GANIS

Working Document

ICAO AVIATION SYSTEM BLOCK UPGRADES

THE FRAMEWORK

FOR GLOBAL HARMONIZATION

WORKING DOCUMENT FOR
GLOBAL AIR NAVIGATION INDUSTRY SYMPOSIUM (GANIS)
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Executive Summary

The 37th Session of the International Civil Aviation Organization (ICAO) General Assembly (2010) directed the Organization to double its efforts for meeting the global needs for airspace interoperability while sustaining its focus on safety. ICAO therefore initiated the "Aviation System Block Upgrades" initiative as a programmatic framework that develops a set of air traffic management (ATM) solutions or upgrades, takes advantage of current equipage, establishes a transition plan, and enables global interoperability.

Aviation System Block Upgrades comprise a suite of modules, each having the essential qualities of:

- A clearly-defined measurable operational improvement and success metric;
- Necessary equipment and/or systems in aircraft and on ground along with an operational approval or certification plan;
- Standards and procedures for both airborne and ground systems; and
- A positive business case over a clearly defined period of time.

Modules are organized into flexible and scalable building blocks that can be introduced and implemented in a State or a region depending on the need and level of readiness, while recognizing that all the modules are not required in all airspaces.

The concept of the block upgrades originates from existing near-term implementation plans and access to benefits in many regions of the world. Block upgrades are based largely on operational concepts extracted from the United States' Next Generation Air Transportation System (NextGen), Europe's Single European Sky ATM Research (SESAR) and Japan's Collaborative Actions for Renovation of Air Traffic Systems (CARATS) programmes. It is also aligned with the ICAO *Global Air Traffic Management Operational Concept* (Doc 9854). The intent is to apply key capabilities and performance improvements, drawn from these programmes, across other regional and local environments with the same level of performance and associated benefits on a global scale.

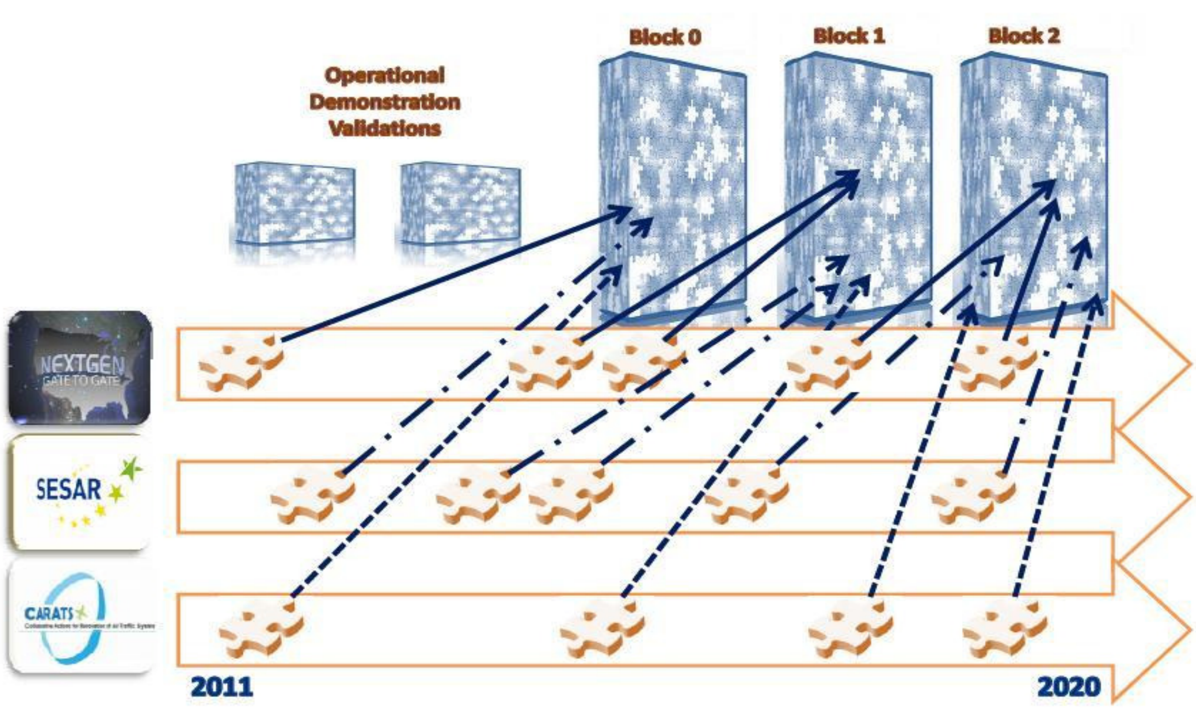
Block upgrades describe a way to apply the concepts defined in the ICAO *Global Air Navigation Plan* (Doc 9750) with the goal of implementing regional performance improvements. It includes the development of technology roadmaps, to ensure that standards are mature and to facilitate the synchronization between air and ground systems, as well as between regions. The ultimate goal is to achieve global interoperability. Safety demands this level of interoperability and harmonization. Safety must be achieved at a reasonable cost with commensurate benefits. Leveraging upon existing technologies, block upgrades are organized in five-year time increments starting in 2013 through 2028 and beyond. Such a structured approach provides a basis for sound investment strategies and commitment from equipment manufacturers, States and operators/service providers.

The block upgrades initiative will be formalized at the Twelfth Air Navigation Conference, in November 2012. It will be included into the Global Air Navigation Plan (GANP). The Global Air Navigation Industry Symposium, in September 2011, will allow industry partners as well as States to gain insight, provide feedback and ultimately commit to the initiative. *Such feedback can be provided on-line at http://www2.icao.int/en/GANIS/Lists/EFeedback/NewForm.aspx or by email using the feedback form given in Appendix D.*

The development of block upgrades will be realized by the change of focus from top-down planning to a more bottom-up and pragmatic implementation actions in the regions. The block upgrades initiative is an instrument that will influence ICAO's work programme in the coming years, specifically in the area of standards development and associated performance improvements.

