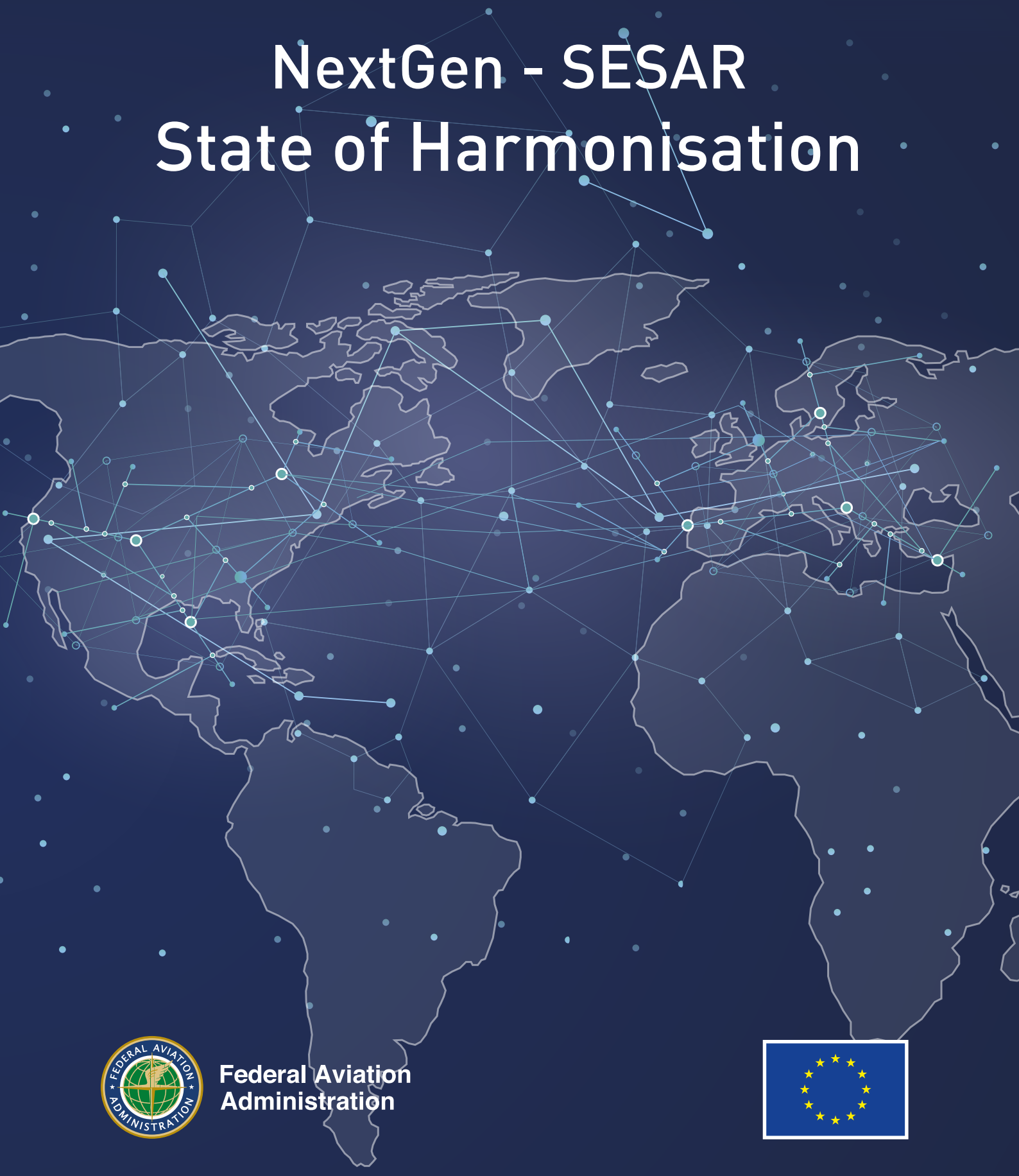
NextGEN SESAR

# NextGen - SESAR
# State of Harmonisation



Federal Aviation Administration

Second edition

# NextGen – SESAR
# State of Harmonisation

Report prepared by the Coordination Committee (CCOM)
for the US–EU MoC Annex 1 High-Level Committee

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# About

## Next Generation Air Transportation System (NextGen)

In the United States, the Next Generation Air Transportation System (NextGen) is the complete modernisation of their national airspace system (NAS). It is a comprehensive suite of upgrades, technologies and procedures that improve every phase of flight and enable aircraft to move more efficiently from departure to arrival. NextGen will use satellite technology to enhance navigation and surveillance, deploy digital systems for communication, and improve information management. NextGen replaces automation systems and adds more operational capabilities to the NAS. The Federal Aviation Administration (FAA) continues to validate NextGen benefits through demonstrations, trials, and initial deployment of new systems and procedures. NAS operators and users, particularly participants in demonstrations and trials, are already benefiting from NextGen. Information gained from the demonstrations provides direct measurements of the ways specific NextGen capabilities can benefit NAS stakeholders and the public. Overall, NextGen expects to deliver USD 160.6 billion in benefits through 2030.

www.faa.gov/nextgen

## Single European Sky ATM Research (SESAR)

As the technological pillar of the Single European Sky (SES) initiative, SESAR's goal is to define, develop and deploy the operational solutions with technology enablers needed to increase the performance of Europe's air traffic management (ATM) system. The SESAR lifecycle is composed of three parts: definition, development and deployment.

Established in 2007, the SESAR Joint Undertaking (SESAR JU) is responsible for coordinating and concentrating all ATM-relevant research and innovation (R & I) efforts in the EU. It is a public–private partnership (PPP) between the main public stakeholders (European Union — represented by the European Commission — and Eurocontrol represented by its Agency) and European aviation and ATM service and manufacturing industry. The SESAR JU is also responsible for the definition of SESAR through the European ATM Master Plan with the enabler roadmaps driving ATM modernisation in Europe.

Established in 2014, The SESAR Deployment Manager (SESAR DM) is responsible for the implementation of SESAR through a series of 'Common Projects'. These are based on SESAR Solutions deemed as essential functional packages derived from the European ATM Master Plan which require a synchronised European implementation, and as such are mandated by EU law. The SESAR DM plans, coordinates, synchronises and reports on the implementation of common projects. The SESAR DM is a consortium composed of European air navigation service providers, airports and airspace users.

www.sesar.eu

## NextGen–SESAR collaboration

In 2011, the US and the European Union signed a Memorandum of Cooperation (MoC) on civil aviation research and development (R & D). The MoC has two annexes with Annex I covering cooperation between the modernisation initiatives of NextGen and SESAR to ensure necessary harmonisation and to secure global interoperability. This annex covers five specific areas across the aviation and ATM domain and is based on respective identified coordination needs. The five areas are broken down into specific coordination plans (CPs) refining the identified key issues under the management of appointed co-leaders from the US and Europe. The coordination plans are short descriptions that state the terms of reference, goals and the activities to be taken to achieve the global interoperability or harmonisation deliverables to a satisfactory level in time for safeguarding developments and mitigating risks.

