a taste of some of the concepts and new ideas researched as part of the SESAR exploratory research portfolio.

TAKING CONTROL OF AIRPORT COMPLEXITY

The growing demand for air travel, coupled with European airports' limited ability to extend their physical footprint, is leading to increasingly complicated operational scenarios. This difficult situation is further exacerbated by airports' commitment to environmental mitigation efforts.

It is therefore vital to support air traffic controllers (ATCO) in their work to ensure the safe handling of this evolving complexity at many large airports.

Introducing automated tools to help controllers manage and optimise ground traffic management while simultaneously meeting established safety and environmental goals was the aim of the TaCo (take control) project.

Malta International Airport was the testbed for TaCo. Two traffic configurations and four runway configurations were defined to act as baseline scenarios to test the design and functionality of suitable automation and human-machine collaboration strategies.

Aside from a workable handover strategy between human and machine, the test case at Malta explored proof of concept for several automated tools, including flight sequencing and conflict detection and resolution.

The main objectives of TaCo were:

- Defining algorithms and solutions to automate and optimise both the decision-making and implementation tasks for the controller involved in the ground movement of airport vehicles and aircraft;

- Identifying and providing the controller with suitable and usable tools to supervise, monitor and reprogramme the system;

- Studying the interaction between humans and automation, with a focus on the transfer from machine to human, to handle situations where human cognitive skills are essential.

▼ © TaCo

SEEING THE BIGGER PICTURE

The classic ATM image is an air traffic controller standing in the tower, binoculars pressed firmly to their eyes as the skies are scanned for arriving aircraft.

Though this picture encapsulates a bygone area, it is in fact not far from a vision of the future. Imagine that instead of binoculars the air traffic controller is sporting a head-mounted unit equipped with synthetic vision and augmented reality technologies. As aircraft come into view, information pops up beside them. Symbolic representations of such meteorological data as wind direction and speed, wind shear and wake vortexes will accompany flight details and other relevant information.

This was the aim of the resilient synthetic vision for the advanced control tower air navigation service provision (RETINA) project. It will free controllers from the limitations of what the human eye can physically see out of the tower windows. What were previously "head down" operations – examining radar screens, checking weather reports, confirming e-strip information and so forth – will become a single "head up" process, making operations in and around the airport safer.

> *RETINA may prove to be a particular boon to smaller airports. This visual tracking and surveillance system requires only a limited investment compared with the full implementation of modern navigational aids."*

RETINA may prove to be a particular boon to smaller airports. This visual tracking and surveillance system requires only a limited investment compared with the full implementation of modern navigational aids. So, facilities where only an aerodrome traffic information service (AFIS) is provided can be boosted to full air traffic services.

Not only will safety be improved, but also an airport could begin to market itself more extensively, increasing its network. Aircraft arriving and departing on a more frequent basis for passenger transportation or freight services would have a positive social impact on the nearby community, creating jobs and prosperity.

AUTOMATIC SPEECH RECOGNITION

ATC systems need up-to-date data in order to be safe and efficient. Aside from inputting data, controllers can now use automatic speech recognition to convert speech into text. Prior to SESAR, tools have been tested in Düsseldorf and Vienna; these have shown that they can help reduce the time taken to keep data up to date and increase ATM efficiency. Fuel savings of 50-65 litres per flight are possible.

Modern models of speech recognition require manual adaptation to local environments. The MALORCA (machine learning of speech recognition models for controller

assistance) project, however, investigated a low-cost solution that adapts the speech recognition tools for use at other airports. The solution automatically learns local speech patterns and controllers' models from radar and speech data recordings, which are then automatically encoded into the recognition software.

UNDERSTANDING PASSENGER BEHAVIOUR

Big data is becoming a big deal for airports, as it is increasingly used to better analyse market demand, optimise security control and customise the passenger experience.

The use of big data analytics is being put to work to better understand how passenger behaviour can impact air traffic management. Research in these areas has so far been constrained by the limited availability of behavioural data; these are typically obtained from static demographic and economic datasets, which often consist of very small samples, and are usually complemented with assumptions about behaviour.

Thanks to the growth of smart devices and interconnected services, researchers now have large-scale, detailed longitudinal data, allowing them to test hypotheses about passenger behaviour.

Partners from the BigData4ATM project investigated how different passenger-centric geo-located data can be analysed and combined with more traditional demographic, economic and air transport data to identify patterns in passenger behaviour, door-to-door travel times, and choices of travel mode.

The project also explored applications of these data and how they could be used to inform ATM decision-making processes.

Ricardo Herranz, BigData4ATM project manager and managing director of Nommon Solutions and Technologies, explained: "passengers' behaviour in the terminal, both airside and landside, has a major impact on flight delays. Knowing more about what passengers want and how they behave at airports will help reduce bottlenecks, waiting times at check-in, security, passport control and gate queues, to ultimately ensure better connections and reduced delays at airports.

"The insights gained also allow for more informed decision-making and improved traffic forecasts, which can help airports more accurately plan for new infrastructure, and, if necessary, the timing of its development."

◄ © RETINA

DRONES AND AIRPORTS: FRIENDS OR FOES?