Two teams of members involved in air transportation modernization define and govern the work of the block upgrades initiative. The Technical Team, comprising subject matter experts, develops the block upgrades' modules that support key performance improvement areas defined in terms of time and evolving technologies. The Challenge Team, comprising government and industry senior executives, provides senior level policy guidance and oversight.

Aviation System Block Upgrades



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ICAO Aviation System Block Upgrades

Introduction

ICAO launched the Aviation System Block Upgrades initiative to progress outcomes of its 37th General Assembly in terms of facilitating interoperability, harmonization, and modernization of air transportation worldwide. To that end, ICAO established a programmatic, collaborative approach to develop a set of air traffic management (ATM) solutions to meet the global needs for an interoperable airspace that takes advantage of current equipage, establishes a transition plan that provides key performance improvements, and enables global interoperability.

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It is recognized that all module solutions are not required in all airspaces.

The specific elements of the block upgrades are defined by a Technical Team, comprised of subject matter experts from ICAO, the Joint Planning and Development Office/Federal Aviation Administration (JPDO/FAA), SESAR Joint Undertaking, EUROCONTROL, International Air Transport Association (IATA), the European Aviation Safety Agency (EASA), International Federation of Air Line Pilots' Associations (IFALPA), International Federation of Air Traffic Controllers' Associations (IFATCA), Civil Air Navigation Services Organisation (CANSO), Airports Council International (ACI), International Business Aviation Council (IBAC), International Council of Aircraft Owner and Pilot Association (IAOPA), the Radio Technical Commission for Aeronautics (RTCA) and the European Organisation for Civil Aviation Equipment (EUROCAE). Additional expertise and perspectives are provided by industry through the International Coordinating Council of Aerospace Industries Associations (ICCAIA) and the NextGen Institute.

Modules consider a broad number of the factors, discussed in more detail below, which include:

- Goals and plans in the ICAO Global ATM Operational Concept and Global Air Navigation Plan (GANP)
- Existing detailed plans for NextGen, SESAR, CARATS, and others as well as experience to-date
- The criticality of global interoperability and harmonization in ATM modernization
- Current knowledge on the feasibility of the modules
- The need for balance, clear operational rationale and measurable value in implementation
- The notion of building upon existing, advanced but underutilized capabilities
- Recognition of the potential risks to implementation and risk identification considerations
- Challenges in moving forward with implementation

The individual block upgrades are identified by points in time relating to when the initial operating capability (IOC) will be available for implementation, along with the necessary ICAO provisions. Block upgrades are separated by a period of five years, with IOC for Block 0 currently available; for Block 1 from 2018; for Block 2 from 2023; and for Block 3 from 2028 and beyond.

ATM Modernization

The availability of international standards with realistic lead times will enable regional regulations to be identified and will allow States, operators and Industry to develop and implement adequate ATM modernization action plans. These action plans will identify the regulations that States need to develop in order to facilitate and drive evolution and, if needed, investment in new facilities and/or infrastructure. This will also allow the Industry to perform business case and market assessments and update their long term business plans in the design, development, production and delivery of products and services integral to the block upgrades' modules.

Block upgrades define a way to progress from the general objectives contained in the ICAO Global Air Navigation Plan toward actual implementation of regional performance improvements. By identifying common targets and various components of operational improvements, block upgrades facilitate stakeholder commitment to efficient implementation along common timelines. Their descriptive material provides specificity and progression of various improvements leading to appropriate standards development and implementation. Interaction of the various modules and elements are described in a way that allows a level of flexibility in implementation. Thus, decisions on operational requirements can made on the basis of regional needs, in a timely manner without jeopardizing global interoperability.

Stakeholder Roles and Responsibilities

Stakeholders including service providers, regulators, airspace users and manufacturers will be facing increased levels of interaction as new, modernized ATM operations are implemented. The highly integrated nature of capabilities covered by the block upgrades requires a significant level of coordination and cooperation among all stakeholders. Working together is essential for achieving global harmonization and interoperability.

For ICAO and its governing bodies, the block upgrades will enable the development and delivery of necessary Standards and Recommended Practices (SARPs) to States and Industry in a prompt and timely manner to facilitate regulation, technological improvement and ensure operational benefits worldwide. This will be enabled by using the standards roundtable process and various technological roadmaps.

States, operators and Industry will benefit from the availability of SARPs with realistic lead times. This will enable regional regulations to be identified allowing for the development of adequate action plans for evolving or, if needed, investing in new facilities and/or infrastructure.

Different stakeholders worldwide should prepare ATM for the future. The block upgrades initiative should constitute the basis for future plans for ATM modernization. Where plans are in existence, they should be revised in line with objectives defined in the block upgrades.

For the Industry, this constitutes a basis for planning future development and delivering products on the market at the proper target time.

For service providers or operators, block upgrades should serve as a planning tool for resource management, capital investment, training as well as potential reorganization.

Where are We Now?

ICAO estimates that US$ 120 billion will be spent on the transformation of air transportation systems in the next ten years. While NextGen and SESAR in the United States and Europe account for a large share of this spending, parallel initiatives are underway in many areas including Latin America, Russia and Japan. Modernization is an enormously complex task but the Industry requires the benefit of these initiatives as traffic levels continue to rise. It is clear that to safely and efficiently accommodate the increase in air traffic demand—as well as respond to the diversified needs of operators, the environment and other inherent issues—it is necessary to renovate ATM systems, providing the greatest operational and performance benefits. The multiple initiatives must be harmonized to achieve seamless global air navigation into the future. ICAO is currently supporting the standardization requirements of the NextGen and SESAR modernization programmes which have been based on the ICAO GANP and Global ATM Operational Concept, while continuing to meet its commitment to the civil aviation community.