Since 2016 a new approach has been introduced to further the cooperation between NextGen and SESAR, whereby the full ATM modernisation lifecycle is addressed, covering definition, development and deployment activities.

# Message from the co-chairs of the High Level Committee

## Responsible for the coordination of Annex 1 of the US–EU MoC

The United States and Europe are in the midst of the most massive modernisation programmes in the history of air navigation services (ANS), with NextGen in the US and SESAR in Europe. To ensure we have a shared vision for these efforts, the FAA and the SESAR Joint Undertaking have committed to the most extensive harmonisation programme ever.

Our shared State of Harmonisation document represents years of preparation and planning to produce alignment on the most sophisticated and innovative solutions for ANS ever envisioned. But there is still a lot of work to do, to achieve harmonisation between the US and Europe, and to ensure that these changes are reflected in future updates to the Global Air Navigation Plan and the related standards and guidelines. The FAA remains committed to working hand-in-hand with our partners in Europe. And as the NextGen and SESAR visions move further into deployment, we will continue to share lessons learned, both across the Atlantic and with the global community.

***Teri Bristol,*** *Chief Operating Officer of the Air Traffic Organization, Federal Aviation Administration, and Co-Chair of the High-Level Committee (HLC)*

Aviation is by its nature global, so it makes sense to ensure the seamless movement of air traffic between world regions. The US is the most important external market for European airlines and thanks to our cooperation ties within the 'Open Skies' agreement with the US, transatlantic traffic has grown by 18 % in the last 10 years, with the number of individual city pairs increasing by 30 % and annual passengers growing to more than 52 million.

Supporting this growth are the collaborative efforts undertaken within the 2011 MoC Annex 1 that seek to ensure harmonisation between our respective ATM modernisation initiatives, NextGen in the US and SESAR in Europe. This second edition of the State of Harmonisation clearly shows what can be achieved when two of the leading regions in aviation join forces. A lot of progress has been made in advancing ATM modernisation and interoperability in recent years, which is described in this report. It is our shared responsibility to further build on these cooperation efforts in the coming years to ensure even greater harmonisation convergence and safe growth of this important and truly global aviation industry.

***Maurizio Castelletti,*** *Head of Unit, Single European Sky, DG MOVE, European Commission, and Co-Chair of the High Level Committee (HLC)*

# Executive summary

The purpose of this publication is to provide a high-level summary of the current state of progress towards achieving the necessary level of harmonisation and global interoperability between NextGen and SESAR.

More broadly, the publication reflects the current and planned collaboration efforts by the United States and the European Union to harmonise and secure the modernisation of air traffic management not just transatlantically but globally in support of the International Civil Aviation Organisation (ICAO) Global Air Navigation Plan (GANP) and its Aviation System Block Upgrade (ASBU) programme.

Both NextGen and SESAR recognise the need to integrate the air and ground parts of their respective ATM systems by addressing efficiency needs of flight trajectories planning and execution and the seamless and timely sharing of accurate information. The US–EU harmonisation work aims to ensure that modernisation and advances in aviation and in the air navigation systems worldwide can be made in a way that supports a high-performing aviation system over time and global cooperation leading to seamless operations and safe and efficient practices for the airspace users and the travelling public.

NextGen and SESAR have together made significant progress in several critical areas since the publication of the first edition of the State of Harmonisation in 2014. This second edition therefore provides an update on each of these areas and captures a number of evolutions that have or will have an impact on the collaborative activities.

- Significant progress has been made on the five collaboration areas under Annex 1 of the MoC on NextGen and SESAR harmonisation

(transversal activities; information management; trajectory management; communication, navigation, and surveillance (CNS) and airborne interoperability; and collaboration projects).

- The US and EU agreed to a revised edition of the GANP for 2016 and have collaborated in order to define a critical recommended path of necessary ATM 'backbone' modules of operational improvements in support of the GANP evolution, all of which are necessary for regional or national ANS safety, capacity and efficiency plans.
- The Europe-wide deployment programme was initiated with the SESAR Deployment Manager and progress has been made by NextGen and SESAR on adding the alignment of implementation strategies with the medium- and longer-term planning on three high-priority implementation programmes, namely air–ground data communications (Air/Ground DataComm), performance-based navigation (PBN), and system-wide information management (SWIM).
- NextGen and SESAR have successfully conducted demonstration activities to showcase the global interoperability of SWIM data exchange for applications using flight information exchange models and technologies.
- Update to the joint US–EU avionics roadmap.
- Delivery of the first air–ground data communication strategy involving industries on both sides.
- Progress on a joint navigation systems roadmap.
- Risk management related to international standardisation and harmonisation has been formally incorporated into the CPs and collected for MoC Coordination Committee reviews. Similarly the international standardisation and harmonisation risk management is also incorporated by the FAA in its Enterprise Risk Management process and by Europe in the planning and work of the European ATM Master Plan and the SESAR DM Deployment Programme.

# Introduction

NextGen in the US and SESAR in Europe are modernising their respective ATM systems through the development of new capabilities introducing new enabling technologies and operational procedures. Specifically, these modernisation efforts have enabled a move from a ground-based ATM system, using radar and voice communications, to an integrated air–ground aviation and ATM system using satellite-based navigation and digital data communications. The goals on each side of the Atlantic are to improve overall aviation and ATM system performance, particularly in the areas of flight efficiency and the environment, while also meeting expected demands for increased capacity and continuing to maintain the highest levels of safety.

In order for airspace users to reap the full benefits of these modernisation initiatives, it is essential that the new systems established in the US and Europe are harmonised and interoperable. This means that flights will be able to operate in both US and European ATM environments with the same set of capabilities of the on-board equipment to navigate, communicate and report their position. Failure to meet this global demand for harmonisation and interoperability will burden airspace users with the need to carry different types of equipment and capabilities, with an associated increase in cost and training.

Ultimately, the collaboration between the US and Europe is not just about achieving transatlantic interoperable standards but to support the broader goal of achieving global harmonisation and interoperability as articulated in the ICAO GANP and ASBUs. For that reason, much of the collaboration work described in this document directly supports global ICAO and industry standardisation efforts. The US and Europe are for the same reason also supporting and engaging in initiatives of industry standardisation bodies, such as the RTCA and EUROCAE.

The purpose of this State of Harmonisation publication is to provide a high-level summary of the current state of progress towards achieving harmonisation and interoperability of the two modernisation programmes. This second edition provides an update on the collaborative activities performed since 2014, as well as new elements arising from the coordination activities and the expansion of scope to include the respective ongoing implementation programmes and activities.

This document serves as an outline for consideration of the current issues at stake and the challenges ahead. It demonstrates that differences are recognised and actions are taken to address them where necessary to ensure interoperability.

# The need for Harmonisation

As two of the world's most significant aviation modernisation undertakings, NextGen and SESAR have a shared interest in harmonisation as a means of ensuring interoperability. Both initiatives have identified common challenges and a performance-driven approach to modernisation. It is widely understood and accepted that the systems cannot be completely identical. However, harmonisation is necessary to:

1. Ensure that flights or aircraft can operate seamlessly between systems;
2. Ensure that common standards are available where needed;
3. Minimise costs and identify synergies by sharing results and efforts.

