The French ATM Strategy

STRATEGIC PLAN TO MODERNIZE
THE FRENCH AIRSPACE
AND AIR TRAFFIC MANAGEMENT

DOCUMENT CONTROL

Version	1.0
Date	16/04/2019
Authors	IATA and DSNA
Reviewed by	DGAC and FNAM (the French Airline Association)
Next steps	Wider industry engagement and further refinement

Foreword

France is a global hub for air traffic. French air navigation services manage one of the largest and most dense areas of airspace in Europe, controlling more than 3 million flights, 60% of which are overflights. Added to this is the provision of air navigation services in the French overseas territories with more than 14 million square kilometers of airspace across the planet.

The civil aviation sector is a key part of the French economy, representing 4.3% of GDP and supporting 1.16 million direct and indirect jobs. The aerospace sector generates €90 billion in sales, including €49 billion in aircraft construction, making it one of the country's largest exporters. Aviation also plays a central role in positioning France as the world's leading tourist destination. France welcomed 90 million visitors in 2018, a figure that is expected to exceed 100 million by 2020.

In March 2019, concluding the French ministerial initiative « Les Assises du transport aérien », Mrs Elisabeth Borne, Minister for Transport, attached to the Ministre d'État, Minister for the Ecological and Inclusive Transition, presented the "National Strategy 2025 for Air Transport" that clearly established the vision of a sustainable development of Air Transport connecting territories at local as well as global levels in a competitive manner provided that it is environmentally acceptable by citizens.

Following this vision, the aviation sector is reliant on the performance and efficiency of the airspace and air traffic management (ATM) system. This performance shall rely on proactive management of safety, taking into account the new cyberthreats, on focusing on all feasible means to reduce the environmental footprint of aviation as regards noise and emissions, and on improving the quality of services to the airspace users and customers.

Actually, the capacity performance of European airspace has started to decline in

MAURICE GEORGES
Air Navigation Service Director at DSNA

recent years due to ever-increasing traffic levels and poor resilience. The European Network Manager was forced to intervene for the first time during the summer of 2018, constraining the flow of traffic to protect the efficiency of congested airspace. This reinforces its role of a coordinator of the industry-wide Collaborative Decision Making (CDM) framework, which is becoming essential to take full advantage of the capacity of European airspace and accommodate future traffic demand.

Air Navigation Service Providers (ANSPs) partners are fully engaged in the modernization of the European airspace and ATM system, driven by the Single European Sky (SES) initiative and Single European Sky ATM Research (SESAR) deployment program. The transformation being carried out by SESAR shall also be supplemented by the Airspace Architecture Study (AAS) that has delivered a proposal for the future architecture of the European airspace to increase capacity and resilience, in a long term perspective.

DSNA, the French State ANSP, is a key partner working closely with the airlines, the Network Manager and SESAR to tackle the environmental and economic challenges facing Europe's airspace and above all to maintain the highest levels of safety and security for all users of aviation in France and its overseas territories.

The next period of economic regulation for European ANSPs (known as Reference Period 3) will have to support the necessary investments, whether for technical modernization, productivity measures or the controlled increase in the recruitment of air traffic controllers as per the recommendations of the Senate Finance Committee's June 2018 report on the modernization of air navigation in France.

The continuation of the 4-FLIGHT/COFLIGHT program (to upgrade DSNA's core suite of ATM systems and tools) was secured in 2018 and shall allow the new systems to be deployed from 2022, delivering performance improvements for customers and creating the platform to introduce more advanced SESAR outputs, in particular, cross-border free route and new short to medium term safety tools, at the core of future performance in highly dense airspace.

In the near term the recruitments in DSNA's en-route centers will start to deliver benefits as from 2021 and will consequently allow the DSNA to take full benefit of the first deployment of 4-FLIGHT in the summer of 2022.

For the summers of 2019, 2020 and 2021, the challenge for DSNA and European ANSPs will be to offer operational solutions using the capability of existing SESAR outputs and enhanced collaboration with the Network Manager to compensate for the structural lack of capacity, contain the growth of delays and guarantee the highest level of safety and security.

DSNA and IATA (the International Air Transport Association) are cooperating on the development and implementation of the strategy outlined in this document and its accompanying plans to support the modernization of airspace and ATM in France and across Europe.

Enhancing performance in Air Traffic Management, including its contribution to reducing environmental nuisance, has been an outstanding item during the Assises du Transport Aérien that took place in 2018 in France. Cooperation with airlines, a steady focus for DSNA, is in my view a key asset in order to ensure that the efforts of the stakeholders reach maximum efficiency. This concern can be found as well at European level in the Network Manager's works and of the functional airspace block FABEC, to which France is party.

MARC BOREL
Air Transport Director

The Air Transport Directorate supports the approach by DSNA and IATA set out in this French ATM Strategy that supports the Performance plan 2020-2024 of FABEC. What is at stake for the next years is clearly getting the ATM capacity back to balancing with the air traffic demand, in France and more broadly through FABEC and Europe. The transitional measures currently applied for managing traffic flows are efficient to reduce delays; in contrast, they oppose continuing the reduction in flight distance, hence in the greenhouse gas emissions. More permanent solutions that will emerge during the reference period 2020-2024 will contribute lowering these emissions per flight again.

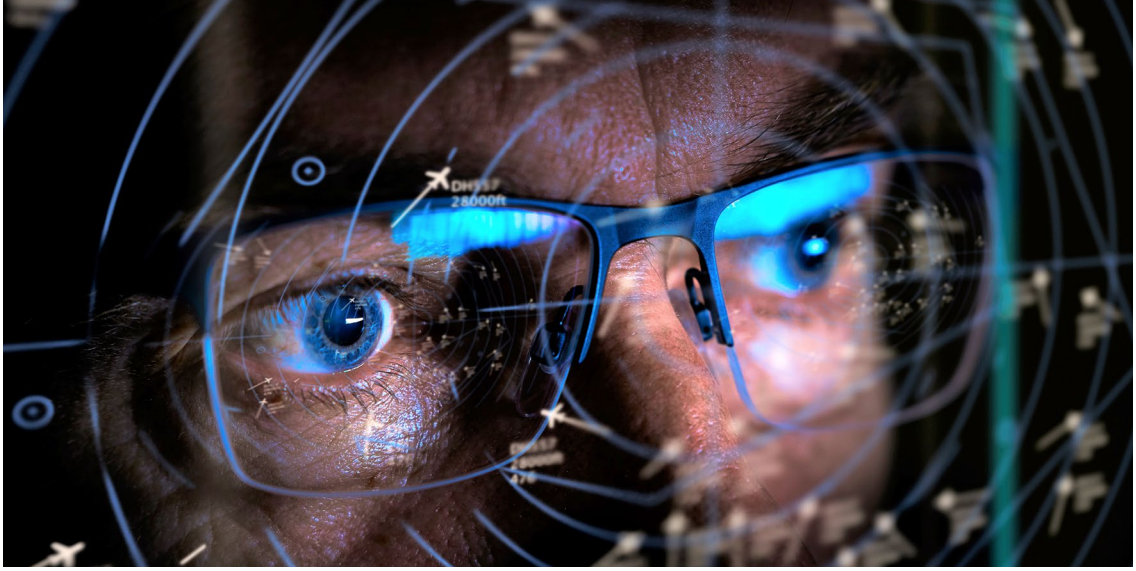
DTA will assist the implementation of this Strategy, altogether through airspace management linking with the military authorities, through consulting on national plans, through local measures to be taken, or decisions to be adopted at European level, regarding inter alia the deployment of SESAR or the role of the Network Manager.

Contents

PART 1

Introduction

THIS DOCUMENT DESCRIBES THE STRATEGY FOR THE MODERNIZATION OF AIRSPACE AND AIR TRAFFIC MANAGEMENT IN MAINLAND FRANCE AND THE OVERSEAS TERRITORIES.



Scope

The scope of the French ATM Strategy (FAS) includes the:

- Environmental performance as a priority to support sustainable development of aviation and flight efficiency;
- Structure and capacity of the French airspace and the routes that aircraft fly;
- Procedures and systems used to manage the flow of traffic;
- Requirements of different airspace users, including commercial air transport, general aviation and the military;
- The improvements to the airspace and ATM in the French overseas territories;
- Communications, navigation and surveillance (CNS) infrastructure that modern aviation relies on to operate safely and efficiently.

Stakeholders

The FAS is intended for all stakeholders with an interest in the aviation sector including the government, the regulator, the military, passengers, aircraft operators, airports, ANSPs, companies that rely on air transport to conduct their business and communities that may be affected by environmental impacts.

This version of the FAS has been developed by DSNA and IATA. The draft FAS will be shared with a broader range of aviation stakeholders to gather their views on the content before it is finalised and submitted to the DGAC for approval and moves into implementation.

The strategic goals of the FAS

1

Set out the main initiatives that aviation stakeholders will progress to modernize the French airspace and ATM in line with European and Global plans.

2

Identify the aviation stakeholders that are responsible for delivering each initiative and the main dependencies between them.

3

Establish a clear line of sight between the implementation of specific initiatives and their expected benefits, in terms of capacity, safety, efficiency, resilience and environmental performance.

4

Provide a basis for aviation stakeholders to coordinate their activities at a national level, oversee progress and make collaborative decisions about how, where and when to implement specific changes.