Global Air Navigation Plan

The GANP is a strategic document that has successfully guided the efforts of States, planning and implementation regional groups and international organizations in enhancing the efficiency of air navigation systems. It contains guidance for systems improvements in the near- and medium-term to support a uniform transition to the global ATM system envisioned in the Global ATM Operational Concept. Long-term initiatives of the operational concept, however, are maturing and the GANP must be updated in order to ensure its relevance and compatibility.

The United States and Europe share a common ATM modernization challenge since both operate highly complex, dense airspaces in support of their national economies. Although quite different in structure, management and control, their systems are built on a safety-focused infrastructure while actively seeking and delivering the required efficiency gains. The United States has a single system that spans the entire country, while Europe's is a patchwork of systems, service providers and airspaces defined mostly by the boundaries of States. Both legacy infrastructures must migrate to a new, upgraded and modernized operational paradigm.

Over the past ten years, as the ATM operational concepts were developed, the need was recognized to 1) integrate the air and ground parts, including airport operations, by addressing flight trajectories as a whole and sharing accurate information across the ATM system; 2) distribute the decision-making process; 3) address safety risks; and 4) change the role of the human with improved integrated automation. These changes will support new capacity-enhancing operational concepts and enable the sustainable growth of the air transportation system.

NextGen Today

In the United States, NextGen is the ongoing transformation of the National Airspace System (NAS) from a ground-based system of air traffic control to a satellite-based system of air traffic management. The NextGen portfolio includes six transformational programmes (Automatic Dependent Surveillance-Broadcast, Data Communications, System Wide Information Management, NextGen Network Enabled Weather, NAS Voice System, and Collaborative Air Traffic Management Technologies), as well as seven solution sets and a suite of implementation portfolios. The NextGen solution sets contain interdependent projects that work together to provide capabilities to targeted user groups and areas, while the NextGen implementation portfolios provide details about mid-term implementation activities.

The FAA continues to validate the system capabilities through demonstrations, trials and the initial deployment of NextGen. Participation has already benefited the NAS operators and users. The information gained from demonstrations provides direct measurements of the ways specific NextGen capabilities can be of benefit to stakeholders enabling them improve their cost/estimates for NextGen equipment purchases and strengthening confidence in their analyses.

The FAA estimates that by 2018, NextGen ATM improvements will reduce total delays, in flight and on the ground, by approximately 35 per cent. The delay reduction will provide US$23 billion in cumulative benefits from 2010 through 2018 to aircraft operators, the travelling public, and the FAA. The United States will save about 1.4 billion gallons of aviation fuel during this period, cutting carbon dioxide emissions by 14 million tons.

SESAR Today

SESAR is the European Union Single European Sky technological pillar which also supports the required ATM evolution of 43 European Civil Aviation Conference (ECAC) States through EUROCONTROL. The SESAR programme is organized in three phases: the Definition Phase (2006-2008); the Development Phase (2008-2014); and the ongoing Deployment Phase. SESAR aims at delivering levels of performance commensurate with the objectives in the European ATM Master Plan, adopted in 2009 by the Transport Ministers and updated regularly. Compared to 2005 levels, for example, the present objectives are to accommodate 1.7 times more traffic in 2030 at acceptable levels of delay, increase safety by a factor 3, reduce ATM costs per operation by 50 per cent and save up to 10 per cent fuel and emissions per flight.

SESAR development and validation of the new concept which will underpin European ATM transformation is under the responsibility of the SESAR Joint Undertaking, a public-private partnership with strong participation of industry alongside the European Commission and EUROCONTROL. The new concept of operations is structured along three steps of time-based operations, trajectory-based operations (TBO) and performance-based operations. The Definition Phase is highly dependent on the implementation of system-wide information management.

Benefits will henceforth become available to stakeholders and more so at the end of the Deployment Phase. Early benefits are expected from the deployment of validated capabilities of the first implementation package with the outcome of SESAR work. This also includes specific financial investment in environmental trials and pilot programmes on topics such as continuous descent approaches, four-dimensional (4D) trajectories, initial data link communications, precision navigation, enhanced surveillance and other new procedures and technologies.

CARATS

Air service is a fundamental economic and social infrastructure in Japan. There is a pressing need to increase domestic and international air services while ensuring convenience and environmental friendliness. This entails increasing the air traffic capacity of congested airports and airspace in the Greater Tokyo Metropolitan Area and other areas. However, there are various problems with the current air traffic system including the concentration of traffic in certain areas arising from partially restricted flexible use of airspace and routes. In addition to improving the infrastructure, it is important to plan strategically for the future to ensure flights for all possible needs. Japan has therefore begun a modernization plan, entitled CARATS, expected to be fully operational by 2025.

Where are We Going?

As the world economy grows, air traffic and airspace congestion grow, exerting increasing pressure on infrastructure and facilities already stretched to the limit in many parts of the world. Inevitably, delays will multiply while access and predictability will suffer.

ICAO aims for the block upgrades initiative to become the global approach for facilitating interoperability, harmonization, and modernization of air transportation world-wide. As implementation proceeds, the highly integrated nature of the block upgrades will necessitate transparency between all stakeholders to achieve a successful and timely ATM modernization.

A key element of a block upgrade is to ensure that all of its capabilities and performance modules reflect proven operational applications and technologies, along with validation and data on the cost/benefits of implementation. This will be supported by the development of ICAO SARPs, guidance material, processes and methodology that apply across the block upgrades.

As implementation proceeds, the highly integrated nature of block upgrades necessitates transparency among all stakeholders to achieve successful and timely ATM modernization. Block upgrades establish a basis for initial and on-going measurement of the ATM system performance by identifying and developing key performance areas and value/benefits for the various modules.

The Twelfth Air Navigation Conference provides the rare opportunity to make significant progress and arrive at decisions toward global coordinated deployment for the block upgrades. The anticipated result of the block upgrades work will represent a new process to take the above factors into account. Following its first application, progress reviews and updates are foreseen at regular intervals.