The scope of what should be harmonised is derived from the requirements expressed by airspace users through the consultation processes of both modernisation initiatives. Before agreeing on harmonised and interoperable solutions and standards, a number of harmonised methods such as comparing and validating concepts and identifying risks are important keys to the collaboration.

## Global implications

NextGen and SESAR are the two largest aviation modernisation efforts in the world, although there are parallel initiatives in other regions. ATM modernisation is a complex task, but aviation industry stakeholders seek to harness the benefits of all of these initiatives, especially as traffic levels in civil aviation increase and new demands are placed on the system. In order to provide the greatest operational and performance benefits, these modernisation initiatives must harmonise to achieve seamless operations of global air navigation once deployed. ICAO is supporting the modernisation and standardisation requirements of NextGen and SESAR and recognises them as global leaders of ATM modernisation, while meeting ICAO's commitment to the global civil aviation community. These complex and comprehensive initiatives are therefore ensuring alignment with the GANP and supporting the ASBU programme.

# Harmonisation status

Significant collaborative work has taken place since 2014 in the five main work areas defined in Annex 1 of the MoC, namely transversal activities; information management; trajectory management; communication, navigation, and surveillance (CNS) and airborne interoperability; and collaboration projects. Each area is described hereafter with specific information on the rationale for harmonisation, the latest status of the work and anticipated next steps.

## A. Transversal activities

### A1 | ICAO Global Air Navigation Plan (GANP) and Aviation System Block Upgrades (ASBU)

#### Description

Transversal activities are those strategic activities that cross all harmonisation work areas. They cover such areas as standardisation and joint work in support of ICAO initiatives, as well as operational concepts and architecture.

Both the US and Europe were instrumental in supporting ICAO initiatives in the development of the GANP and the ASBU programme. The ASBUs provide a series of measurable, operational performance improvements, organised into flexible and scalable building blocks, modules and elements. The elements can be introduced as needed and implemented as each individual state and/or region determines feasible based on their respective needs, capabilities and resources. The ASBUs provide the basis for ICAO's GANP 15-year outlook. The ASBUs are arranged as 5-year time increments starting in 2013 and continuing through 2028 and beyond. These dates indicate when the standards and regulations need to be in place in order to support regions and states in modernising their own aviation and ATM system thereby contributing to the modernisation of the global aviation system.

#### Rationale for harmonisation

These major developments represent a leadership position for the US and Europe within the international aviation scene, reflecting the collaborative effort to harmonise all plans and global approaches with other regions of the world to promote and support modernisation. The key aim for the US and Europe will be to continue to ensure that the language in the GANP is broad enough to encompass the needs of NextGen and SESAR, while allowing for regional and national implementation.

#### Status

The current GANP was agreed upon and recommended for adoption by the 2012 Air Navigation Conference (ANC-12) and subsequently endorsed by the 38th ICAO Assembly (2013). In support of ICAO's 39th Assembly and the GANP 2016, the US and Europe provided ICAO with their jointly coordinated inventories of the standards necessary to support ASBU implementation. These inventories have been used by ICAO to develop a prioritised list of required ICAO standards to be further worked on by ICAO.

The US and Europe are supporting ICAO in developing the next edition of the GANP in preparation for the 40th ICAO Assembly in 2019.

At the request of the ICAO Secretariat, based on an ANC-12 recommendation, the US and Europe jointly developed a first draft of a logical architectural framework for the GANP 2016, which will be further developed for the 2019 GANP update. In parallel, the US and Europe have worked through the ICAO Panels to develop a 'critical recommended path' of ATM backbone operational performance improvements provisions. The purpose of the critical recommended path is to assist regions and states in identifying and selecting priority provisions in the ASBU modules.

### Next steps

The update of the GANP for 2019 will commence in earnest following the 39th ICAO Assembly. This next update is expected to provide more detailed definitions of ASBU Blocks 2 and 3 than are included in the current GANP as well as a path to a possible Block 4. Coordination between the US and Europe has started and is ongoing on the GANP changes for 2019, with a particular emphasis on completing the logical architecture framework in time for its inclusion in the programme. It is important for these developments to remain aligned with the NextGen Implementation Plans, the European ATM Master Plan and the SESAR Deployment Programme in order to reflect the needs of the US and European systems.

## A2 Joint communications, navigation and surveillance (CNS) infrastructure harmonisation strategies

### Description

Both the US and the EU each have established roadmaps for the development and implementation planning of communications, navigation and surveillance (CNS) capabilities based on their respective ATM modernisation programme results, business and operational performance needs, and budgets. These roadmaps have been developed in consultation with the necessary stakeholders and in accordance with their required regulatory arrangements.

### Rationale for harmonisation

Harmonisation is important in the areas where interoperability between regions is required or desired as well as for airspace users operating in or across both regions. The joint CNS strategies balance long-, medium- and short-term requirements in terms of understanding the interoperability risks related to current deployment plans and in the options for developing and implementing solutions in the medium and longer term. There is therefore also a need to jointly identify any challenges and opportunities facing harmonisation and interoperability in developments, in particular in response to the operational performance needs of the CNS infrastructure within the target trajectory-based environment.

A detailed description is available in section D.

### Status and next steps

Air–ground data communications strategy

Very high frequency (VHF) data link mode 2 (VDL2) is a standardised technology in ICAO, EUROCAE, RTCA and AEEC. It is already deployed operationally in some areas including the US and Europe. However, as the use of the system becomes widespread, the need for continued improvement is confirmed. One of the latest areas of work in the VDL2 standards concerns the so-called 'multi-frequency' capability, i.e. the operational usage of the planned capability of VDL2 to work in multiple channels. In this context, the coordination plan between the US and the EU has allowed for exchanging best practices, findings, capacity assessments, in service observations and future plans.

In addition, a future terrestrial datalink is being investigated as an alternative to the VDL2 link as well as possible satellite communications alternatives. While the US does not have the same requirement for either alternative at this point, the US will support Europe on the development of common standards.

Navigation strategy

A joint navigation systems roadmap possibly leading to a joint navigation strategy is currently under development as a first step. The roadmap describes the expected and planned sustainability and evolution of the ground-based and satellite-based navigation infrastructure to support performance-based navigation (PBN) and precision approaches in both regions.

Surveillance strategy

Discussions are ongoing regarding the possibility of having a joint strategy that would provide a holistic view of surveillance infrastructure needs and capabilities. The strategy would build upon

already positive coordination efforts between the NextGen and SESAR on potential new surveillance technological enablers and associated key applications.

See section D3 for details of the specific CNS strategies.