As these research projects show, technology is disrupting the way air traffic is managed, both in the sky and at airports. This is especially true when considering the speed at which drone technology is advancing and impacting operations.

Drones and their larger cousin, remotely piloted aircraft systems (RPAS), will therefore be a key consideration for airports going forward. All forecasts show that civil drone and RPAS use will grow hugely in the years ahead. The drone services market is expected to grow substantially.

Estimates vary between €10 billion by 2035 and €127 billion for the coming years. A recent forecast predicts that by 2020 the global drone market size will grow by 42 % in precision agriculture, 26 % in media and entertainment, by 36 % in inspection and monitoring of infrastructures, and by 30 % for leisure activities [8].

Airports are deliberating how they will use this new technology. It is likely, for example, that drones will be used for a host of regular inspections. A recent survey amongst ACI members suggests that routine activities, such as aircraft checks, aerial photography for planning, mapping or marketing purposes and the inspection of runways, airport perimeters and airfield for damage or for security reasons, are seen as promising applications for drones at airports.

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Airports can also acquire new revenue streams by allowing larger drones or RPAS to land. But drones can also mean having to rethink surface operations and investing in geofencing technologies to safeguard existing manned traffic.

Some of these challenges are reflected in ACI EUROPE's position paper on drones, published in January 2018. The paper strongly argues for a two-pronged approach:

1. Keeping airports safe from unauthorised drone activities, especially by leisure drone pilots or criminal acts.

2. Facilitating the use of drone technology where it adds value to an airport's operations or commercial activities.

Large-scale demonstrations are taking place where these U-space solutions are being demonstrated for visual line of sight (VLOS) and BVLOS drone flights. The scope covers operations in rural and urban areas, in the vicinity of airports, in uncontrolled and controlled airspace, and in mixed

[8] Aviation: Commission is taking the European drone sector to new heights, European Commission Press Release, June 2017.

environments with manned aviation. Projects are, for example, examining how to handle VLL operations where general aviation, commercial aviation and drones share the airspace.

At the same time, SESAR members are investigating how best to integrate these vehicles into non-segregated airspace alongside commercial traffic, particularly in the approach segment of the airspace near airports. Work is also ongoing to enable large drones to access the airport surface, by examining integration with manned aircraft and compliance with air traffic control requirements. Specifically, testing is focusing on "taxi-in" and "taxi-out" operations in both nominal and contingency situations (loss of command and control, loss of communication).

SESAR has set out a roadmap for the integration of drones, both large and small (9). This embeds not just the timeline for U-space, for which the initial roll-out is expected in 2019, but it also outlines the steps to be taken to ensure a coordinated implementation of solutions that will enable the use of larger drones alongside commercial airspace.

The airport industry must join hands to develop standard scenarios for drone operations at airports, which can be applied across the European Aviation Safety Agency member states for drone operations at airports (these are essentially defined, approved and safety-assessed operational use cases for the operation of drones, which can be applied across the European Aviation Safety Agency member states). Manned and unmanned aviation will continue to grow side by side. The legal, technological and operational conditions have to be put in place now to ensure that Europe flies ahead of the pack.

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(9) European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace, SESAR Joint Undertaking, 2019.

CONCLUSION

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CONCLUSION

The solutions covered by this publication clearly show that the digital transformation of airports and their airside operations is under way. By embracing automation, virtualisation and machine learning, among other technologies, airports can improve their business operations. Now and in the coming years, SESAR can provide airports with the means to go further in this direction, evolving processes and services to deliver a better experience to all passengers and customers.

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KEY RESOURCES

- **SESAR Solutions Catalogue (2nd edition, 2017):** *https://www.sesarju.eu/newsroom/brochures-publications/sesar-solutions-catalogue*

  Please see the full list of SESAR solutions addressed in this publication on the following pages.

- **European ATM Master Plan:** *https://www.sesarju.eu/masterplan*

- **EU's Pilot Common Project:** *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.190.01.0019.01.ENG*

- **ACI World Airport Digital Transformation Best Practice (November 2017):** *http://www.aci.aero/Publications/Full-Publications-Listing/Airport-Digital-Transformation-Best-Practice*

- **NEXTT – Let's build the journey of the future** (a joint ACI and IATA initiative that aims to develop a common vision of the future of air transport by examining how passengers, cargo, baggage and aircraft move through the complete travel journey, with a focus on three emerging concepts: off-airport activities, advanced processing technology, and interactive decision-making): *https://nextt.iata.org/*

- **U-Space & SESAR R&D on drones:** *https://www.sesarju.eu/U-space*

- **ACI EUROPE Position Paper on Drone Technology (January 2018):** *https://www.aci-europe.org/component/downloads/downloads/5339.html*

- **ACI EUROPE Guidelines for Passenger Services at European Airports (2nd edition, June 2018):** *https://www.aci-europe.org/component/downloads/downloads/5591.html*

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SESAR SOLUTIONS ADDRESSED IN THIS PUBLICATION

CHAPTER 2

RUNWAY MANAGEMENT

SATELLITE TECHNOLOGIES ALLOW NEW APPROACHES

- **SESAR 1 Solution #55** – Precision approaches using GBAS Category II/III.
- **SESAR 2020 Solution PJ02-02** – Enhanced arrival procedures.
- **SESAR 2020 Solution PJ02-11** – Enhanced Terminal Area for efficient curved operation.