Why We Should Go There?

The stakes are high. The global growth of air traffic and airspace congestion, the increasing pressure on infrastructure and facilities—which are already stretched to the limit in many parts of the world—and the potential lack of global harmonization will restrict air transportation if we continue along the same path. Ultimately, the future of global economic depends on more, not less, connectivity. As a result, the future ATM programmes simply have to work and must be interoperable; there is no other viable option to accommodate these future challenges.

What is an Aviation System Block Upgrade?

An Aviation System Block Upgrade designates a set of improvements that can be implemented globally from a defined point in time to enhance the performance of the ATM System. A block is made up of modules. Each module represents a specific, well bounded improvement. A module can be the grouping of several elements which can contain communications, navigation, surveillance components in the airplane, a communication system, a ground component of the ATC automation or decision support tool for controllers, etc. The elements mutually make the module comprehensive and cohesive.

A module is a deployable package (performance) or capability. A module will offer an understandable performance benefit, related to a change in operations, supported by procedures, technology, regulation/standards as necessary, and a business case. A module will be also characterized by the operating environment within which it may be applied.

Of some importance is the need for each of the modules to be both flexible and scalable to the point where their application could be managed through any set of regional plans and realize the intended benefits. The preferential basis for the development of the modules relied on the applications being adjustable to fit many regional needs as an alternative to being made mandated as a one-size-fits-all application. Even so, it is clear that many of the modules developed in the block upgrades will not be necessary to manage the complexity of air traffic management in many parts of the world.

A series of dependent modules across the block upgrades represent a coherent transition thread in time from basic to more advanced capability and associated performance. The date considered for allocating a module to a block is that of the IOC.

The following block upgrades have been defined:

- Block 0: available now
- Block 1: available to be deployed globally from 2018
- Block 2: available to be deployed globally from 2023
- Block 3: available to be deployed globally from 2028 and beyond

The dates refer to the availability or ability to use the module in an operational manner and generate operational benefits. There are several activities (research, development, validation) which need to be properly planned and executed before reaching the IOC dates and they are an integral part of the plan (e.g. the necessary infrastructure to support a block upgrade capability).

The inclusion of a module in a block is dependent on the time at which the appropriate ICAO provisions will be made available and the operational capability deployable.

The notion of blocks introduces a form of quantization of the dates in five years intervals. However, detailed descriptions will allow the setting of more accurate implementation dates, often not at the exact reference date of a block upgrade. The purpose is not to indicate when a module implementation must be completed, unless dependencies among modules logically suggest such a completion date.

For Block 0, no new airborne technologies are required, although modules may imply the deployment of existing technologies to a larger aircraft population depending on chosen modules respectively paired with tied benefits.

The modules have been grouped to support a transition in time as follows:

- *Threads*: a thread describes the evolution of a given capability through the successive block upgrades, from basic to more advanced capability and associated performance, and representing aspect of the global ATM concept.
- *Performance Improvement Areas (PIA)*: sets of threads that group operational and performance objectives in relation to the environment to which they apply, thus forming an executive view of the intended evolution. The PIAs facilitate comparison of ongoing programmes.

The four Performance Improvement Areas are as follows:

1. *Greener Airports*
2. *Globally Interoperable Systems and Data* – through Globally Interoperable System-Wide Information Management
3. *Optimum Capacity and Flexible Flights* – through Global Collaborative ATM
4. *Efficient Flight Path* – through Trajectory Based Operations

When identifying the capabilities, focus was given to global interoperability issues and, therefore, a need for ICAO and/or industry standards. Interoperability concerns the interaction of aircraft with other aircraft and/or ground systems, as well as the interactions among ground ATM systems or elements.

It is anticipated that the block upgrades will provide the basis for a revised Global Air Navigation Plan. The block upgrades aim at delivering improved performance. The technical enablers, in particular Communications, Navigation and Surveillance (CNS), will be derived from the modules and presented for convenience as individual but consistent roadmaps. A technical enabler may support several modules of the same block.

In effect, the Roadmaps in the GANP will identify the longitudinal technology path over time whereas the block upgrades provide a vertical slice of those capabilities over defined five-year terms with all of the supporting information for their implementation included for completeness.

A summary of the block upgrades and their modules is presented in Table 1 and in Appendix A. Detailed descriptions of the modules are given in Appendix B. Each module contained in the block upgrades has its own descriptions according to the outline of the example modules. The draft descriptions given in Appendix B will provided for review in advance of the Global Air Navigation Industry Symposium (GANIS). Following the GANIS feedback on these will be sought. *Such feedback can be provided on-line or by correspondence using the feedback form given in Appendix D*

While it is recognized that not all stakeholders see the ATM system from the same view point, the Technical Team strove to ensure the overall consistency of the block upgrades, but was keen to present them from several complementary perspectives.