## A3 | Separation provisions: Wake vortex/ Re-categorisation (RECAT)

### Description

Wake vortex separation provisions need to be modernised to yield improvements in efficiency and throughput at airports, especially those with capacity constraints. The US and Europe have been collaborating on an effort to re-categorise wake turbulence separation standards as a contribution to the ICAO Wake Turbulence Study Group. This initiative, called 'RECAT', is split into three phases as follows:

- RECAT-1: Optimisation of the ICAO wake turbulence separation classes, with up to six categories;
- RECAT-2: Replacement of the separation classes with a static 'pair-wise' regime, whereby each aircraft pair has its appropriate wake turbulence separation minima; and
- RECAT-3: Dynamic pair-wise separation, where actual conditions, such as aircraft mass and atmospheric/meteorological conditions, are considered when establishing the required wake turbulence separation minima.

To date, the RECAT-1 effort has identified different methods for reclassifying aircraft into new separation-related categories, taking into account a thorough analysis of the effect of wake turbulence. A working arrangement between the respective safety regulators (EASA and FAA Flight Standards) on determining wake turbulence separation minima for new heavy aircraft has been discussed. Both the US and Europe have completed implementation plans for RECAT-1 (known as RECAT-EU in Europe and RECAT Phase I in the US), which divide the current ICAO heavy and medium categories into two sub-categories and sees the creation of a new super heavy category.

Coordination activities currently planned for the US and Europe cover all aspects of separation provision; however, the short-term focus is on contributions to the international effort to revise the ICAO wake vortex separation standards. In particular, the joint contributions will include development and validation of the concept of pair-wise wake vortex separation (RECAT-2), a necessary first step towards dynamic pair-wise wake vortex separation (RECAT-3).

### Rationale for harmonisation

This work will involve coordination through ICAO on standards, regulatory roadmaps, and implementation planning of the related ASBU modules, and identification of the main challenges to the deployment of related results.

### Status

While implementation plans are underway in the US and Europe on RECAT-1, further work is required to find agreement on a common set of separation minima to form the global proposal to ICAO for RECAT-2. A working arrangement between the respective safety regulators (FAA Flight Standards and EASA) on determining wake turbulence separation minima for new heavy aircraft is ongoing, which will facilitate a stronger basis for achieving a common RECAT-2 proposal to ICAO.

### Next steps

The next significant milestone will be agreement on common metrics for developing separation minima that can be used to prepare a RECAT proposal to ICAO comprising a static pair-wise matrix (for example 115 × 115 aircraft) of separation minima for RECAT-2, together with guidance on grouping aircraft into six or more categories that take into account specific airport mix (RECAT-1). Work on RECAT-3 will further develop the separation minima, introducing dynamic variables, such as wind speed, direction, actual take-off weight, among others.

## A4 | Integrating the lifecycle framework

### Description

The US and the EU conduct transversal activities that aim to capture the full ATM modernisation lifecycle, which goes from definition, research and development (R & D), to deployment. In doing so, standardisation needs as well as global issues or risks are brought to ICAO level.

### Rationale for harmonisation

This full lifecycle approach between NextGen and SESAR is seen as instrumental for implementing global interoperability and for achieving the necessary harmonisation of standards, technologies and procedures for the benefit of external stakeholders and airspace users in particular. An early identification of needs for harmonisation and alignment, resulting in an integrated and sometimes iterative approach along the full life cycle, facilitates an efficient path towards deployment and the early mitigation of risks for implementation.

### Status and next steps

Together NextGen and SESAR are mapping the ICAO ASBUs to the European ATM Master Plan, SESAR Deployment Programme, and the NextGen Implementation Plans. The mapping has identified priorities and the need for cooperation throughout the lifecycle, which is now underway in key focus areas, such as performance-based navigation (PBN), system-wide information management (SWIM) and air–ground data communications. With the inclusion of actual deployment programme experiences in the scope of cooperation, NextGen and SESAR also share information about their respective deployment strategies, implementation priorities, timelines, and associated milestones. In doing so, the goal is to identify potential gaps, needs, lessons learned, and best practices discovered during implementation, in terms of industry standards criticality and applications. It also helps to identify risks to timely implementation and risks for global interoperability and harmonisation.

## A5 | Harmonising risk assessment

### Description

Up until now, the US and Europe have been successful in mitigating known risks to harmonisation. However, both sides have agreed to now formally define a process for identifying and prioritising new risks and to add harmonisation risk assessment to their internal and cooperative processes.

### Rationale for harmonisation

When looking into GANP Block 2 and 3 timeframes, NextGen and SESAR may identify issues with the applicability of standards or even missing standards. In such cases, it must be determined whether the new or amended standards should be only regional in nature or whether they should be addressed more globally to ensure alignment with the GANP. Should the standards be considered globally relevant, NextGen and SESAR would initiate research and/or standards bodies would be asked to take action to revise the standards.

### Status and next steps

The development of the process is well underway, with the first assessment to be conducted by January 2017 and annually thereafter. Risks impacting research, standards development and deployment will be assigned to the respective coordination plans of the MoC.

## A6 | Remotely piloted aircraft systems (RPAS)

### Description

NextGen and SESAR work together on the integration of RPAS — a growing and significant category of airspace users — into the aviation system and more specifically ATM. The purpose of the collaboration between NextGen and SESAR is to initiate, coordinate, and prioritise the activities necessary to support the evolution of all RPAS categories as legitimate airspace users that are able to operate from an ATM perspective in a manner that is transparent to manned aircraft.

### Rationale for harmonisation

To achieve ATM system transparency, it is necessary to address issues relating to RPAS technology and operational standards, certification, and operational regulations from the perspective of equivalent and existing regulations for manned aircraft. The coordination identifies and authorises necessary actions and calls for periodic status reports at the CCOM meetings to develop, harmonise, and propose standards for the safe, efficient, and transparent integration of RPAS operations in ATM. This work involves coordination of content within relevant ICAO roadmaps, such as implementation planning of the ASBUs, and the identification of the main challenges for deployment. The focus is on developing strategies to address issues related to the human factor, detect and avoid, communication, flight planning, collision avoidance, and ATM integration compatibility.

### Status and next steps

Collaboration between NextGen and SESAR is underway aimed at building on the ongoing activities by FAA and NASA to develop an unmanned aircraft system (UAS) traffic management (UTM) concept for civilian UAS operations in low-altitude airspace as well as on the technologies needed to support all RPAS categories integration. The outcomes of the EU Drone Outlook Study (June 2016) have identified the potential economic impact of growth in drone operations. It confirms the anticipated R & D roadmap to support the projected growth. The study will also be evaluated in relation to the global impact and in support of further collaboration on RPAS.

## A7 | Cybersecurity

### Description

Cyber resilience remains a major challenge for both the US and Europe. The fundamental issues are to protect information and reduce the danger of disruption in the cyber environment and the critical infrastructures that depend upon it in order to avoid damage to the ATM system.

### Rationale for harmonisation

The ATM community increasingly depends on the exchange of timely, relevant, accurate, and quality-assured information in order to collaborate and make informed decisions.

### Status

Harmonisation activities have been initiated related to the development of:

1. Common standards and use cases for identity access management (IAM);
2. Common security standards for internet protocol (IP) interoperability;
3. Common framework and guidelines for sharing cybersecurity information between aviation stakeholders.