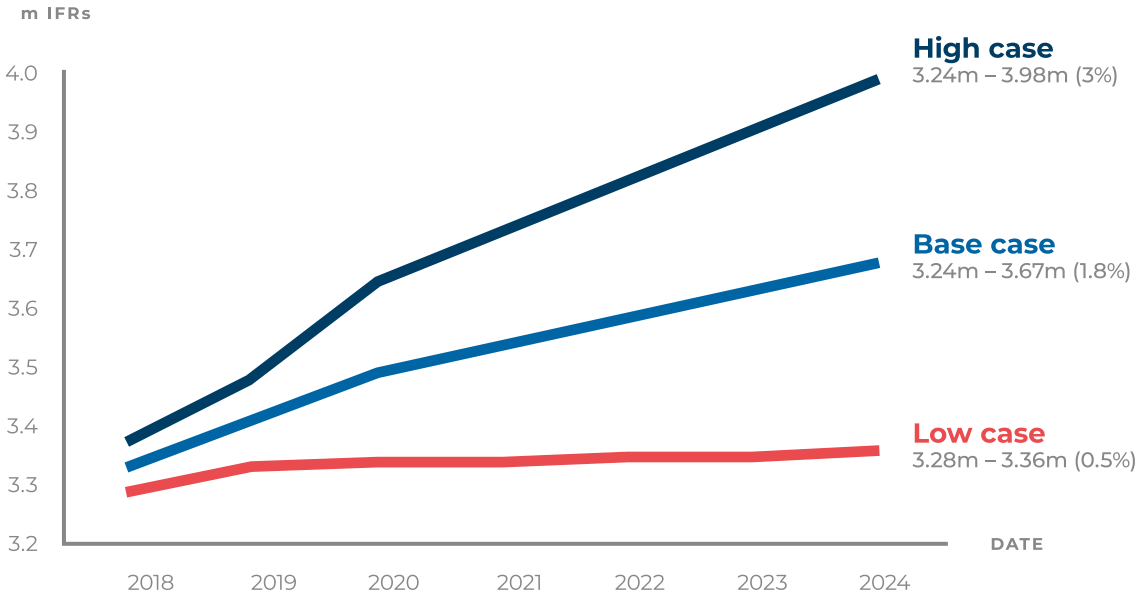
1.1 THE FRENCH AVIATION SECTOR

Aviation keeps people connected and provides the international access that France needs for trade, business and tourism.

France is home to Europe's third largest economy and is the world's biggest tourist destination. The aviation sector contributes approximately 4.3% to the country's GDP representing €90 billion of revenue. Over 80 million tourists visit each year, many travelling by air, spending around €48 billion. Aviation also plays an important role in the French manufacturing sector, where air transport is crucial for many high-value components and products. Over €240 billion worth of export goods are transported each year by air, supporting the supply chain for many French made products including automobiles, aircraft, consumables and electronics. In total, the aviation sector supports around 1.16 million jobs with 320,000 direct jobs in all aspects of air transport and associated services.

The growing demand for air travel is driven by the central position of France in the core of Europe, the large and growing number of overflights, an increase in air routes to other major global cities and iconic events like the Paris 2024 Olympics. Chart 01, illustrates how air transport movements (ATMs) are forecast to grow at a rate somewhere between 1.8% and 3% per year from 2018 to 2024, with total movements increasing to up to 4 million by 2024.

Chart 01



Source – Eurocontrol, Seven-year Forecast, October 2018

1.2 OVERVIEW OF THE FRENCH AIRSPACE AND ATM

The aviation sector relies greatly on the performance of the French airspace and air traffic management to operate safely, efficiently, and environmentally friendly.

The French airspace extends over 14m sq KM across mainland France, the Mediterranean, Atlantic and French overseas territories. The airspace can be grouped into two main categories, controlled and uncontrolled. Most flights in controlled airspace are commercial air transport carrying passengers and freight. The general aviation (GA) sector that includes business aviation, private pilots, gliders and a wide range of other operators mainly uses uncontrolled airspace. The military is a significant user of both controlled and uncontrolled airspace to protect the nation's borders and maintain the operational capability to project force internationally when and where required. The French airspace is also increasingly requested to accommodate the rapid growth in unmanned aerial vehicles (UAVs).

DSNA is the largest ANSP in Europe, controlling over 3.2 million flights in 2018, an average of 8,800 flights per day, with peak days of up to 11,000 flights. Enroute services are coordinated through five Area Control Centres (ACCs) located in Brest, Athis-Mons (identified as Paris ACC), Reims, Bordeaux and Aix-en-Provence (identified as Marseille ACC). The coverage of the five ACCs is illustrated in Chart 02. DSNA also provides air navigation services in the overseas territories of Reunion Island, Mayotte, West Indies-Guyana, Polynésia, New-Caledonia and Wallis and Futuna.

DSNA provides Approach and Aerodrome control services on 70 airports in mainland France and six overseas airports. The eight largest airports handling the majority of passengers in mainland France are listed hereafter by size.

AIRPORT	#PAX (m), 2018
Paris Charles de Gaulle	69.5
Paris Orly	32.0
Nice Cote d'Azur	13.3
Lyon – Saint Exupery	10.3
Toulouse – Blagnac	9.6
Marseille Provence	9.0
Bale – Mulhouse	7.9
Bordeaux	6.2

Chart 02
Coverage of the five ACCs

1.3 DRIVERS FOR AIRSPACE AND ATM MODERNIZATION

Airspace and ATM modernization is essential to accommodate forecast traffic demand in a safe, efficient, sustainable way and as a means of connectivity for national territories.

Table 1 describes the 7 main drivers for airspace and ATM modernization in France

#	DRIVER	DESCRIPTION OF DRIVER
1	Safety and security enhancements	To deliver continuous enhancements in aviation safety and manage the growing threats linked to cyber security by investing in new ATM systems, tools and procedures.
2	Efficiency and environmental performance	To improve the efficiency of airspace design and management, reducing aircraft fuel burn and emissions per flight and better managing the impacts of aircraft noise on local communities.
3	Capacity and punctuality	To introduce additional capacity to accommodate forecast traffic punctuality growth without delays and tackle key pinch points that cause congestion in the network.
4	Connectivity	To enable airlines and airports to meet the demand for global connectivity by offering new routes to popular destinations and emerging markets.
5	Resilience	To strengthen the resilience of the French airspace and ATM to bad weather, technical failures and other forms of disruption, including mitigating the impact of disruptions occurring in neighbouring states' airspace.
6	SES and SESAR	To support the implementation of the SES initiative and SESAR that provide the overarching framework to modernize European airspace and ATM.
7	UAV integration	To integrate the rapidly growing numbers of UAVs into the French airspace and enable new UAV companies to operate and grow as efficiently as possible.

Single European Sky (SES) and the SES ATM Research (SESAR) Program

Airspace modernization in France forms a key part of the wider Single European Sky (SES) initiative. The SES initiative is sponsored by the European Commission and provides the overarching framework to upgrade the airspace and ATM network across Europe. DSNA is a member of three institutional SES cooperation's, 1) SESAR Joint Undertaking, 2) SES Deployment Manager, and 3) the Functional Airspace Block – Europe Central. France is also member of the pan European organisation Eurocontrol under the umbrella of which operates the Network Manager.

The SESAR Programme is a key strand of the SES framework that aims to develop and deploy new concepts and technologies in support of airspace modernization. DSNA and some of France's largest airports have been heavily involved in the development, testing and implementation of the SESAR outputs through the Pilot Common Project (PCP). The SESAR PCP coordinates the deployment of six core ATM functionalities (AF) that are considered essential for the modernization of airspace across Europe, these are:

AF1
EXTENDED ARRIVAL MANAGEMENT AND PBN IN HIGH-DENSITY TMA

AF2
AIRPORT INTEGRATION AND THROUGHPUT

AF3
FLEXIBLE AIRSPACE MANAGEMENT AND FREE ROUTE

AF4
NETWORK COLLABORATIVE MANAGEMENT.

AF5
INITIAL SYSTEM WIDE INFORMATION MANAGEMENT (ISWIM).

AF6
INITIAL TRAJECTORY INFORMATION SHARING

The French ATM Strategy supports the implementation of the functionalities advocated by the SESAR PCP in the timelines required. Many of the solutions are planned for implementation at a wide range of French airports even through their operations are not legally covered by the PCP. The French ATM Strategy takes also into account the reflexion launched by EC on the target architecture of European airspace (Single European Airspace System) as a tentative update of SES framework.

1.3 DRIVERS FOR AIRSPACE AND ATM MODERNIZATION

The FAS describes a range of airspace and ATM modernization initiatives that aim to address the seven drivers using new concepts and technologies.

Table 2 sets out the main FAS initiatives and links them to the drivers they aim to address

1. Safety & Security
2. Efficiency & Env't
3. Capacity & Punctuality
4. Connectivity
5. Resilience
6. SES Implementation
7. UAV Integration

FAS INITIATIVE	DESCRIPTION	1	2	3	4	5	6	7
Modernizing the busy terminal airspace (section 2.1)	Deploying advanced terminal route networks using more accurate and flexible Performance-Based Navigation (PBN) capabilities.	✔	✔	✔	✔	✔	✔	
Redesigning airport arrival and departure routes (section 2.1)	Deploying new routes that are more resilient, enable flights to climb and descend continuously and better manage noise impacts.	✔	✔		✔	✔	✔	
Deploying free route airspace in the enroute network (section 2.2)	Deploying a user-oriented flight planning capacity (free route airspace), so aircraft can follow optimized flight paths through the enroute network with less reference to fixed routes and an increasing choice of trajectory planning.		✔	✔		✔		
Improving the Flexible Use of Airspace (section 2.2)	Providing civil and military airspace users with efficient access to the airspace in line with the demands of their operations.	✔	✔	✔		✔	✔	
Deploying new ATM systems, tools and infrastructure (section 2.3)	Improving the flow of traffic by managing flights according to their preferred business trajectories deploying enhanced deconfliction tools and upgrading the CNS infrastructure that supports modern aviation.	✔	✔		✔		✔	
Integrating UAV operations (section 2.4)	Integrating UAVs in a safe, secure and efficient way that protects the resilience of traditional operations.	✔				✔		✔

1.4 BENEFITS AND CHALLENGES OF AIRSPACE AND ATM MODERNIZATION

Airspace modernization is expected to generate a range of benefits for a broad mix of stakeholder groups, but some benefits may conflict with one another.