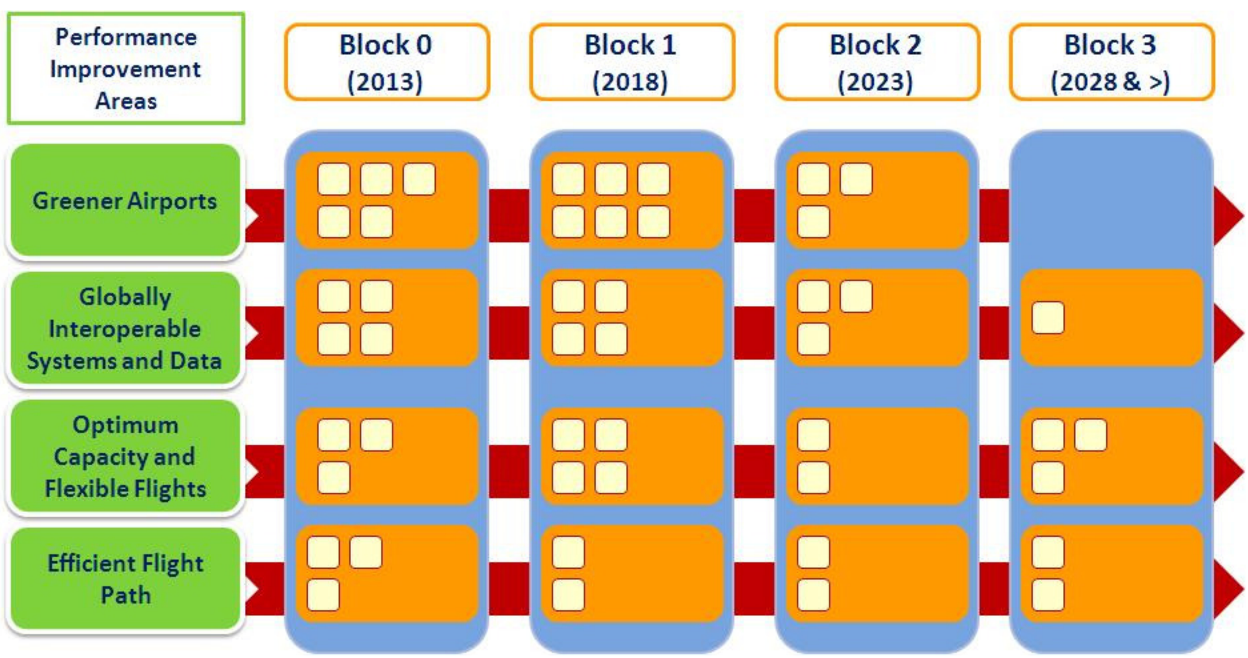

Table 1. Summary of Blocks Mapped to Performance Improvement Areas

For each module, a common description structure has been used. It includes the following:

- Link to the Global ATM Operational Concept and the GANP's Global Plan Initiatives (GPIs);
- Timescale
- Intended performance operational improvement/metric to determine success;
- Domain (e.g. en-route, TMA, etc);
- Applicability (e.g. local, larger geographical scale, network);
- Minimum level of fleet equipage to get benefits, etc;
- Narrative description;
- Necessary procedures (air and ground);
- Necessary technology (air and ground);
- Business case (specific to the block);
- Regulatory/standardization needs and approval plan (air and ground);
- Implementation and demonstration activities; and
- Main dependencies and risks.

The diagram below summarizes the lifecycle of a typical improvement. The date considered for allocating a module to a block is that of the IOC. Figure 1 also indicates that the periods at which ICAO standardization takes place are mainly V2 to V4, i.e. from the general agreement of a concept up to the completion of the industrialization of the relevant products.

The position of a particular topic along the lifecycle is an indication of its level of maturity and of the remaining work before it can be used. Successive decisions with an increasing level of certainty and commitment are identified along the lifecycle. They mark the ability to move to the next phase.

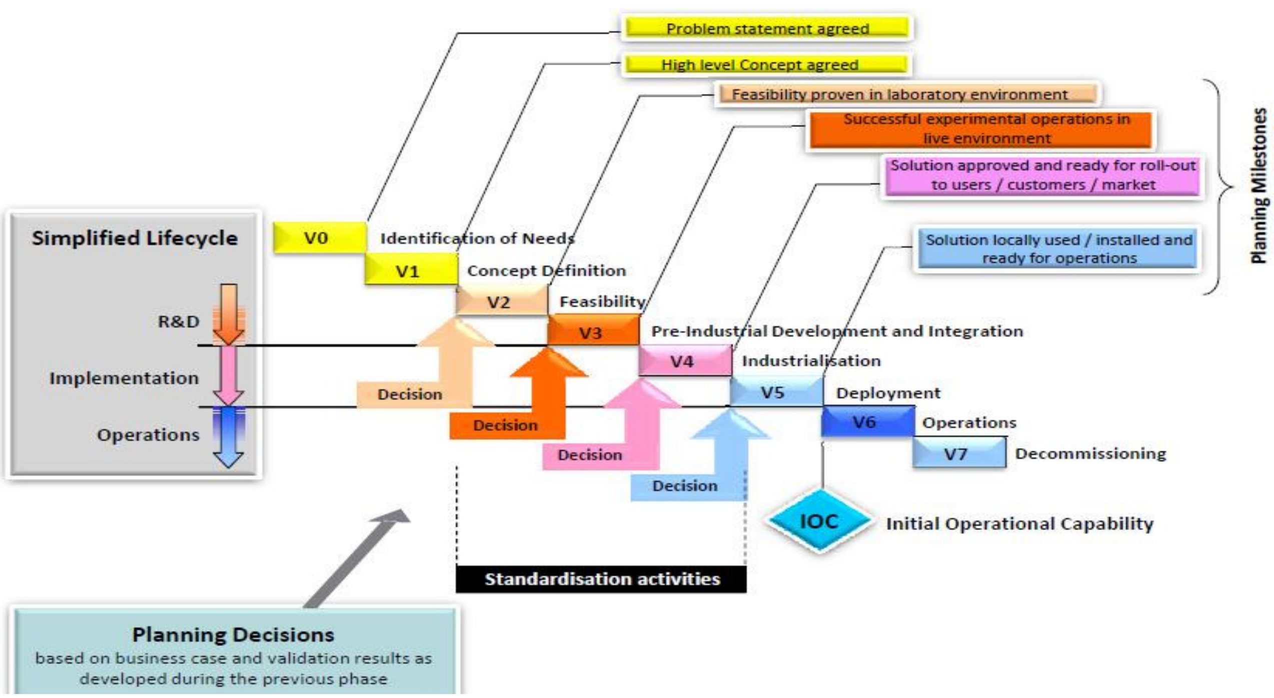

Figure 1. Lifecycle of a typical improvement

An illustration of the improvements brought by Block 0 for the different phases of flight is presented in Figure 2. It highlights that all flight phases are subject to proposed improvements, as well as the network as a whole, information management and infrastructure.