Additionally, some activities have been initiated related to cybersecurity in ATM, such as training and awareness, and enhancing governance arrangements at national and international levels.

### Next steps

The aim is to make progress on a number of aspects, such as defining a possible common public key infrastructure (PKI) framework at ICAO level, which would be implemented regionally, and performing trials to demonstrate interoperability among regional PKIs.

This collaboration activity will also look into the potential for setting up structures and system tools to support cybersecurity information sharing between information sharing and analysis centres (ISAC), computer emergency response teams (CERT), and security operations centres (SOC) run by air navigation service providers, airport operators and airlines. In doing so, the aim would be to monitor the systems in order to detect and react to cyber threats. The sharing of best practices, intelligence on cybersecurity threats and coordinating responses to cyber incidents are other areas for future coordination work.

# B. Information management

## B1 | System-wide information management (SWIM)

### Description

The SWIM concept introduces a significant change in business practices regarding how information is managed during the lifecycle of an ATM system. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability. It also addresses the need to provide better data distribution and accessibility in terms of quality and timeliness, and facilitates the provision of quality information to the right people at the right time.

SWIM consists of standards, infrastructure and governance enabling the streamlined management of ATM-related information and its information exchange among multiple parties. The focus of the harmonisation collaboration is on standards, policy, procedures, and controls as part of SWIM overall governance. Standards harmonisation is focused on information models, information exchange service definitions, and technical interoperability standards for aeronautical, meteorological and flight information. With respect to deployment, processes and requirements are intended to be harmonised as much as possible to support the airspace users' global operation, eventually to avoid unnecessary complexity or duplication of SWIM-related certificates and administration processes.

### Rationale for harmonisation

The goal is interoperability for the user operating at a global level. SWIM harmonisation does not imply that all information exchange standards and infrastructure need to be harmonised. Global standardisation will be focused on information exchanges between global participants — both air and ground based. Services that are tailored for information exchange within one single ICAO region may only need to be standardised within that region.

### Status

Progress has been made on standardisation in a number of areas of information exchange:

#### ATM information

A SWIM concept of operations (Conops) has been prepared in a joint effort to support ICAO's ATM Requirements and Performance Panel (ATMRPP), forming the baseline for the work of the ICAO Information Management Panel (IMP), where SWIM is now further refined with major contributions from NextGen and SESAR. The US and Europe collaborate to make sure SWIM developments are jointly raised to the IMP and ATMRPP.

In November 2012 during the ICAO 12th Air Navigation Conference (ANC/12), a decision was taken to create an ICAO ATM information reference model (AIRM), which NextGen and SESAR are currently developing. An initial service development framework has been defined and, when further validated, will supply information exchange service definitions. Significant progress has also been made in aligning NextGen and SESAR registry requirements to administer information models and ICAO guidance on service definitions and service implementation.

#### Aeronautical information

Developed jointly by the US and EU, the aeronautical information exchange model (AIXM) has become a de facto global standard for new digital aeronautical information management (AIM) systems that is now being deployed globally.

#### Weather information

Developed jointly by the US, EU and the World Meteorological Organisation (WMO), the weather information exchange model (WXXM) supports the latest ICAO requirements and aligns with international standards for geospatial and temporal information.

#### Flight and flow information

A baseline information model has been established defining current operations and some elements of flight and flow information for collaborative environment (FF-ICE). This model is referred to as the flight information exchange model (FIXM) and is developed through global coordination, reporting to the relevant ICAO panels for FF-ICE development, with major contributions from both the US and the EU.

### Next steps

The governance of SWIM standards is an area for ongoing coordination in order to prepare and achieve common positions for presentation to ICAO through the ICAO IMP.

Building on the already coordinated service development framework and registry definitions, services for global information exchange will be defined, aligned and validated through future demonstration activities as described in Section E of this publication.

With respect to deployment, NextGen and SESAR will exchange and analyse information and work on harmonised processes and implementation frameworks where assessed beneficial. Further topics related to US and European SWIM implementation cooperation are risks, opportunities, and lessons learned, e.g. validation and verification procedures, public key infrastructure (PKI) and SWIM registry and stakeholder management, that leads to common solutions and greater efficiency for global users.

## C. Trajectory management

### C1 | 4D Trajectory (4DT) management

#### Description

Trajectory management aims to improve air traffic operations and increase the overall predictability to all users of the aviation and ATM system. This benefits all aviation partners and stakeholders alike.

Four-dimensional (4D) trajectory management is a precise description of the aircraft path derived from the current flight plan (latitude, longitude, altitude) and the additional component of time. FIXM is the vehicle used to exchange 4D trajectory information. 4D trajectory management enables airspace users to plan and agree to fly an intended route, allowing for predictable target times within agreed and predictable time windows while maintaining safety and taking into account weather conditions.

A major component of the 4D trajectory management concept is FF-ICE, which supports trajectory-based operations (TBO) through the exchange and distribution of information. NextGen and SESAR are leading efforts with global partners to coordinate work in the area of 4D trajectory management and FF-ICE.

#### Rationale for harmonisation

Global harmonisation is required for the trajectory management concept as well as for information and operational procedures. Trajectory-based operations (TBO) are a key objective for NextGen and SESAR and harmonising 4D trajectory management is critical for the successful global adoption of this operational evolution.

#### Status

FIXM remains an integral component of the development of 4D trajectory management. Progress is being made on the inclusion of 4D trajectory management scenarios into FIXM. The US and Europe have also made strong inroads in 4D trajectory management and FF-ICE development via ICAO panels, specifically the ATMRPP, and through work with the ICAO Secretariat. In March 2014, the ICAO ATMRPP panel initiated and are well under way with the development of a global trajectory-

based operations (TBO) concept under the joint leadership of the US and Europe.

The US and Europe are reaching agreement on the exchange of ground-to-ground and air-to-ground trajectories. However, work remains to be completed on future concepts for the dynamic interaction between ANSP systems, the airborne flight deck and avionics systems.

For the implementation phase of NextGen and SESAR, the FAA and EU have initiated technical discussions focusing on the exchange of system and procedural information pertaining to arrival management (Time-based flow management in the US and AMAN in Europe). This exchange of information will result in reconciling any differences between the European AMAN and the TBFM programmes. In this respect, TBFM and AMAN lexicons have been developed to ensure clear communications when discussing performance-based harmonisation and collaborative efforts. The exchange of information has provided a better understanding on how each system works and how these systems relate and interact with each other. Significant work is ongoing in SESAR and NextGen to determine if arrival management information can be delivered to allow the performance of required early sequencing actions.

## Next steps

The contribution from both the US and Europe to ICAO panels in the areas of 4D trajectory management and FF-ICE/1 are especially relevant and timely, given that ICAO panels covering 4D trajectory management and FF-ICE/1 are being reorganised. The US and Europe have taken the lead in developing the implementing documentation for initial FF-ICE/1. This effort includes proposed updates to the provisions related to flight information as well as the guidance material. The provision and guidance material are expected to be completed in 2016.