Benefits of airspace and ATM modernization

The FAS will generate benefits for a wide range of stakeholders. However, due to the complexity of the French airspace, creating benefits that fall to one stakeholder group may at times generate counter-benefits for others. The trade-offs between benefits and counter-benefits across stakeholders must be carefully overseen (see Part 3 on implementation).

FOR PASSENGERS AND THE WIDER ECONOMY, the benefits of airspace and ATM modernization are clear – fewer flight delays and service disruptions are expected to save time and improve the passenger experience. Also aligning the growth in airport capacity with airspace changes will accommodate new flights, leading to more choice, better value, and enhanced global connections. The close coordination at the European level between airport capacity growth and airspace capacity growth will benefit to European passengers and economy.

FOR COMMERCIAL AIR TRANSPORT OPERATORS, airspace and ATM modernization will introduce more airspace capacity, reducing delays while maintaining high levels of safety. The modernization will also improve flight efficiency, punctuality and costs per flight, enabling the airlines to the capitalise on the performance of their fleet.

FOR GA OPERATORS AND BUSINESS AVIATION, modernization offers the opportunity to access more volumes of airspace that are not required by commercial air transport, either through the rationalisation of controlled airspace or greater flexibility in the reservation and release of segregated areas. Modernization is also expected to improve safety in the GA sector by enhancing CNS information and aeronautical information management (AIM). The widespread adoption of PBN capabilities will create safety and efficiency benefits for GA and business aviation users that are already widely equipped with the required avionics.

FOR THE MILITARY, modernization is expected to enable more efficient operations throughout the French airspace, supported by greater dynamism in the reservation and release of flexible airspace structures. Airspace modernization will ensure that Military operators have access to suitably sized and sited areas of airspace to fulfil their objectives. New military aircraft (both manned and unmanned) often require larger volumes of segregated airspace in which to train and maintain operational readiness.

FOR UAV OPERATORS, modernization will enable safe and efficient access to the controlled airspace, enabled by the development and deployment of a UAV Traffic Management (UTM) system efficiently interfacing with ATM, and support the development of fast-growing companies within the French drone sector.

FOR AIRPORTS, airspace and ATM modernization will improve the integration of ground operations with airborne traffic flows, increasing runway throughput and enabling greater access to airfields during adverse weather conditions as well as preventing environmental impact through the optimization of current infrastructure prior to building new capacity. For some airports, remote tower technologies have the potential to transform how air traffic services are provided offering operation enhancements, greater efficiency and resilience.

FOR LOCAL COMMUNITIES, airspace and ATM modernization is expected to induce an overall reduction in average noise levels per flight, but the redistribution of noise impacts between different areas may lead to disruption for communities living under flight paths. The goal of the FAS is to limit and, where possible, reduce the adverse effects of aircraft noise. The trade-off between improving noise management at lower altitudes and many of the other potential benefits of modernization is one of the hardest to balance.

1.4 BENEFITS AND CHALLENGES OF AIRSPACE AND ATM MODERNIZATION

Aviation brings significant benefits to passengers, the economy and society, while taking care of environmental challenges.

Environmental challenges associated with airspace and ATM modernization

The government and aviation sector have important roles to play in ensuring that the results of airspace and ATM modernization are sustainable and enable improvements in environmental performance. The government sets the policy framework that encourages the industry to improve environmental performance in line with international agreements.

The FAS aims to provide clear direction for industry stakeholders to build on this framework and ensure that France leads the way in taking advantage of opportunities to better manage aviation's environmental impacts through airspace and ATM modernization.

Better management of aircraft noise

One of the most important environmental impacts associated with the airspace and ATM at lower altitudes concerns the effects of aircraft noise. The effects of new, more frequent or concentrated aircraft noise may increase the risks of causing general annoyance, sleep disturbance, lower levels of productivity and health impacts.

Aviation noise performance has improved significantly in recent decades, mainly driven by the introduction of quieter aircraft. The sound power generated by aircraft jet engines has reduced by 95% since their introduction. However, some communities experience more noise, especially around France's larger airports.

Routes designed to use advanced satellite navigation (also known as Performance- Based Navigation – PBN) significantly enhance aircraft track-keeping accuracy and improve the effectiveness of noise management. The decisions as to which procedures to apply must be made in close consultation with the airports and the local communities that are affected by aircraft noise.

Reducing aviation greenhouse gas (GHG) emissions

Air traffic in France represents 1.1% of total CO_2 emissions in France and 2.8% of CO_2 emissions in the transport sector. The long term growth in the number of flights is adding to the pressure on the aviation sector to improve its environmental performance. While progress is being made to increase aircraft engine efficiencies, such technological improvements are not sufficient, placing the focus on opportunities linked to airspace and ATM modernization.

The French aviation sector is contributing to ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (known as CORSIA), which is designed to complement the actions that the industry is already taking to reduce GHG emissions. The CORSIA scheme includes the deployment of operational improvements enabled by airspace and ATM modernization within its scope. The main operational improvements will be delivered by DSNA in line with the SESAR program and include the optimization of the overall air transport route network in France, implementation of free route airspace and upgrades to the terminal airspace so that aircraft can fly more direct routes at more efficient profiles and speeds. These improvements are described in greater detail in Part 2.

Altitude-based priorities

Reducing aircraft noise and greenhouse gas emissions simultaneously are two objectives that are not always compatible. Over 80% of the emissions from aircraft are released at altitudes higher than 6,000ft. Therefore, the French environmental policy regarding airspace emphasizes that:

- Below 6,000ft (FL60) the priority of airspace and ATM modernization is placed on better management of noise impacts;
- Above 6,000ft (FL60) the priority is on increasing capacity and flight efficiency to reduce greenhouse gas emissions.

Consultation with local communities living under flight paths is mandatory (law) for any change to the airspace or the introduction of approach or departure procedures. The results of the consultations are submitted to the environmental consultative committee (CCE), and the Independent State Authority (ACNUSA) for an advisory opinion.

The CCE is chaired by the regional authority (Préfet). It is composed of DGAC (not deliberating) and representatives from the airlines, airports and local communities. The decision about the new or amended procedures is influenced by the outcome of these consultations.

PART 2

Initiatives


AIRFRANCE
AIRFRANCE KLM

2.1A PARIS AIRSPACE OPTIMIZATION PLAN

Optimizing the Paris terminal airspace aims to significantly increase the capacity and efficiency of one of the world's busiest air transport networks, while limiting the effects on the environment.

The Paris airspace optimization plan

The terminal airspace that supports the Paris region is one of the busiest and most complex in the world. The terminal airspace extends from the ground to 25,000ft and is designed to manage high volumes of climbing and descending traffic between airports and the enroute network.

The structures and route network that makes up the Paris terminal airspace were designed many years ago when traffic levels and aircraft performance were lower. As traffic levels have grown, the frequency and complexity of the interactions between traffic flows inbound and outbound of the Paris terminal airspace has increased significantly.

Flights often follow longer routes and fly inefficient profiles to avoid crossing traffic in busy areas. The workload placed on air traffic controllers to manage high numbers of crossing traffic is a constraint on the potential to further increase the capacity and efficiency in the terminal airspace and the overall resilience of the operation. The plans to further improve the Paris terminal airspace are based on four main concepts:

- Widespread deployment of PBN routes;
- As announced in March 2019 in conclusion of the Assises du transport aérien, launch a proactive programme to generalize H24 by 2023 the continuous descent approach profiles at Paris-CDG, developments;
- Greater systemization of the airspace to minimize tactical intervention from ATC;
- Use of new sequencing tools to manage traffic flows and delays.

These concepts have been developed in collaboration with the SESAR program and form a key part of the Paris CDG Collaborative Decision Making (CDM) Roadmap, which is the main driver for the modernization of the Paris terminal airspace.

The scale of the Paris airports

The two main Paris airports served around 105m passengers on 710,000 flights in 2018, which accounts for over 60% of all air passenger journeys in France.

Paris CDG is the country's largest airport serving 72m passengers on 481,000 flights.

Orly is the second largest airport serving 33m passengers on 229,000 flights.

Both airports provide essential hub connectivity to global destinations with 11m transfer passengers travelling through the airports in 2017. Collectively the two airports also handle 90% of the country's air freight.

2.1A PARIS AIRSPACE OPTIMIZATION PLAN

Four main concepts for terminal airspace design and management to support the sustainable growth and efficiency of Paris airports.

1) Widespread deployment of PBN routes

The widespread deployment of PBN routes supports the optimization of the existing network in the Paris terminal airspace so that aircraft can automatically follow a large number of dedicated arrival and departure routes between each runway end and the enroute airspace. PBN increases the accuracy of aircraft track-keeping so that flight paths can be designed more closely and flexibly. PBN routes are separated from one another as part of their design and do not interact, meaning that:

- In normal operations, controllers are not required to separate traffic tactically;
- The main Paris airports and other surrounding airports in the region can release traffic into the terminal airspace without reference to, or dependency on, any other flows of traffic.