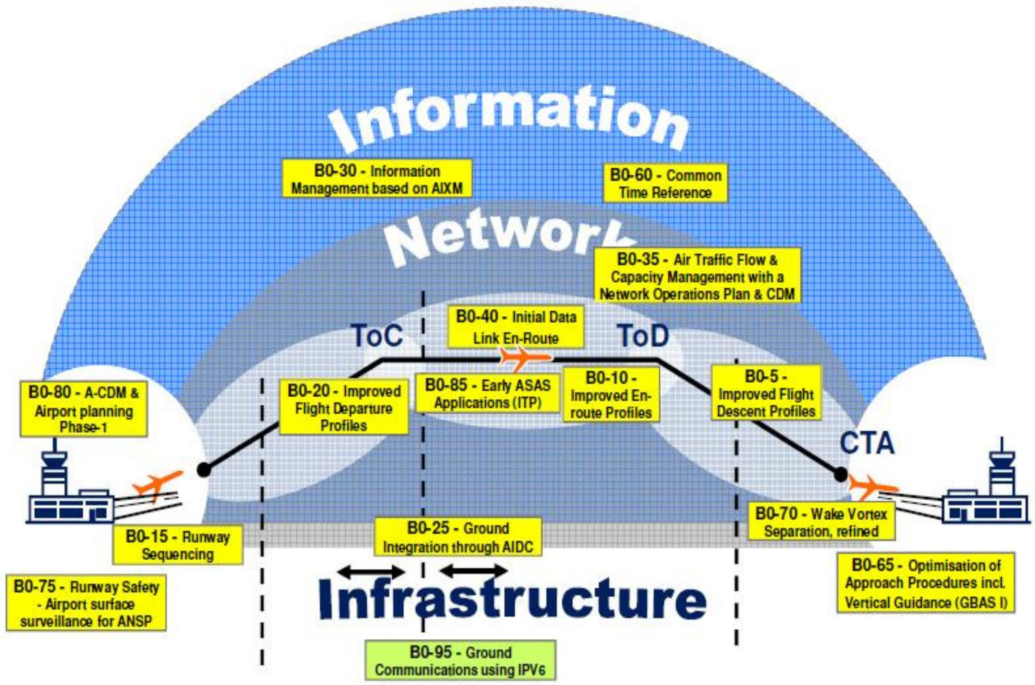

Figure 2. Block 0 in Perspective

Risks, Challenges and Next Steps

All programmes face risks and require appropriate mitigation strategies. The most significant risk in global airspace modernization is related to timing and the mix of technical, political, and infrastructure requirements. The block upgrades described are expected to mitigate the risks anticipated in establishing a globally harmonized airspace.

As the airspace is “right sized” to the State’s unique needs and a business case developed that supports viable operational benefits, there are a set of risks that exist independent of the specific solution chosen. These include:

- Non-homogeneous deployment across the regions
- Lack of synchronization of air and ground deployments
- Future investment in the existing ATM programmes by key stakeholders not secured
- Delays in standards development and approvals
- AIM not implemented in a global interoperable way
- SWIM not implemented in correct form

The deployment of block upgrades has been chosen to resolve many of these identified risks. The timing and sizing of these are in response to the need for mature standards, integrated air and ground solutions, and the establishment of positive business cases that bring identifiable benefits forward for a level of equipage and infrastructure cost. Those capabilities that lack specific maturity in content or described benefit are purposefully placed in the later block upgrades.

Block upgrades also respond to the issue of “non-homogeneous deployment across regions”. Each block and its underlying components are intended to interoperate seamlessly, independent of how they are implemented in

neighboring States. This ensures that procedures, training, policy and other “infrastructure” are consistent, enabling a safe transition to more capable airspace.

Block upgrades were defined to minimize their specific risks but, it is not possible to foresee all potential issues associated with timing and adoption. In that regard, block upgrades bring the following risks:

- States may not be capable of ensuring successful deployment of Block 0
- If Block 0 is not implemented as a foundation, certain functionalities may not be available as enablers for future blocks
- Identification and resolution of policies necessary to enable the future blocks
- Delays in availability of new technologies to support implementation of Blocks 1, 2 and 3
- Delays in availability of SARPs
- National regulatory frameworks may be unable to support implementation of Blocks 1, 2 and 3

Having established a structured roadmap, stakeholders now benefit from a framework for discussion and resolution of open issues associated with the specific risks that come with the block upgrades. The mapping provided by the block upgrades gives ICAO and industry standards makers a tool to unify and synchronize action in a coherent manner. This is expected to limit the scope and complexity of the challenge of achieving global airspace modernization.

For the standards makers (ICAO, RTCA, EUROCAE, SAE), this provides a basis to coordinate efforts, avoid duplication and deliver global and interoperable, unified standards. Various actors in industry standardization should combine their efforts to support those of ICAO as well as in delivering the proper framework to the Industry to develop and implement the relevant technology.

ICAO through the Twelfth Air Navigation Conference is expected to arrive at a proper level of agreement on the GANP and associated roadmaps. This includes establishing work programmes and working methods and to achieve timely availability of adequate material.

Equipped with a global mapping of the block upgrades and various roadmaps which will constitute the revamped GANP, it will be possible to develop or update the Regional Air Navigation Plans taking into account the necessity of maintaining interoperability and having a clear picture of the various components of the desired operational benefits.

Conclusion

The Aviation System Global Block Upgrade initiative should constitute the framework for a worldwide agenda towards ATM system modernization. Offering a structure based on expected operational benefits, it should support investment and implementation processes, making a clear relation between the needed technology and operational improvement.