The agreement of both the US and Europe to support 4D trajectory management and FF-ICE on the IMP and other panels is fundamental for the development of several areas of the MoC. This work will require continued close transatlantic collaboration.

The next steps will be to agree on how to integrate and coordinate flight, aeronautical, and MET information exchange models into the overarching architecture of information management in relation to 4D trajectory based operations, and to further study the impact of TBO on the cooperation of the MoC towards continued support for the collaborative work with ICAO.

# D. Communications, navigation and surveillance (CNS) and airborne interoperability

The transition from current tactical operations towards TBO is a cornerstone of both the SESAR and NextGen initiatives. With TBO, the ATM system will facilitate gate-to-gate optimisations where flights can operate performance-based trajectories both in the air and on the ground. In this environment, CNS and avionics play a key enabling role. The transition towards TBO implies an evolution of the CNS and avionics infrastructure to ensure the foreseen services can actually be delivered in a TBO environment.

## D1 | Avionics roadmap

### Description

The joint US–EU avionics roadmap, developed in collaboration with the aviation industry, aims to identify evolutions foreseen in US–EU avionics technologies. This baseline roadmap identifies and provides timelines for development of aircraft capabilities for navigation, surveillance, and data communications in line with the evolution of the airborne–ground integrated ATM concept and architecture.

### Rationale for harmonisation

Many future air navigation systems and procedures will impact aircraft avionics. This collaborative work therefore seeks to identify the standards required for users to operate in both US and European airspace.

### Status

The joint US–EU avionics roadmap was updated to reflect the impact of regulatory guidance material scheduled for publication in 2016. In parallel, operational capabilities are being addressed through joint RTCA-EUROCAE standards development activities.

### Next steps

The roadmap will be updated to include new standards, including industry standards, as necessary when there are agreed results from other areas of US–EU cooperation and in particular as a consequence of the Air/Ground Data Communications strategy.

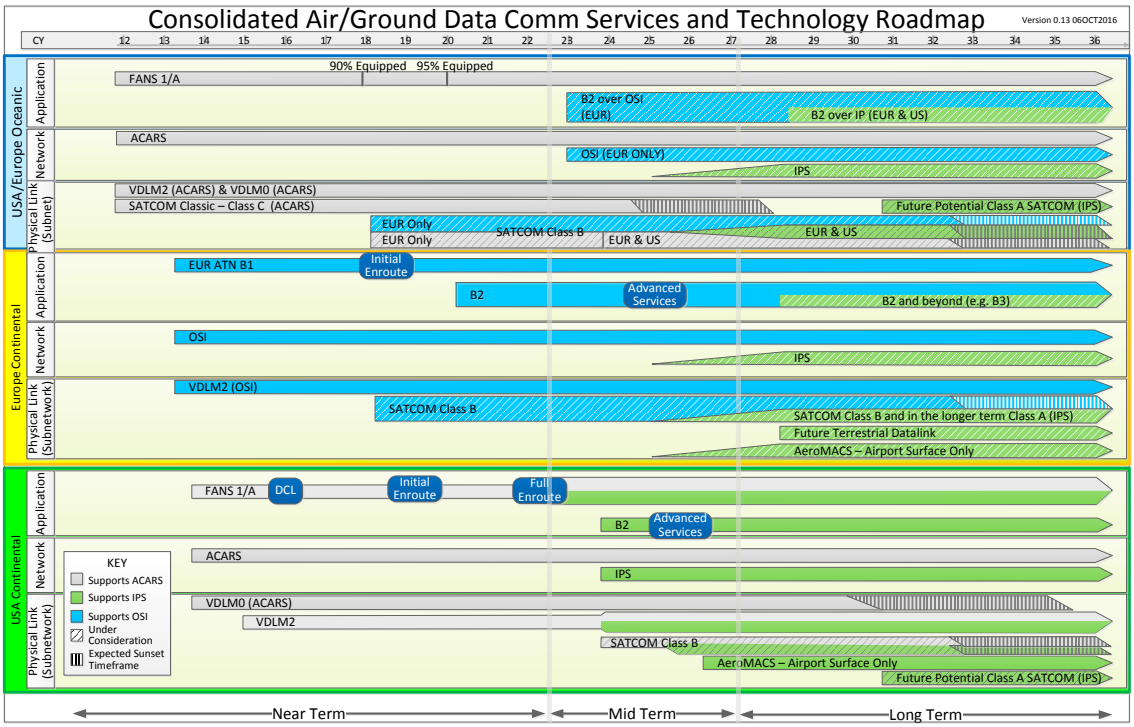
## D2 | Data communications (DataComm)

### Description

Both NextGen and SESAR are developing procedures requiring the integration of added air/ground data communications (DataComm) capabilities. Harmonisation work has concentrated on datalink applications and datalink technologies. This includes, but is not limited to, very high frequency (VHF) datalink, satellite communications, aeronautical mobile airport communication system (AeroMACS), and internet protocols for air–ground data communications.

### Rationale for harmonisation

Air-ground DataComm is a cornerstone of US–EU modernisation efforts and introduces services that allow the evolution from the current workload-intensive, voice-based air traffic control to a data message environment. The move to data communications will result in greater efficiency by reducing voice read-back, hear-back operations, and improved safety by reducing the possibility of error. It also allows more complex information to




be communicated via data than can be provided by voice today. The airspace user is at the heart of this DataComm harmonisation process. For this reason, US and EU aim to achieve interoperability and harmonisation to the level needed for airspace users to operate seamlessly in or out or overfly the airspace without the need for separate equipment for similar ATM capabilities.

## Status and next steps

### DataComm strategy

A joint NextGen–SESAR air-ground DataComm strategy was developed within the framework of the MoC's transversal activities (see section A2). This strategy identifies the target data communications environment that will ensure convergence between the US and EU. It also describes possible combinations of three elements, namely applications, networks and physical links, which are required for enabling interoperability.

It is important to note that the agreed joint target of using internet protocol suite (IPS) standards for the network component in the medium and longer term, will trigger interoperability and harmonisation opportunities that will need to be clarified and elaborated upon across all three abovementioned elements. It will therefore be important to support standards development for IPS in parallel (see below).

### DataComm applications: datalink applications

Although there are similarities within the modernisation strategies for DataComm by both NextGen and SESAR, they do not completely align. Agreement has therefore been reached on a timeline for convergence towards a standard for baseline 2 (B2) DataComm services to facilitate wider stakeholder buy-in and commitment.

The agreement has resulted in a first step of a first and initial release of a standard to allow for the European implementation of initial 4D trajectory (i4D) operations. This first release of the B2 DataComm services standard was subsequently finalised and published by RTCA and EUROCAE in the first half of 2014. A second step will allow for the US implementation with a release of a second and final standard for the full convergence towards common B2 DataComm services.

Specifically, this final standard will:

- allow for more advanced communications between the aircraft and ground ATM, making it possible to better plan and time slot arrivals;

- enable more advanced communication regarding the use of satellite-based procedures, such as required navigation performance, thus providing increased flexibility to use more efficient routes;
- allow controllers to convey detailed information to pilots about wind conditions along the path they are scheduled to fly;
- address aircraft spacing.