TIME-BASED SEPARATION INCREASES EFFICIENCY

- **SESAR 1 Solution #64** – Time-based separation.

SEPARATION OF OPTIMISATION

- **SESAR 2020 Solution PJ02-01** – Wake turbulence separation optimisation.
- **SESAR 2020 Solution PJ02-03** – Minimum-pair separations based on RSP.

FLIGHT SEQUENCING FOR ARRIVALS AND DEPARTURES

- **SESAR 1 Solution #106** – Departure manager (DMAN) baseline for integrated AMAN DMAN.
- **SESAR 1 Solution #53** – Pre-departure sequencing supported by route planning.
- **SESAR 1 Solution #14** – Departure management integrating surface management constraints.
- **SESAR 1 Solution #54** – Flow-based integration of arrival and departure management.
- **SESAR 2020 Solution PJ02-08** – Traffic optimisation on single and multiple runway airports.

ENHANCED ACCESSIBILITY TO SMALLER AIRPORTS

- **SESAR 1 Solution #117** – Reducing landing minima in low-visibility conditions using enhanced flight vision systems (EFVS).

- **SESAR 2020 Solution PJ02-06** – Improved access into secondary airports in low-visibility conditions.

- **SESAR 2020 Solution PJ03a-03** – Enhanced navigation and accuracy in low-visibility conditions (LVC) on the airport surface.

- **SESAR 2020 Solution PJ03a-04** – Enhanced visual operations.

SURFACE MANAGEMENT

SURFACE MOVEMENT ENHANCEMENTS

- **SESAR 1 Solution #22** – Automated assistance to controllers for surface movement planning and routing.

- **SESAR 1 Solution #23** – D-TAXI service for controller-pilot datalink communications (CPDLC) application.

- **SESAR 2020 Solution PJ03a-01** – Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing.

FOLLOW THE GREENS

- **SESAR 1 Solution #47** – Guidance assistance through airfield ground lighting.

- **SESAR 2020 Solution PJ03a-01** – Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing.

VIRTUAL STOP BARS

- **SESAR 1 Solution #48** – Virtual block control in low-visibility procedures.

- **SESAR 2020 Solution PJ03a-01** – EEnhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing.

ENHANCED AIRPORT OPERATIONS MANAGEMENT

TOTAL AIRPORT MANAGEMENT

- **SESAR 1 Solution #61** – A low-cost and simple departure data entry panel for the airport controller working position.
- **SESAR 1 Solution #21** – Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP).
- **SESAR 2020 Solution PJ04-01** – Enhanced collaborative airport performance planning and monitoring.
- **SESAR 2020 Solution PJ04-02** – Enhanced collaborative airport performance management.

IMPROVED WEATHER FORECASTING FOR DE-ICING

- **SESAR 1 Solution #116** – De-icing management tool.

METEREOLOGICAL INFORMATION EXCHANGE

- **SESAR 1 Solution #35** – Meteorological information exchange.

REMOTE TOWERS; SAFETY AND COSTS EFFECTIVENESS

- **SESAR 1 Solution #71** – ATC and AFIS service in a single low-density aerodrome from a remote controller working position (CWP).
- **SESAR 1 Solution #12** – Single remote tower operations for medium traffic volumes.
- **SESAR 1 Solution #52** – Remote tower for two low-density aerodromes.
- **SESAR 1 Solution #13** – Remotely provided air traffic services for contingency situations at aerodromes.
- **SESAR 2020 Solution PJ05-02** – Remotely provided air traffic service for multiple aerodromes.
- **SESAR 2020 Solution PJ05-03** – Remotely provided air traffic services from a remote tower centre with a flexible allocation of aerodromes to remote tower modules.
- **SESAR 2020 Solution PJ05-05** – Advanced automated MET system for remote airport.

SAFETY NETS

PROTECTING THE RUNWAY

- **SESAR 1 Solution #01** – Runway status lights.

SAFETY SUPPORT TOOLS FOR RUNWAY EXCURSIONS

- **SESAR 2020 Solution PJ03b-06** – Safety support tools for avoiding runway excursions.

AIRPORT SAFETY NETS FOR PILOTS

- **SESAR 2020 Solution PJ03b-03** – Conformance monitoring safety net for pilots.
- **SESAR 2020 Solution PJ03b-05** – Traffic alerts for pilots for airport operations.

ADVANCED AIRPORT SAFETY NETS

- **SESAR 1 Solution #02** – Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.
- **SESAR 2020 Solution PJ03b-01** – Enhanced airport safety nets for controllers.

A MOVING MAP OF TRAFFIC

- **SESAR 1 Solution #04** – Enhanced traffic situational awareness and airport safety nets for vehicle drivers.

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Produced by ACI EUROPE with technical
support from SESAR JU.

Designed by Simplicity, Madrid
www.simplicity.com.es

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(2nd edition)