However, block upgrades will only play their intended role if sound and consistent technology roadmaps are developed and validated. As well, all stakeholders involved in the worldwide ATM modernization should accept to align their activities and planning to the related Block upgrades. The challenge of the Twelfth Air Navigation Conference will be to establish a solid and worldwide endorsement of the Aviation System

Block Upgrades as well as the related technology roadmaps into the revised Global Air Navigation Plan, under the concept of One Sky.

APPENDIX A – Summary Table of Aviation System Block Upgrades Mapped to Performance Improvement Areas

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Appendix A: Summary Table of Aviation System Block Upgrades Mapped to Performance Improvement Areas

Performance Improvement Area 1: Greener Airports

Block 0	Block 1	Block 2	Block 3
B0-65 **Improved Airport Accessibility** This is the first step toward universal implementation of GNSS-based approaches	**B1-65** **Optimised Airport Accessibility** This is the next step in the universal implementation of GNSS-based approaches		
B0-70 **Increased Runway Throughput through Wake Vortex Separation** Improved throughput on departure and arrival runways through the revision of current ICAO wake vortex separation minima and procedures (re-categorisation, CSPR and WIDAO)	**B1-70** **Increased Runway Throughput through Dynamic Wake Vortex Separation** Improved throughput on departure and arrival runways through the dynamic management of wake vortex separation minima based on the real-time identification of wake vortex hazards	**B2-70** **Advanced Wake Vortex Separation (Time-based)**	
B0-75 **Improved Runway Safety (A-SMGCS)** Airport surface surveillance for ANSP	**B1-75** **Enhanced Safety and Efficiency of Surface Operations (A-SMGCS/ATSA-SURF)** Airport surface surveillance for ANSP and flight crews with safety logic, cockpit moving map displays and visual systems for taxi operations	**B2-75** **Optimised Surface Routing and Safety Benefits (A-SMGCS Level 3-4, ATSA-SURF IA and SVS)** Taxi routing and guidance evolving to trajectory based with ground / cockpit monitoring and data link delivery of clearances and information. Cockpit synthetic visualisation systems	
B0-80 **Improved Airport Operations through A-CDM** Airport operational improvements through the way operational partners at airports work together	**B1-80** **Optimised Airport Operations through A-CDM** Airport operational improvements through the way operational partners at airports work together		
	B1-81 **Remote Operated Aerodrome Control Tower** Remotely operated Aerodrome Control Tower contingency and remote provision of ATS to aerodromes through visualisation systems and tools		
B0-15 **Improved Traffic Flow through Runway Metering** Time-based metering to sequence departing and arriving flights	**B1-15** **Improved Approach and Departure Management through Integration** Integrated surface management and departure sequencing, bring robustness to departure management and improvement on arrival management	**B2-15** **Linked AMAN/DMAN** Synchronised AMAN/DMAN will promote more agile and efficient en-route and terminal operations	**B3-15** **Integrated AMAN/DMAN/SMAN** Fully synchronised network management between departure airport and arrival airports for all aircraft in the air traffic system at any given point in time

Performance Improvement Area 2:
Globally Interoperable Systems and Data – Through Globally Interoperable System Wide Information Management

Block 0	Block 1	Block 2	Block 3
B0-25 **Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration** Supports the coordination of ground-ground data communication between ATSU based on ATS Inter-facility Data Communication (AIDC) defined by ICO Document 9694	**B1-25** **Increased Interoperability, Efficiency and Capacity though FF-ICE/1 application before Departure** Introduction of FF-ICE step 1, to implement ground-ground exchanges using common flight information reference model, FIXM, XML and the flight object used before departure	**B2-25** **Improved Coordination through multi-centre Ground-Ground Integration: (FF-ICE/1 and Flight Object, SWIM)** FF-ICE supporting trajectory-based operations through exchange and distribution of information for multicentre operations using flight object implementation and IOP standards	
B0-30 **Service Improvement through Digital Aeronautical Information Management** Initial introduction of digital processing and management of information, by the implementation of AIS/AIM making use of AIXM, moving to electronic AIP and better quality and availability of data	**B1-30** **Service Improvement through Integration of all Digital ATM Information** Implementation of the ATM information reference model integrating all ATM information using UML and enabling XML data representations and data exchange based on internet protocols with WXXM for meteorological information		**B3-25** **Improved Operational Performance through the introduction of Full FF-ICE** All data for all relevant flights systematically shared between air and ground systems using SWIM in support of collaborative ATM and trajectory-based operations
	B1-31 **Performance Improvement through the application of System Wide Information Management (SWIM)** Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximise interoperability	**B2-31** **Enabling Airborne Participation in collaborative ATM through SWIM** Connection of the aircraft an information node in SWIM enabling participation in collaborative ATM processes with access to rich voluminous dynamic data including meteorology	

Performance Improvement Area 3:
Optimum Capacity and Flexible Flights – Through Global Collaborative ATM