DataComm technology: VHF datalink

A future terrestrial datalink is being investigated as an alternative to the VDL2 link and to satcomm alternatives. While the US does not have the same requirement for either alternative at this point, the US will support Europe on the development of common standards when applicable.

VDL2 is a standardised technology in ICAO, EUROCAE, RTCA and AEEC. It is already deployed operationally in some areas including the US and Europe. However, as the use of the system becomes widespread, the need for continued improvement is confirmed. One of the latest areas of work in the VDL2 standards concerns the so-called 'multi-frequency' capability, i.e. the operational usage of the planned capability of VDL2 to work in multiple channels. In this context, the coordination plan between the US and the EU has allowed for exchanging best practices, findings, capacity assessment, in-service observations and future plans.

DataComm technology: Satellite communication (Satcom)

The RTCA, EUROCAE, ICAO and SAE/AEEC have approved the initiation of Satcom standards development to support NextGen and SESAR requirements. These new standards are for new technologies, which are expected to be part of the future communications infrastructure underpinning ATM data communications. The Satcom standards will indicate the system requirements necessary to achieve the required communication performance (RCP) for oceanic and continental airspace operations. The new Satcom systems will provide supplements to the VDL-2 communications for domestic data communications.

With the completion of the standards, including minimum operational performance specification (MOPS), minimum aviation system performance standard (MASPS), standards and recommended practices (SARPS), and SAE/AEEC standards for the new Satcom systems, these documents will help to achieve harmonisation both for oceanic operations as well as continental operations. Additional approval is required by each associated spectrum

licensing authority to ensure that use of the new Satcom systems is permitted in domestic airspace. Satcom systems are leading the way in terms of offering broadband data channels that will interface to a variety of legacy and next generation avionics. During standards development, it is important to ensure commonality of interfaces and architectural provisions that facilitate both NextGen and SESAR concepts for domestic air traffic service data communication.

DataComm technology: AeroMACS

Aeronautical mobile airport communication cystem (AeroMACS) is the first of the new standardised communications enablers in the context of the future communications infrastructure required to support emerging operating concepts from NextGen and SESAR. Since very early on, the US and Europe have worked in close coordination to find synergies and avoid duplication on AeroMACS activities. This has resulted in the joint development of an AeroMACS profile (a selected subset of the capabilities offered by the worldwide interoperability for microwave access or WIMAX standard), which identifies the required features in order to support global interoperability. The profile has been published by both RTCA and EUROCAE, which have also jointly developed and published the AeroMACS MOPS. In addition, the ICAO SARPS and Technical Manual are now complete and the ARINC AEEC form, fit and function standards are under development.

DataComm technology: Internet protocol for air-ground data communications:

RTCA, EUROCAE, ICAO and SAE/AEEC have agreed on initiating IPS development as part of the future communications infrastructure. The IPS standards will provide a more efficient protocol to that of the current aeronautical telecommunications network (ATN) open systems interconnection (OSI) protocol, which was specifically designed for aviation use.

Moving to IPS standards will lead to reduced costs and improved performance.

There has been ongoing coordination and collaboration to this point in gaining approvals from the standards development bodies to carry out this work. Committees have been formed and in all cases work has been initiated. The end result will be a profile, MOPS, SARPS and SAE/AEE standards for IPS, which will enable harmonisation between all future air-ground communications systems.

## D3 | Navigation

### Description

A joint navigation systems roadmap is currently under development as the first step, focusing on global navigation satellite system (GNSS) such as satellite-based augmentation systems (SBAS), ground-based augmentation systems (GBAS) (including GAST-D and multi-constellation/multi-frequency-based systems), and performance-based navigation (PBN). It also addresses the interoperability of the PBN infrastructure regarding the redundant or alternative system to GNSS.

### Rationale for harmonisation

This aim is to ensure the harmonised development of avionics equipment and associated ground and satellite infrastructure in support of global interoperability. Efforts are also being conducted to ensure a consistency with ICAO's Navigation Systems Panel (NSP), RTCA and EUROCAE.

### Status

The first version of a draft dual-frequency, multi-constellation (DFMC) SBAS MOPS is targeted for 2018. Final closure of the draft GAST-D ICAO SARPS is anticipated in 2016 by the International GBAS Working Group meeting.

A short-term approach to provide alternate positioning, navigation and timing (APNT) based on distance measuring equipment (DME), to provide required navigation performance (RNP) without equipment changes, has been proposed through SESAR to several international fora. The FAA is planning to use a very high frequency omnidirectional range (VOR)/DME solution for near-term APNT needs.

### Next steps

A navigation systems roadmap is now being finalised and will serve as a starting point for the development of a joint navigation strategy. The US and Europe will continue efforts to coordinate standards development activities through RTCA and EUROCAE.

## D4 | Surveillance

### Description

Harmonisation work has continued in the areas of automatic dependent surveillance-broadcast (ADS-B), and the evolution of airborne separation assistance systems (ASAS) and applications that use ADS-B in the cockpit to support situational awareness, support airborne 'spacing' applications, and eventually the development of airborne 'separation' applications. Discussions are ongoing regarding the possibility of having a joint strategy that would provide a holistic view of surveillance infrastructure needs.

### Rationale for harmonisation

Given the positive coordination between the U.S and EU on specific surveillance technological enablers and associated key applications (namely concerning ADS-B), it has become clear that sharing a joint strategic and holistic view on the surveillance infra-structure would benefit the community. Discussions are ongoing regarding the possibility of including a joint strategy on surveillance that would provide a holistic view of surveillance infrastructure needs.

As ADS-B is widely used for ATM application and as new surveillance enablers like space-based ADS-B are rolled out, a future opportunity to include a joint strategic activity on surveillance will allow both regions to compare plans, and harmonise performance requirements and services.

### Status

Harmonisation has been well managed in the area of ADS-B applications and technologies, with the publication of numerous RTCA and EUROCAE documents in the areas of MOPS and safety, performance and interoperability requirements. Developments continue in this joint forum supported by NextGen and SESAR, including updates to the technical standards and development of further application standards.

### Next steps

The US and Europe will continue efforts to define and coordinate R & D activities and share findings before reaching the standards development stage through RTCA and EUROCAE.

# E. Collaboration Projects

## Description

NextGen and SESAR work collaboratively on demonstration activities to show to global audiences the interoperability of new or updated technologies and procedures and the performance gains that can be achieved. The scope of these demonstrations may cover all phases of flight (planning, surface, departure, en-route and arrivals), with joint trials focussing primarily on flights between North America and Europe. As part of this activity, work consists of discussing joint, shared or supporting projects with common goals, accelerating the developments and/or deployment of certain technologies and operational procedures contributing to global interoperability in support of ICAO's GANP and implementation of the ASBUs.

## Rationale for harmonisation

It is key to demonstrate the interoperability of new technologies and capabilities and the benefits that they can bring in terms of operational and cost efficiency, the environment and safety, among other performance gains. These globally focussed demonstrations facilitate the accelerated development and implementation of technologies, operational capabilities, and procedures. Close cooperation ensures a consistent full life cycle approach, mitigating the risk for implementing stakeholders by the early identification of areas where information needs to be shared and subsequently where coordination may be required.