2) Continuous descent at Paris CDG

Paris-Charles de Gaulle conducted an operational experiment in the EUROCONTROL experimental center of Brétigny as part of SESAR for a new trajectory design ("PBN to ILS"). These research works led to the launch of a project of an operational deployment aimed at generalization of continuous descents on the CDG airport at the horizon 2023, in compliance with the commitments of the French Minister of Transport at the end of the Assises du Transport Aérien on 8 March 2019. This roadmap for the deployment of continuous descents even in periods of simultaneous used of both runway pairs, in day-time and at night-time, will require three key milestones: first, the proof of the contribution of the precision of satellite guiding to making the management of both CDG landing runways operationally independent; next, the validation of the regulatory framework authorizing this management mode (concept of aircraft "established on RNP satellite procedure" similar to the current concept of aircraft "established" on the ground system guiding the landing with precision (ILS)); finally, an essential milestone of consultation concerning the social acceptability of the concentration of disturbances to which this device may lead.

3) Systemisation of the terminal airspace

Optimizing the terminal airspace with such refinement that all routes are designed not to interact with one another is known as airspace 'systemization'. Once Paris terminal airspace is fully systemised, aircraft in the area will use PBN routes to accurately fly arrival and departure procedures following a series of horizontal and vertical restrictions that effectively contain their flight paths within isolated 3D tubes.

The increase in airspace capacity and flight efficiency created by systemizing the terminal route network into 3D tubes is an important step towards managing flights according to their preferred 4D business trajectories.

4) Use of the sequencing tools

Flights inbound to the Paris terminal airspace during busy periods can experience congestion that results in delays. Air traffic controllers use sequencing tools to integrate traffic flows and organize flights into an optimal order for arrival. This process is known as Arrival Management (AMAN). Similar tools are used to sequence the aircraft turnaround

process, supported by Airport Collaborative Decision Making (ACDM) processes, and outbound traffic flows into the terminal airspace known as Departure Management (DMAN). In the plans to optimize the Paris terminal airspace AMAN tools will be enhanced so that arrival delays are absorbed in the upper airspace and more airports will share information to support ACDM and DMAN. DSNA is working with neighbouring ANSPs in the UK, Netherlands, Germany, Switzerland and Italy as part of the SESAR program to integrate their AMAN tools and maximise the area of the upper airspace where arrival management can be used (a concept known as Extended AMAN or even Cross-border AMAN).

Benefits of the Paris terminal optimization plan

SAFETY ENHANCEMENTS

By reducing key risk factors associated with the terminal operation like crossing traffic, route interactions and network pinch-points.

GREATER FLIGHT EFFICIENCY

By deploying PBN routes with greater precision and flexibility, reducing track miles and increasing the potential for continuous climbs and descents.

ENVIRONMENTAL IMPROVEMENTS

The precision and flexibility of PBN routes creates opportunities to reduce aircraft emissions per flight and better manage noise impacts. These opportunities must be balanced against the challenges created by more precise flight paths that concentrate aircraft noise into narrower contours.

ADDITIONAL AIRSPACE CAPACITY

By implementing more closely spaced PBN arrival and departure routes to each runway end at individual airports that are separated by design and no longer require controllers to intervene tactically to manage traffic interactions.

GREATER RESILIENCE

The additional airspace capacity and the introduction of dedicated PBN routes for each airport will strengthen the resilience of the terminal operation to poor weather and other forms of disruption. However, the reduction in tactical controller intervention that is associated with airspace systemization may create new resilience challenges if parts of the systemized network are temporarily closed off and traffic cannot be efficiently vectored tactically by controllers.

2.1B AIRSPACE AND ATM MODERNIZATION AT FRENCH AIRPORTS

Airspace and ATM modernization is essential to enable French airports to grow sustainably and better manage the environmental impacts of aviation.

Across France, airspace and ATM modernization is essential to enable airports to maintain and increase their operations in a safe, efficient and environmentally sustainable way. Three of the main initiatives to modernize the airspace and ATM at French airports are:

- Optimization of airport arrival and departure routes using PBN.
- Deployment of Airport Collaborative Decision-Making (ACDM) systems and Network Management (NM) connection.
- Deployment of a new electronic ATM system for approaches and towers.

Optimizing arrival and departure routes

Most arrival and departure routes in France are designed around long-established ground navigation beacons. Although well-known and highly structured, the fixed locations of these beacons create inflexible and at times inefficient flight paths.

Optimizing arrival and departure routes using PBN can increase airspace capacity, create more efficient flight paths and improve the management of aircraft noise around airports. PBN is based primarily on satellite navigation and removes the need to rely on ground beacons, offering much more flexibility in the way that the airports' routes can be optimized.

Capacity can be added by implementing more closely spaced routes. Efficiency can be improved by changing the routes' climb and descent profiles and reducing track length. Environmental performance can be improved by deploying one (or a combination of) the four main noise management techniques in section 1.4.

The diversity in navigational capability across the fleet can constrain how and where PBN routes are deployed at airports. Although the majority of aircraft are equipped to fly to a basic PBN standard, the deployment of more advanced routes that deliver greater benefits may be limited by the need to accommodate aircraft that are not sufficiently capable. This can be supported where beneficial by a balanced use of the "best equipped best served" principle.

ACDM systems and NM connection

ACDM involves the introduction of new systems and processes that focuses on:

- Creation, refinement and exchange of information between airports and the network.
- Progress of each flight's arrival plan and turnaround.
- Up-to-date timings shared for each flight to push back, taxi out and take off.
- Optimized departure sequencing. (supported by the use of DMAN tools).

With this information ACDM systems allow air traffic controllers to construct an optimized sequence of departures tailored to the prevailing conditions of the runway and the surrounding airspace. ACDM systems also gather the latest estimated landing times for inbound flights to improve the management of ground operations by airlines and airports that are often the cause of air traffic delays. The systems also provide data sharing services with airspace users, airports and the network, to support CDM and increase resilience during adverse conditions and traffic congestion.

SYSAT deployment at French airports

SYSAT is a new ATM system designed to modernize the tower and approach services. The system features (in its final version), a fully electronic environment, new controller working positions, enhanced ground surveillance, additional runway and ground safety nets, ATC tools for sequencing, taxi and runway operations, the integration of AMAN/DMAN HMI and the facilitation of interfaces between airports.

SYSAT deployment at France's three largest airports (CDG, Orly and Nice) will ensure compliance with the SESAR PCP IR, in the areas covering electronic flight strip requirements following the EFS capability (provided by DMAN HMI implementation) and integrated safety nets. Once deployed this new ATM system is expected to deliver significant safety enhancements by offering conflict alerts at all controller positions.

The SYSAT system also includes an integrated Time-Based Separation (TBS) tool to fine-tune the separation between two aircraft on the final approach and ensure the minimal separation as regards to wake turbulence and wind strength.

The electronic environment provided by SYSAT will reduce the workload for controllers to complete common tasks, leading to an increase in runway capacity. These capacity increases are supported by automated guidance for controllers to optimize taxi routes and the integration of ground surveillance.

SYSAT deployment will start in the Paris region with Paris-CDG receiving a new Automated Surface Management, Guidance and Control System (ASMGCS) in winter 2021 as the first step towards full implementation by 2025.

In the meantime, Orly and Le Bourget will also receive versions of the SYSAT systems. At the remaining 69 airports the system modernization roadmap supported by the SYSAT program will prioritize the components that best address the challenges of their local operation, taking into account European regulations and the airports existing CDM commitments.

Airspace and ATM modernization at France's largest airports.

This section summarizes the strategic developments at France's nine largest airports that shape how and when key airspace and ATM modernization initiatives will be deployed.

Paris CDG is the second largest airport in Europe. The airport has invested in a very efficient ATM system with four parallel runways that can be operated independently for take-offs and landings. Operations at Paris Le Bourget airport that is located three miles to the south-west are integrated into the CDG ATM system. Paris CDG is now focused on optimizing the performance of the infrastructure through the CDM@CDG Roadmap that guides the implementation and integration of several key ATM projects including enhancing the ACDM system, deploying advanced PBN arrival and departure routes, SYSAT implementation, reducing the spacing between successive arrivals and departures through TBS and improving the management of surface movements.

Paris CDG is now the first European airport capable of proposing triple parallel independent approaches combining simultaneous ILS and PBN landing operations. This new feature is most helpful to maintain the airport landing capacity e.g. when one ILS is out of service. DSNA and the Minister of Transport are also committed to the development of a new "PBN to ILS" concept that aims to enhance continuous descent from 2023.

Paris Orly is undergoing a major transformation program to optimize the performance of its operation. The airport operates to a cap of 250,000 flights per year across the three runways. There is also a night-time curfew in place at the airport from 23.30 to 06.00.

An ACDM system has been implemented to maximise the punctuality and resilience of the turnaround and departure phases. Optimized PBN arrival and departure routes will also be implemented in due course, offering opportunities to better manage noise impacts and increase runway throughput.

Nice Cote d'Azur is part way through a major infrastructure expansion program to meet the forecast growth in traffic levels. The airport will implement several airspace and ATM modernization projects to support the expansion program including upgrading arrival and departure routes and implementing the PCP Electronic Flight Strip roadmap: ACDM system and SYSAT.

In 2019, Nice is introducing a PBN approach and landing procedures known as Required Navigation Performance for Approach or RNP APCH. All airlines and business jets operating to Nice are required to have the capability to fly RNP APCH from 1st March 2019. This evolution will make Nice the first European PCP airport to land aircraft routinely through PBN approach procedures.

Lyon – Saint Exupery expects to grow its operations to handle significantly more passengers. The airport investment program is designed to optimize the performance of the existing infrastructure and is supported by the modernization of arrival and departure routes, the implementation of an ACDM system and the deployment of the SYSAT system.