## Status

The FAA, SESAR and partnering organisations ran a number of global interoperability demonstrations on SWIM, namely the FAA's Mini Global in April 2016 and the SESAR SWIM Global Demonstration in June 2016.

Following the success of the FAA's MiniGlobal I in 2014, MiniGlobal II looked at the 'cloud' infrastructure, and connectivity and data sharing using a global enterprise messaging service (GEMS) between multiple enterprise messaging services (EMS). The demonstration validated aeronautical and weather information standards by using additional datasets for complex use cases, and addressed the backwards compatibility of those global exchange standards.

Building on the positive outcomes of the SESAR SWIM demo in 2013, the SESAR SWIM Global Demo focused on demonstrating that global interoperability improves all ATM stakeholders' situational awareness and planning when information is shared and continuously updated via SWIM. The demonstrations exchanged data in real time between operators and stakeholders over secured connections. In several cases operational systems were used, thus demonstrating the global interoperability of SWIM.

## Next steps

The FAA and SESAR will explore the possibility of performing collaborative validations and demonstration activities in the field that is complementary and building on the initial 4D trajectory (i4D) results towards increased predictability of AMAN and TBFM and TBO services.

The FAA will conduct a 4DT demonstration leveraging previous i4D trials and the second release of the ATN B2 DataComm services standard under development by RTCA SC-214 and EUROCAE WG-78. The 4DT demonstration will include the engagement of global avionics industry partners to ensure that the avionics and prototypes are in place to use these standards. The purpose of this work is to demonstrate the use of ATN B2 datalink standards for the exchange of 4D trajectories between ground automation systems and aircraft to exercise TBO services including dynamic required navigation performance (DRNP), advance interval management (A-IM) and ATC winds.

SESAR members will participate in the 4DT demonstrations as active observers. It is anticipated that the outcomes from this 4DT demonstration will complement future development of i4D trials as well as revisions to the ATN B2 standards.

# F. New areas for collaboration

NextGen and SESAR have started to address in greater detail the two initiatives' respective exploratory research activities as part of the agreed move to a complete life cycle approach for ATM modernisation as described in the previous sections.

## F1 | Exploratory research

This activity will serve as a clearing house to identify research topics that are currently missing from the MoC's collaboration in order that the activities span the full life cycle, specifically from definition and early research to industrialisation and deployment planning.

The activity builds on and fosters the good relationship already established between the US and the EU ATM modernisation initiatives and will endeavour to enhance this collaboration by further bringing together research organisations, academia and industry from both sides of the Atlantic that are relevant to NextGen and SESAR. Working with this long-established network community will raise awareness of the NextGen–SESAR exploratory research needs and will provide a deeper scientific perspective that will directly benefit the harmonisation and interoperability objectives.

### Rationale for harmonisation

A shared and harmonised understanding of respective exploratory activities in aviation supporting NextGen and SESAR goals is needed to support global interoperability. Bringing in the scientific perspective and support of respective research organisations and academia are essential to both SESAR and NextGen especially in focussing on performance improvements.

Specifically, this activity will help to harmonise concept development with relevant use cases verifying a common understanding and language, which will form a sound basis for future development activities, and a areas where a wider and/or more long-term scientific perspective may be needed (i.e. problem statements) and establish priorities in relation to identified harmonisation and interoperability gaps where collaborative exploratory research would bring value.

The activity opens up the possibility for the US and Europe for new opportunities and in enhancing the current open annual or bi-annual R & D seminars/ conferences for other global partners with a specific focus on NextGen–SESAR exploratory research results.

### Status and next steps

The coordination work has started and a first report is expected in 2017 clarifying the key priorities and activities.

# Glossary

| | |
|---|---|
| ADS-B | Automatic dependent surveillance-broadcast |
| AeroMACS | Aeronautical mobile airport communication system |
| AEEC | Airlines Electronic Engineering Committee (AEEC) |
| AMAN | Arrival management |
| AIM | Aeronautical information management |
| A-IM | Advance interval management |
| AIXM | Aeronautical information exchange model |
| AIRM | ATM information reference model |
| ANSP | Air navigation service provider |
| APNT | Alternate positioning, navigation and timing |
| APV | Approach procedure with vertical guidance |
| ATN | Aeronautical telecommunications network |
| ATMRPP | ATM Requirements and Performance Panel |
| ASAS | Airborne separation assistance systems (ASAS) |
| ASBU | Aviation System Block Upgrade |
| CCOM | Coordination Committee |
| CERT | Computer emergency response teams |
| CNS | Communication, navigation, and surveillance |
| Conops | Concept of Operations |
| CP | Coordination plans |
| DFMC | Draft dual-frequency, multi-constellation |
| DME | Distance measuring equipment |
| DRNP | Dynamic required navigation performance |
| EMS | Enterprise messaging services |
| FAA | Federal Aviation Administration |
| FF-ICE | Flight and flow information for collaborative environment |
| FIXM | Flight information exchange model |
| 4DT | Four dimensional trajectory |
| GANP | Global Air Navigation Plan |
| GAST D | GBAS Approach Service Type D |
| GBAS | Ground-based augmentation systems |
| GEMS | Global enterprise messaging service |
| GNSS | Global navigation satellite system |
| i4D | Initial 4D trajectory |
| IAM | Identity access management |
| ICAO | International Civil Aviation Organisation |
| IFPP | ICAO Instrument Flight Procedures Panel |
| IMP | ICAO Information Management Panel |
| IP | Internet protocol |
| IPS | Internet protocol suite |
| ISAC | Information sharing and analysis centres |
| NAS | National Airspace System |
| NSP | ICAO's Navigation Systems Panel |
| MoC | Memorandum of Cooperation |
| MOPS | Minimum operational performance specification |
| OSI | Open systems interconnection |

| | |
|---|---|
| PBN | Performance-based navigation |
| PKI | Public key infrastructure |
| RF | Radius-to-fix |
| RNP | Required navigation performance |
| RPAS | Remotely piloted aircraft systems |
| R&D | Research and development |
| SAE | Society of Automotive Engineers |
| SAI | AEEC Systems, Architecture and Interfaces Committee |
| SARPS | Standards and recommended practices |
| Satcom | Satellite communications |
| SBAS | Satellite-based augmentation systems |
| SES | Single European Sky |
| SESAR | Single European Sky ATM Research Programme |
| SOC | Security operations centres |
| SWIM | System-wide information management |
| TBO | Trajectory-based operations |
| TBFM | Time-based flow management |
| UAS | Unmanned aircraft systems |
| UTM | UAS traffic management |
| VOR | Very high frequency omnidirectional range |
| WIMAX | Worldwide interoperability for microwave access |
| WMO | World Meteorological Organisation |
| WXXM | Weather information exchange model |

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NextGEN

www.faa.gov/nextgen

SESAR

www.sesar.eu

U.S Department of Transportation
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