Marseille Provence launched a major investment program in 2015 to transform the airport and meet the forecast growth in demand out to 2030. The program will see around €500m invested between now and 2026, enabling the airport to serve over 11m passengers per year.

Tolouse-Blagnac is modernizing its infrastructure, airspace and ATM capability to expand the numbers of both low-cost traffic and long- haul flights. The modernization initiatives aim at increasing the airport's capacity to up to 12m passengers per year.

Bale – Mulhouse serves a network of 100 destinations in 30 countries. It is a major gateway to the tri-national region that is a major tourist attraction. Airspace and ATM modernization at the airport aims at supporting plans to further expand its network to include Eastern European destinations.

Bordeaux has experienced 10% annual average growth over the last eight years, increasing its annual passenger count by 2.3m. In response, the airport is investing in a major infrastructure program that will see the arrivals halls, terminals and surface transport options all upgraded. Airspace and ATM modernization initiatives are required to ensure that ground movements and arrival and departure routes are efficient, resilient and sustainable.

Nantes Atlantique: A public consultation on "Nantes Atlantique airport project" will take place on June and July 2019. Depending on its conclusions, the modernization of terminal airspace could be one of the measures decided in response to the public expectations. In this case, modernization would take benefit of the most advanced potential of PBN procedures, in addition to the implementation of an ILS to ensure the highest level of safety.

Airspace and ATM modernization at regional and smaller airports

The French aviation sector includes a further 64 regional and smaller controlled airports that typically serve anywhere between 100,000 and 5m passengers per year. Low-cost operators are largely accountable for the growth in traffic levels at regional airports and have contributed to more than half of the overall growth

in traffic levels across French airports.

The deployment of PBN approach and landing procedures at these airports will continue to progress, focusing on the benefits that can be generated for each operation. Approach and landing procedures are nearly all published and will be fully implemented in the next two years.

For the future, as part of the CDM approach supported by the FAS, DSNA is engaging with all airports, local operators and other airport stakeholders to gather their perspectives on the types of PBN routes that should be deployed where and when.

DSNA is also evaluating with some regional airports the prospect of developing a light touch connection between the airport and the network manager (known as an Advanced ATC Tower) and to deploy a tailored concept of ACDM.

Digital and remote tower technologies

The integration of digital and remote tower technologies at regional and smaller airports has the potential to deliver significant benefits. The technologies can offer a range of performance improvements that may help to manage the specific challenges faced by regional and smaller airports in the mainland and overseas.

The construction of full remote tower operations centers may enable air traffic services to be provided to multiple airports from one location making it easier and more efficient to scale up and scale down the capacity of specific airport operations. DSNA

is currently working with airports to develop pioneer projects that will consolidate the business cases and concept of operation supported by digital and remote tower technologies. The first deployments of remote tower technologies are scheduled at Cannes, Tours Val de Loire, Pau and Miquelon in the 2023 timeframe. The feedback from these trials will be used to better define the real world opportunities associated with digital and remote tower technologies in different operational scenarios. This will serve as input to further decisions concerning longer-term investment.

Modernization in overseas territories

DSNA provides air navigation services to the overseas territories including the Reunion Island, Mayotte, West Indies, Guyana and Saint-Pierre and Miquelon communities. In Polynesia, New Caledonia and Wallis and Futuna, air navigation functions are provided by civil aviation territorial services that are directly linked to the DGAC. The scope of the services provided is tailored to meet the local requirements in each region while remaining as consistent as possible with mainland operations. A similar approach is followed in oceanic areas of control delegated to France by ICAO in Polynesia, managed from Tahiti, and in the Atlantic off the coast of Guyana, managed by Cayenne. DSNA also assumes responsibility for developing Search and Rescue services in these regions.

The modernization of airspace and ATM in overseas territories must manage three main challenges:

- Large geographic distances associated with overseas territories.
- Different expectations and operating approaches of various international airspace user groups.
- Regional partnerships with international organizations that are required to develop and implement innovative new approaches.

The strategy to modernize airspace and ATM in overseas territories and tackle these challenges is grouped into five key objectives:

1. To maintain and improve the high- performance levels of air navigation services and personnel operating in overseas territories.
2. To modernize the ATM systems and tools used to provide services in overseas territories.
3. To modernize the surveillance infrastructure in overseas regions using ADS-B.
4. To create a strong collaborative decision making (CDM) organization with airspace users for crisis management.
5. To maintain and improve the provision of Search and Rescue (SAR) services in line with DSNA's commitment to ICAO.

Overseas territories roadmap

The strategic objectives for the overseas territories are addressed in regional roadmaps for:

The Indian Ocean where an approach system at Dzaoudzi is scheduled for implementation by 2023, to be operated from Reunion Island, and accompanied an ADS-B Tier 2 service.

West Indies-Guyana where continuous improvements to the quality of the oceanic service are planned through the modernization of ATM control systems and the introduction of an ADS-B Tier 2 service, which will also consolidate regional (West Indies) coordination of the SAR service through synergies with the maritime affairs service.

Saint-Pierre and Miquelon: where DSNA will continue to develop and implement a new airfield control service for Miquelon, delivered remotely from the St-Pierre tower.

Polynesia: where the modernization roadmap concentrates on the development of an ADS-B Tier 1 service in the 2023/24 timeframe that would aim to achieve a separation objective of 10nm and be accompanied by the closure of the Mount Marau radar.

New Caledonia: The introduction of an ADS-B Tier 2 surveillance system is currently being certified for launch later in 2019.

2.2A IMPLEMENTING FREE ROUTE AIRSPACE

Free route airspace offers aircraft the flexibility to plan and fly the shortest, quickest, most efficient routes through the upper airspace, which benefit the environment.

The concept of free route airspace

Aircraft often fly further than necessary in the upper airspace, following routes that are determined by a fixed structure of waypoints, rather than the shortest, most direct track to their destination. Most of the waypoints are based on the position of ground navigation beacons.

The capacity, efficiency and resilience of the upper airspace is largely determined by the ability of air traffic controllers to safely manage the flow of traffic through the fixed waypoints in each sector. Flow restrictions are applied to sectors when the volume of traffic exceeds a level that the controllers can manage safely.

These restrictions can create bottlenecks which cause aircraft to be delayed or re-routed. The goal of free route airspace is to reduce the dependency on a fixed waypoint structure, enabling aircraft to fly as close to their preferred trajectory as possible. Aircraft will use satellite navigation to route directly between the most efficient combination of free route airspace entry and exit points. As the concept matures operators will be able to plan and fly free route trajectories across State boundaries supported by integrated ATM systems and tools (see section 2.3).

Free route airspace implementation

Free route airspace in France is being implemented as part of the Functional Airspace Block Europe Central (FABEC) project and in line with the SESAR PCP IR which instructs all European States to remove fixed waypoints above Flight Level (FL) 310 (31,000ft).

The FABEC project defines a stepped and gradual implementation approach for free route airspace, where each country's ACC's, in cooperation with airline flight planning service providers, will develop and implement cross-border free route airspace based on a single common FABEC concept of operations, which complies with the standards defined by the European Network Manager. As part of the FABEC project, free route airspace is scheduled for implementation across the Brest ACC upper airspace, followed by Bordeaux and the remaining French upper airspace in line with the cross-border free route 2025 milestone highlighted by the Airspace Architecture Study. To prepare for free route airspace, DSNA will work in the coming years on airspace design projects such as the transfer of a part of Brest ACC FIR to the IROISE approach (below FL195).

The benefits of free route airspace

SAFETY BENEFITS are linked to the additional capacity by reducing the risk factors associated with traffic congestion around pinch points in the fixed airspace structure. Safety benefits are also supported by improvements in the predictability of traffic flows as aircraft flight plans become more reflective of actual routeings. The transition period towards free route airspace will however require close monitoring with regard to safety.

FLIGHT EFFICIENCY AND ENVIRONMENTAL BENEFITS are enabled by the flexibility to flight plan and fly more direct routes at more efficient altitudes than available when following fixed waypoints – reducing average levels of aircraft fuel burn and emissions per flight.

AIRSPACE CAPACITY BENEFITS are expected from the removal of fixed waypoints and enabling controllers to manage more flights through the same sectors of airspace.

RESILIENCE BENEFITS are expected from the flexibility to plan and re-plan flight paths in response to poor weather, disruption and other airspace restrictions.

2.2B IMPROVING THE FLEXIBLE USE OF AIRSPACE

Improving the flexible use of airspace enables airspace users to fly optimized flight paths taking into account temporary airspace restrictions.

Some parts of the French airspace are temporary segregated or restricted areas (TSA or TRA) for military purposes like training and weapons testing. Military authorities reserve the airspace and hand it back for civil use when it is no longer needed. The process of reserving and handing back areas that are shared between civil and military users is known as the Flexible Use of Airspace (FUA). The FUA concept is also used to optimize civil/civil operations, for example when DSNA temporarily transfers control of an area of the French airspace to the Swiss ANSP to manage depending on the prevailing wind at Geneva airport. The FAS approach is to improve the tools and processes used to manage FUA and use a SESAR requirement known as Advanced FUA (A-FUA). A-FUA enables Military authorities to reserve and release airspace more efficiently to best meet their training and mission requirements.

Like the free route airspace concept, the goal of A-FUA for civil users is to enable aircraft to fly as close to their optimized flight path, as possible without being limited by unnecessary airspace segregation. A-FUA has been deployed in France by DSNA and the French military authorities in line with the requirements set out in the SESAR PCP.

A-FUA relies on the deployment of new airspace management (ASM) tools that communicate changes in the status of segregated areas more dynamically. Civil and military ANSPs follow joint A-FUA processes to manage segregated areas using the most accurate information provided by ASM tools. Common interoperability standards allow for A-FUA information to be shared with other State ANSPs, airspace users and flight plan service provider so that they can optimize their planning and operations.

The benefits of flexible use airspace

SAFETY BENEFITS
Better information about airspace usage reduces the potential for infringements by civil users into segregated areas.

RESILIENCE BENEFITS
Civil users can plan flight paths through segregated areas when they are not being used in response to poor weather or disruption.

AIRSPACE CAPACITY BENEFITS
Civil users can plan and fly through segregated areas when they are not being used, increasing the available airspace capacity.

FLIGHT EFFICIENCY AND ENVIRONMENTAL BENEFITS
Civil users flying through segregated areas when they are not being used can reduce flight times, track miles and aircraft emissions.

2.3A MODERNIZING ATM SYSTEMS AND TOOLS

New ATM systems and tools will enhance safety, increase capacity, support flight efficiency and enable air traffic controllers to maximize the benefits of airspace modernization.

DSNA is investing significantly in the modernization of the systems and tools used to manage air traffic. New ATM systems and tools provide access to more flight information. This helps controllers to understand the preferred flight path of each aircraft. The successful implementation of the airspace modernization initiatives described in sections 2.1 and 2.2 are dependent on several new ATM systems and tools, specifically:

- ERATO – An electronic conflict resolution tool for air traffic controllers.
- COFLIGHT – A next-generation Flight Data Processing System.
- 4-FLIGHT – A new generation electronic ATM system for air traffic controllers and future SESAR functionalities such as enhanced short and medium term conflict prediction tools.
- Aeronautical Information Management.
- Big data applications and cyber security.

ERATO Implementation

ERATO is an ATM tool that provides the first step towards Medium Term Conflict Detection (MTCD). The flight paths of crossing traffic can be identified and deconflicted using the ERATO agenda tool. Early identification of crossing traffic offers controllers more time and more options to resolve the potential conflicts, allowing better management of the overall flow of traffic, thus increasing airspace safety, capacity and efficiency.

The ERATO tool was implemented into the Brest and Bordeaux ACCs in 2016 and has increased since then the capacity of some high-level sectors by up to 20%. Some features of the ERATO tool have also been deployed into the other three French ACCs in preparation for the transition to the COFLIGHT / 4-FLIGHT environment. MTCD is a key functionality to support the full benefits of free route airspace that will be enhanced within the 4-FLIGHT ATM system based on the ERATO tool as a precursor.

COFLIGHT development and deployment

COFLIGHT is a new generation Flight Data Processing System (FDPS) that is designed to meet the SESAR objective of gate-to- gate 4D trajectory management. The system has been developed in collaboration with the Italian ANSP (ENAV) and the SESAR program. COFLIGHT features a range of advanced functions including 4D trajectory prediction, datalink integration, traffic flow optimization and interoperability across European ACCs.

When used in conjunction with the new generation ATM system 4-FLIGHT, the COFLIGHT FDPS is expected to deliver significant safety enhancements by improving the accuracy of forecast flight positions and profiles, route adherence and conflict detection.

In this perspective, COFLIGHT is a key component of the target architecture stemming from Airspace Architecture Study, both as an enabler of a network system based on predictability rather than punctuality and as an enabler of virtualization of services.

While existing systems are limited to distributing filed flight plan information to controllers, COFLIGHT continuously enriches

initial flight plan information with real-time data, based on the actions taken by controllers.

COFLIGHT deployment is underway as a pilot project in two DSNA ACCs, Reims and Marseille, where it will enter into service from in 2021/2022. Plans to deploy the system at the Paris ACC have already begun, with deployment scheduled for winter 2022/2023. All five ACCs will operate using COFLIGHT by 2024. A first version is already in operation through a BtoB service to fuel XMAN and the ATFCM system with enhanced flight data, yet improving the predictability of the benefit of the network.

4-FLIGHT development and deployment

4-FLIGHT is a next-generation ATM system that provides a fully electronic environment for enroute air traffic control. The system uses data drawn from the COFLIGHT FDPS and features a range of innovative controller tools that will enhance safety and help optimize capacity and efficiency.

The main functions that will be implemented as part of 4-FLIGHT are:

- A full set of air traffic controller tools to manage current and future traffic flows.
- Tactical Control Tools (TCT) for conflict detection with a 5-minute look-ahead.
- Electronic negotiation of “what if” data that coordinates aircraft flight levels and direct routes with adjacent sectors.
- Cooperative tools for shared situational awareness, creating safety and efficiency improvements by improving the distribution of workload.

The first operational version of the 4-FLIGHT ATM system has been deployed to the Marseille and Reims ACCs for testing, validation and controller training. An upgraded version of the system is being developed for the Paris ACC to support the complexity of the airspace in that region.

Full implementation of the 4-FLIGHT ATM system across all five ACCs is expected by 2024. One of the first expected benefits following full implementation is a 20% increase in overall network capacity across the French airspace.

4-FLIGHT and COFLIGHT represent the core of the modernization of the French ATM system at the end of PCP deployment phase supporting further SESAR transition towards full Trajectory Based Operations (TBO).

Aeronautical information management (AIM) and System Wide Information Management (SWIM)

The Aeronautical Information Exchange Model (AIXM) and System Wide Information Management (SWIM) concept set out specifications that enable the distribution of key data in a common digital format. Advanced data exchange services are required to communicate up to date aeronautical information (e.g. flight plans, weather, airport data etc.) that helps operational stakeholders to maximize the benefits of new ATM systems and tools.

The use of big data applications

From 2021 onwards, DSNA will progressively integrate the functionalities of COFLIGHT, 4-FLIGHT, ERATO, AIM and SWIM. The range of data generated and shared by these systems creates the opportunity to deploy so-called ‘big data’ applications that can add value by:

- Producing real-time performance dashboards that provide operational stakeholders with up to date information to support their decision making.
- Incorporating artificial intelligence and machine learning into the assessment of performance and development of options to optimize the airspace.
- Improving post operational analysis that can be shared with stakeholders to continuously improve their daily operations.

Cyber security

DSNA is investing in a new state-of-art IT architecture and enhanced software solutions to mitigate the growing threat of a cyber security breach. A Cyber Action Plan has been developed by DSNA and validated by the DGAC and the National Cybersecurity Agency (ANSSI). The plan features the creation of a new Security Operating Center (SOC) and steps to strengthen cooperation with the military to share expertise in the field of cybersecurity and protect the enhanced interoperability of the new generation of civil and military ATM systems and the deployment of AIM, SWIM and Big Data services.

2.3B UPGRADING THE FRENCH CNS INFRASTRUCTURE

The communications, navigation and surveillance infrastructure that supports the French airspace and ATM is being upgraded to support the modernization process.

The CNS section of the strategy focuses on the transition from radios, ground navigation beacons and primary radars to satellite-based and datalink technologies. The transition from conventional ground- based CNS infrastructure to satellite-based, digital capabilities is a key enabler for the French airspace and ATM modernization process. In the near term, some ground- based infrastructure will, however, need to be kept active for defence, security and resilience purposes. In the longer term, the expansion of satellite-based technologies will help to mitigate the risk of single- source failures and enable the further rationalisation of ground infrastructure.

Communications infrastructure

Digital technologies are changing the preferred method of communications between air traffic controllers and aircraft, allowing larger volumes of information to be shared faster and more consistently via datalink transfer. New airspace and ATM concepts often rely on greater volumes of operational and planning data, placing greater pressure on the radio frequency spectrum that is traditionally used to conduct voice communications. Radio-frequency spectrum is an asset in high demand. The introduction of datalink services is a European and International ambition for the aviation sector that aims at reducing the number of radio communications and at supporting a more consistent, reliable and less workload intensive exchange of information. Initially, datalink solutions are being used to replace standard air traffic message exchanges, with more complex interactions developing as experience is gained. The full benefits of datalink are dependent on the airlines which must equip their fleets and modify their procedures to realize the benefits of datalink services.

Navigation infrastructure

The avionics capability of modern aircraft has advanced significantly in the past two decades, allowing a shift from the reliance on ground-based navigation beacons to autonomous aircraft operations dependent on a satellite-based navigation source. The French ground-based navigation infrastructure currently includes 272 assets (72 Instrument Landing Systems, 96 VHF Omni Ranges, 104 Non-Directional Beacons). A study of what could be the minimum operational network of ground- based assets required to meet the demands of all airspace users, as well as applicable security and resilience requirements is currently being conducted by DSNA. Pending the outputs of this analysis, the ground-based infrastructure will be further rationalized delivering significant cost savings.

This lower cost, national approach to navigation infrastructure is being developed in parallel with the on-going deployment of new PBN approaches at French aerodromes, including 50+ small and medium-sized airports that support general aviation users. The deployment of PBN approaches has already enabled the creation of a Minimal Operating Network (MON) of ILS through the removal or transfer of 50 instrument landing systems between 2016 and 2017, generating significant cost and resilience improvements and confirming DSNA as the European early mover ANSP towards full PBN deployment.

Surveillance infrastructure

The widespread adoption of electronic surveillance solutions that make all aircraft more visible is needed to maintain high safety standards, especially around smaller aerodromes that have limited surveillance capabilities. An additional mid-air collision risk arises from airspace infringements – where an aircraft flying in uncontrolled airspace inadvertently enters controlled airspace.

The adoption of digital communications and satellite navigation allows airspace users to transmit precise positional information to air traffic controllers, increasing both ground and airborne situational awareness. It is recognised that a primary aviation surveillance capability (i.e. radars) will still be required for the foreseeable future, at a minimum to support defence and security objectives. However, ATM and CNS modernization offers the opportunity to enhance surveillance capabilities in the air and on the ground by:

- Increasing the uptake of aircraft broadcast position information and availability of portable technology, allowing an affordable option for all aircraft operators to share electronic surveillance information;
- Developing and deploying new technologies and equipment for ANSPs and airports to gather, process and display aircraft position information from various sources.

The benefits of new ATM systems, tools and infrastructure

SAFETY BENEFITS

New ATM systems and tools enhance the ability of air traffic controllers to conduct safety critical safety tasks, including aircraft separation and deconfliction.

AIRSPACE CAPACITY BENEFITS

New ATM systems and tools add capacity by reducing controller workload and creating efficiency improvements from greater automation and date augmentation.

RESILIENCE BENEFITS

New ATM systems and tools are provided on a modern IT platforms that are less suspectable to technical failures.

FLIGHT EFFICIENCY AND ENVIRONMENTAL BENEFITS

New ATM systems and tools enable trajectory operations that generate more efficient fight path options and reduce flight times, track miles and aircraft emissions.

2.3C RESILIENCE AND BUSINESS CONTINUITY

Airspace and ATM performance is dependent on the resilience and business continuity of ANSPs that deliver essential services and infrastructure.

Across Europe, ANSPs deliver essential services and infrastructure that support the performance of the airspace and air transport network. Within the aviation value-chain, the ANSP plays an essential role in facilitating safe and efficient access to airspace and providing connectivity within and beyond European borders. Even if European airspace remains managed along or across national boundaries by monopoly service providers, cross-border optimization and organization are already deployed, for example through the delegation of airspace, Letter of Arrangements for the provision of Air traffic services signed between ANSPs and European plans committing DSNA under the umbrella of the Network Manager.

The resilience of the European air transport network is a growing concern for airspace users, with service failures becoming a routine event, causing flight delays and cancellations. Service failures encompass any event, technical or social, which results in a significant reduction or complete inability to provide normal capacity levels and air navigation services through a volume of airspace in the enroute, terminal or airport environments. Business continuity is defined as the capability of organizations' to continue delivering their services at acceptable predefined levels following a disruptive event that would otherwise result in a service failure.

The management of airspace resilience and the business continuity for air navigation services are already statutory requirements placed on DSNA by the State. These requirements cover:

- Resilience: critical business functions and the supporting airspace infrastructure are designed and engineered so as to be materially unaffected by most disruptions, for example through the provision of redundancy;
- Recovery: pre-arranged mechanisms are in place to quickly recover or restore critical business functions that fail for any reason;
- Contingency: the ANSP has established a general capability, readiness and clear plans to cope effectively with whatever major incident and disaster that could occur, including those that were not, and perhaps, could not have been foreseen. Contingency constitutes a last-resort response if resilience and recovery arrangements should prove inadequate in practice.

The foundations of resilience and business continuity for the French airspace and ATM are the agreements, infrastructure and supporting procedures needed to ensure the ANSP can maintain the provision of its services without disruption, irrespective of the adverse circumstances or events.

While the French airspace and ATM improves through the modernization progress it is important to recognize that resilience and business continuity encompass both the human and technical aspects of the ATM system. When assessing the relative frequency of service failures across European ANSPs, addressing the human factors is considered essential.

There is a range of measures within the scope of the FAS that are being taken forward by the government, regulator, ANSP and MET provider to ensure robust resilience and business continuity, for example:

- The French government and European legislators have mandated contingency plans to support minimum service levels to mitigate the consequences of service failures should they occur;
- The regulator has laid down the specific aspects of the ANSP's licence agreement that include the requirements to maintain service levels for key infrastructure and systems, and to report transparently on the performance of business continuity management;
- DSNA continues to invest in systems and infrastructure that are engineered with redundancy protections and fall back modes designed to reduce the likelihood and impact of service failures – taking into account the balance between business continuity readiness and costs.
- DSNA is also working with Météo-France, the MET provider to strengthen the airspace resilience and business continuity arrangements in case of adverse weather events. Notably, DSNA and Météo France have agreed on a CDM airports network which benefits from the new high value-added Met service offered by Météo-France.

2.4A AIRSPACE AND ATM FOR GENERAL AVIATION

ATM modernization is expected to enhance safety, efficiency and access for all forms of general aviation operations in the French airspace.

General aviation is defined by ICAO as all civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire. In France the term general aviation encompasses a wide range of operations that typically take place in uncontrolled airspace, including:

- Business aviation
- Pilot training
- Recreation, including light aircraft, balloon, glider and model aircraft flying
- Agriculture, including crop spraying
- Emergency medical transport
- Monitoring ground traffic movements from the air
- Civilian search and rescue
- Law enforcement including operations against smuggling
- Aerial surveying
- Flying displays

General Aviation Roadmap Development

General aviation in France is regulated by the DGAC, which has a specific light, general and helicopter aviation service (MALGH) that promotes the development of general aviation, whilst at the same time working with stakeholders to improve safety levels across the sector. From a regulatory perspective, the DGAC and European Aviation Safety Agency (EASA) have recognized that a generic top-down, one-size-fits-all regulatory approach is potentially stifling further growth and innovation in the general aviation sector.

France, as both a member state of EASA and a EASA Management Board Member, has adopted the EASA General Aviation Roadmap with the following strategic objectives, to:

- Facilitate access to airspace and greater integration of airspace user groups.
- Allow and promote the introduction of new technologies.
- Develop the use of industry standards for communications, navigation and surveillance solutions.
- Adopt a performance-based approach to regulation and simplify certification processes.
- Simplify and reduce the costs of maintenance of general aviation aircraft.

Like other European countries, France is also following the requirements of the SES initiative in developing clear standards and low-cost solutions that support interoperability and will allow the integration of all airspace users (including general aviation) in a safe, efficient and non-discriminatory manner. The use of new technologies developed to industry agreed standards in the general aviation sector is also supported by the SESAR program.

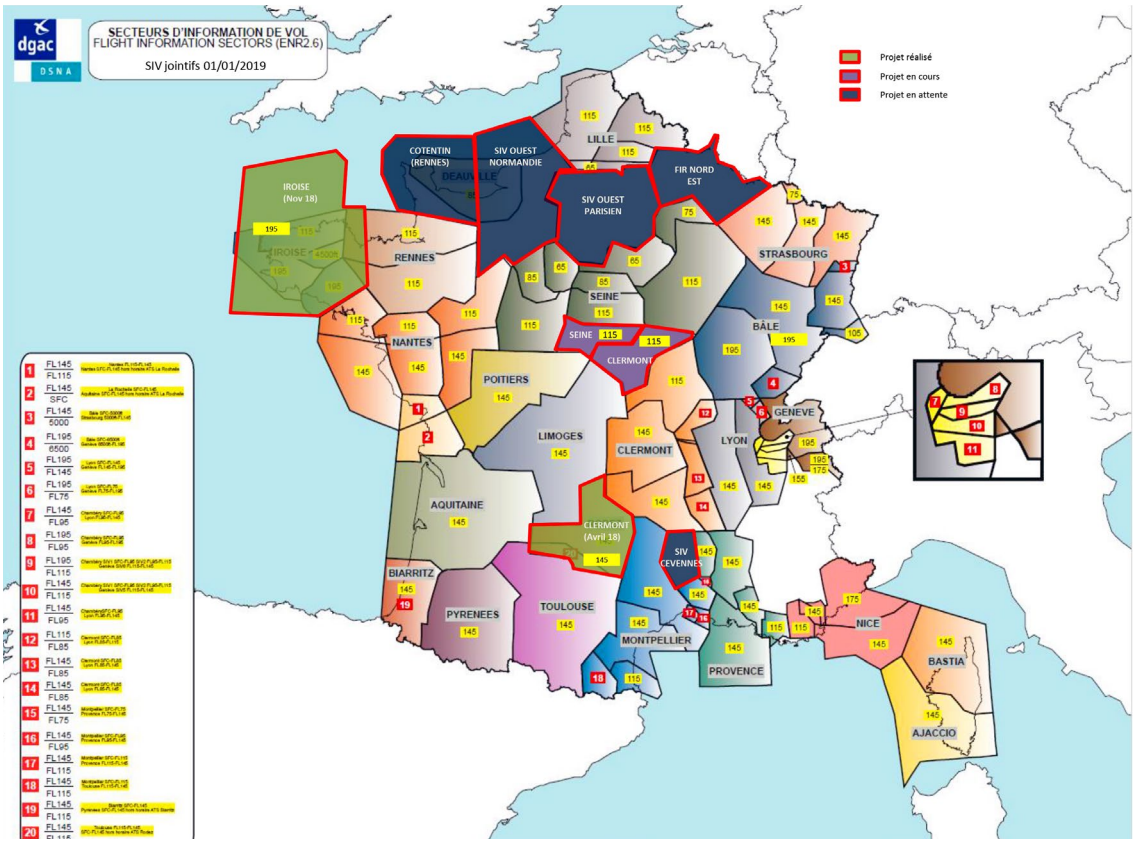
To complement and support this strategic roadmap, DSNA will continue to implement Flight Information Sectors over France which is a priority for the GA community.

General aviation in France

France has a large and varied general aviation sector that includes over 32,000 registered general aviation aircraft, 600 aerodromes and airstrips, 50 commercial airports with access to general aviation users and 1,400 aeroclubs. In addition, the general aviation sector in France sustains a large community of qualified engineers, flying instructors, and, of course, pilots, many of whom go on to roles in commercial air transport and the military.

Across Europe general aviation has an estimated economic value of c.€28bn and supports c.40,000 jobs.

Chart 05 illustrates that the Flight Information sectors are planned to cover the whole France



2.4B INTEGRATING UNMANNED DRONE OPERATIONS

Unmanned operations will increase significantly in the next decade and must be integrated safely and efficiently with conventional forms of aviation.

By 2030 unmanned drone operations are predicted to become a significant form of air traffic type in terms of total flight numbers. During the same timeframe, demand from the established commercial air transport, general aviation and military sectors will continue. New airspace designs, ATM concepts and CNS capabilities are required to integrate unmanned operations with established airspace users in a safe and efficient way that protects resilience.

The initiative to support the integration of unmanned drone operations in the French airspace must be in line with the wider European approach that is currently under development. The drone sector in France has been steadily growing since the publication of the first regulations dedicated to unmanned operations.

As a result, unmanned drone operators are already offering services in sectors that were previously reserved exclusively for conventional forms of aviation, including aerial photography, mapping, inspections, agriculture and logistics. Over the timescales of this strategy, with the development of new types of UAVs and supporting services, drones are expected to expand into the air-taxi and personal transport markets.

Today, unmanned aircraft flights are restricted to operations performed in the visual line of sight (VLOS) and by aircraft weighing no more than 150kg (flights for commercial purposes in the weight range 25kg-150kg are subject to additional restrictions). Other operations (for example those beyond visual line of sight or BVLOS) can only take place in segregated airspace. Intensive work is being carried out in France, across Europe and globally to define the approach to allowing more forms of BVLOS operations.

This strategy aims to enable the expansion of the drone sector in a way that is safe, and efficient while safeguarding the resilience of conventional forms of aviation. This approach to drone integration is supported by the design and development of the French UAV Traffic Management (UTM) system.

DSNA is currently working with the SESAR program on the scope and functionality of an initial UTM system for France that aligns with the European drone integration blueprint. DSNA is also deploying in CDG airport a dedicated surveillance prototype system aiming at validating the concept of operations needed to ensure both the seamless drones operation in a complex airport environment and the business continuity of a major airport vis-à-vis potential non-cooperative drones.

PART 3

Implementation

3.1 COORDINATION, OVERSIGHT AND ENGAGEMENT

Successful implementation of the FAS initiatives described in Part 2 will require strong governance and a coordinated approach to delivery.

European level coordination and oversight

Many aspects of the FAS are coordinated at the European level through the SES initiative and SESAR program. The SESAR PCP requires the FAS initiatives described in sections 2.1, 2.2 and 2.3 to modernize the terminal airspace, implement free route airspace, improve the flexible use of airspace and upgrade ATM systems and tools.

Table 3 sets out each of the SESAR PCP AFs alongside the relevant sections of the FAS that support their implementation.

It is important that the FAS supports the implementation of the functionalities required by the SESAR PCP in the expected timelines; whilst also influencing at the European level, when developments in France are more advanced than the PCP program and associated SES and SESAR deliverables.

Table 3
SESAR PCP ATM Functionalities linked to the FAS

AF	DESCRIPTION	RELEVANT SECTIONS OF THE FAS
1	Extended Arrival Management and PBN in high density TMA.	Section 2.1a The Paris terminal airspace optimization plan.
2	Airport Integration and Throughput.	Section 2.1b ATM modernization upgrades at Paris CDG and Orly
3	Flexible Airspace Management and Free Route.	Section 2.2a and section 2.2b on free route airspace and FUA
4	Network Collaborative Management.	Section 2.3a ATM systems and tools
5	Initial System Wide Information Management (iSWIM).	Section 2.3a ATM systems and tools
6	Initial Trajectory Information Sharing (i4D).	Section 2.3a ATM systems and tools

National level coordination and oversight

In addition to the European level coordination provided by SES and SESAR, the FAS at a national level aims to provide guidance for the aviation industry on airspace modernization within France and in close collaboration with other States' airspace.

It is important that the FAS document stands as an overarching strategic roadmap for airspace and ATM modernization in France. Thus the national strategy's coordination and oversight role will include, but not limited to:

- Providing the government and regulator with well-considered strategic industry advice on airspace and ATM modernization and related matters;
- Providing aviation stakeholders in France with strategic information about airspace and ATM modernization and a set of key initiatives;
- Development of industry positions on the implementation of the key modernization initiatives;
- Assisting stakeholders in the development and deployment of specific airspace and ATM-related projects.

The FAS sets out a framework of airspace and ATM modernization initiatives, incorporating the requirements of key aviation stakeholders. It also refers to some important factors which will have an impact on all aviation stakeholders, in particular:

- Planned air traffic in the French airspace – in terms of numbers of passengers and movements;
- Need to alleviate the mismatch between traffic demand and capacity that is already impacting aviation performance in the core European area, by generating additional airspace capacity and a better use of the available capacity for routing air traffic in a way that minimizes ATFM delays;
- Integrated research, development and deployment of new airspace and ATM (especially those linked to the SESAR program).

A variety of stakeholders will be invited to provide their feedback and contribute to future editions of the FAS. In this context, stakeholders are invited to:

- Identify how best to incorporate and coordinate the adoption/integration of new and emerging technologies including integration of unmanned operations;
- Offer their views of what communications, navigation and surveillance systems should be capable of achieving in the short, medium and long term;
- Make recommendations regarding continuing investments in, maintenance, or disposal of, key air traffic infrastructure;
- Provide contributions to reviews and make recommendations for the updating of future editions of the FAS.

3.2 CONCLUSION AND NEXT STEPS

The French ATM Strategy is the first layer of a three- tier framework for coordinating airspace and ATM modernization across France.

The French ATM Strategy offers a high- level description of the drivers for airspace and ATM modernization in France and the main initiatives that are being developed and deployed to improve aviation safety, security, efficiency, environmental performance, capacity and resilience. The Strategy document represents the first layer of a three-tier framework for coordinating airspace and ATM modernization across the wide range of stakeholders that are participating in the initiatives.

The second tier of the framework is aimed at refining and agreeing detailed implementation plans for each major FAS initiative described in the tier 1 document. For example, The French PBN Implementation Plan, Free Route Implementation Plan. Paris Terminal Airspace Optimization Plan and UAV Integration Plan might each be considered tier 2 FAS plans. The tier 2 plans will set out the milestones to be delivered by each stakeholder group to successfully implement the initiative, along with timelines and dependencies. Some of the information required to build the tier 2 plans is already available. Additional information will be gathered using the CDM approach established by DSNA to support stakeholder engagement. The first set of tier 2 implementation plans will be developed during 2020, following the launch of the tier 1 strategy for consultation.

It is envisaged that the national level coordination and oversight arrangements outlined in section 3.1 will track the development and delivery of tier 2 implementations plans and maintain the tier 1 strategy document.

Tier 3 of the framework concentrates on individual project plans for local deployment of changes that contribute to major tier 2 initiatives. For example, the project plan for deploying PBN procedures at a specific airport or the roll-out of a new ATM system at a specific ACC would each be considered tier 3 plans. These local project implementation plans will be too specific and numerous to track at a national level. However, each tier 2 implementation plan should provide a high-level overview of the size and nature of local tier 3 project plans and report on their progress.

Glossary

AAS Airspace Architecture Study

ACC Area Control Center

ACDM Airport Collaborative Decision-Making

ACNUSA Airport pollution control authority

ADS-B Automatic Dependent Surveillance Broadcast

AF ATM Functionalities

A-FUA Advanced Flexible Use of Airspace

AIM Aeronautical Information Management

AMAN Arrival Management

ANSP Air Navigation Service Provider

ANSSI French National Cybersecurity Agency

ASM Airspace Management

ASMGCS Automated Surface Management, Guidance and Control System

ATC Air Traffic Control

ATM Air Traffic Management

ATMs Air Traffic Movements

BVLOS Beyond Visual Line of Sight

CCE Environmental Consultative Committee

CDG Paris Charles de Gaulle Airport

CDM Collaborative Decision-Making

CNS Communications, Navigation and Surveillance

COFLIGHT Next-generation flight data processing system

CORSIA Carbon Offsetting and Reduction Scheme

DGAC The French Civil Aviation Authority

DMAN Departure Management

DSNA The French Air Navigation Service Provider

EASA European Aviation Safety Agency

EFS Electronic Flight Strips

ERATO Electronic conflict resolution tool for air traffic controllers

FABEC Functional Airspace Block Europe Central

FAS French ATM Strategy

FDPS Flight Data Processing System

FNAM French Airline Association

FRA Free Route Airspace

FUA Flexible Use of Airspace

GA General Aviation

GDP Gross Domestic Product

GHG Greenhouse Gas

Groupe ADP CDG airport owner

HMI Human Machine Interface

IATA International Air Transport Association

ICAO International Civil Aviation Organization

ILS Instrument Landing System

IOP Common interoperability standards

iSWIM initial System Wide Information Management

MET PROVIDER Meteorological services provider

MON Minimum Operating Network

MTCD Medium Term Conflict Detection

PBN Performance-Based Navigation

PCP Pilot Common Project

RMZ Radio Mandatory Zone

RNP APCH Required Navigation Performance for Approach

SAR Search and Rescue

SES Single European Sky

SESAR Single European Sky ATM Research

SESAR PCP IR SESAR PCP Implementation Rule

SOC Security Operating Center

SYSAT Electronic ATM system for approaches and towers

TBS Time-Based Separation

TCT Tactical Control Tools

TMA Terminal Manoeuvring Area

TSA Temporary Segregated Area

TRA Temporary Restricted Area

UAV Unmanned Aerial Vehicle

UTM UAV Traffic Management

VLOS Visual Line of Sight

XMAN Cross-border Arrival Management

Notes