Block 0	Block 1	Block 2	Block 3
B0-10 **Improved Operations through Enhanced En-Route Trajectories** Implementation of performance-based navigation (PBN concept) and flex tracking to avoid significant weather and to offer greater fuel efficiency, flexible use of airspace (FUA) through special activity airspace allocation, airspace planning and time-based metering, and collaborative decision-making (CDM) for en-route airspace with increased information exchange among ATM stakeholders	**B1-10** **Improved Operations through Dynamic ATS Routing** Introduction of free routing in defined airspace, where the flight plan is not defined as segments of a published route network or track system to facilitate adherence to the user-preferred profile		**B3-10** **Traffic Complexity Management** Introduction of complexity management to address events and phenomena that affect traffic flows due to physical limitations, economic reasons or particular events and conditions by exploiting the more accurate and rich information environment of a SWIM-based ATM
B0-35 **Improved Flow Performance through Planning based on a Network-Wide view** Collaborative ATFM measure to regulate peak flows involving departure slots, managed rate of entry into a given piece of airspace for traffic along a certain axis, requested time at a way-point or an FIR/sector boundary along the flight, use of miles-in-trail to smooth flows along a certain traffic axis and re-routing of traffic to avoid saturated areas	**B1-35** **Enhanced Flow Performance through Network Operational Planning** ATFM techniques that integrate the management of airspace, traffic flows including initial user driven prioritisation processes for collaboratively defining ATFM solutions based on commercial/operational priorities	**B2-35** **Increased user involvement in the dynamic utilisation of the network.** Introduction of CDM applications supported by SWIM that permit airspace users manage competition and prioritisation of complex ATFM solutions when the network or its nodes (airports, sector) no longer provide capacity commensurate with user demands	
	B1-105 **Better Operational Decisions through Integrated Weather Information (Strategic >40 Minutes)** Weather information supporting automated decision process or aids involving: weather information, weather translation, ATM impact conversion and ATM decision support		**B3-105** **Better Operational Decisions through Integrated Weather Information (Tactical <40 Minutes)** Weather information supporting both air and ground automated decision support aids for implementing weather mitigation strategies

Performance Improvement Area 3: Optimum Capacity and Flexible Flights – Through Global Collaborative ATM

Block 0	Block 1	Block 2	Block 3
	B1-85 **Increased Capacity and Flexibility through Interval Management** To create operational benefits through precise management of intervals between aircraft whose trajectories are common or merging, thus maximizing airspace throughput while reducing ATC workload and enabling more efficient aircraft fuel burn reducing environmental impacts		**B3-85** **Airborne Separation (ASEP)** • Technology • Conflict management
	B1-86 **Improved access to Optimum Flight Levels through Climb/Descent Procedures using ADS-B** In-trail procedure ADS-B to enable an aircraft to climb or descend through the altitude of other aircraft when the requirements for procedural separation cannot be met		
B0-100 **Air Traffic Situational Awareness (ATSA)** ATSA provides a cockpit display of a graphical depiction of traffic to assist the pilot in out-the-window visual acquisition of traffic: AIRB en-route phase; is used to assist the out-the-window visual acquisition of airborne traffic for enhancing flight crew situational awareness and air traffic safety VSA approach phase (supporting the flight crew to acquire and maintain own separation from the preceding aircraft when performing a visual approach procedure)		**B2-100** **New Collision Avoidance System** Implementation of Airborne Collision Avoidance System (ACAS) to take account of the trajectory-based operations procedures	

Performance Improvement Area 4:
Efficient Flight Path – Through Trajectory-based Operations

Block 0	Block 1	Block 2	Block 3
B0-05 **Improved Flexibility and Efficiency in Descent Profiles (CDOs)** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous descent operations (CDOs)	**B1-05** **Improved Flexibility and Efficiency in Descent Profiles (OPDs)** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Optimised Profile Descents (OPDs)	**B2-05 (tentative)** **Optimised arrivals in dense airspace.** Deployment of performance based airspace and arrival procedures that optimise the aircraft profile taking account of airspace and traffic complexity including Optimised Profile Descents (OPDs), supported by Trajectory-Based Operations and self-separation	
B0-40 **Improved Safety and Efficiency through the initial application of Data Link En-Route** Implementation of an initial set of data link applications for surveillance and communications in ATC	**B1-40** **Improved Traffic Synchronisation and Initial Trajectory-Based Operation.** Use of 4DTRAD capability and airport applications, e.g.; D-TAXI, in trajectory-based operations to improve the synchronisation of traffic flows at en-route merging points and to optimize the approach sequence through air ground exchange of aircraft derived data and specifically related to a single controlled time of arrival (CTA).		**B3-05** **Full 4D Trajectory-based Operations** Trajectory-based operations deploys an accurate four-dimensional trajectory that is shared among all of the aviation system users at the cores of the system. This provides consistent and up-to-date information system-wide which is integrated into decision support tools facilitating global ATM decision-making
B0-20 **Improved Flexibility and Efficiency in Departure Profiles** Deployment of departure procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous climb operations (CCOs)			
	B1-90 **Initial Integration of Remotely Piloted Aircraft (RPA) Systems into non-segregated airspace** Implementation of basic procedures for operating RPAs in non-segregated airspace including detect and avoid	**B2-90** **RPA Integration in Traffic** Implements refined operational procedures that cover lost link (including a unique squawk code for lost link) as well as enhanced detect and avoid technology	**B3-90** **RPA Transparent Management** RPA operate on the aerodrome surface and in non-segregated airspace just like any other aircraft

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Appendix B – Detailed Aviation System Block Upgrades

This Appendix presents the detailed modules which make up each block upgrade. The modules are presented by block, starting with Block 0, and arranged in the same top to bottom order in which, they are presented in the summary table in Appendix A. The reader should refer to Appendix A to follow the thread of each module with each block.

Each module is numbered according to the Block to which it is associated and then assigned a random two or three digit number, such as B0-65. This taxonomy was used to facilitate the development of the modules but can be disregarded by the reader.

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Module N° B0-65: Improved Airport Accessibility

Summary	This is the first step toward universal implementation of GNSS-based approaches. PBN and GLS procedures enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency. These can be achieved through the application of Basic GNSS, Baro VNAV, SBAS and GBAS. The flexibility inherent in PBN approach design can be exploited to increase runway capacity.	
Main Performance Impact	KPA-01 - Access and Equity; KPA-04 – Efficiency; KPA-05 – Environment; KPA-10 - Safety	
Domain / Flight Phases	Approach	
Applicability Considerations	This module is applicable to all instrument and precision instrument runway ends, and to a limited extent, non-instrument runway ends	
Global Concept Component(s)	AUO – Airspace User Operations AO – Aerodrome Operations	
Global Plan Initiatives (GPI)	GPI-5 RNAV and RNP (PBN) GPI-14 Runway Operations GPI-20 WGS84	
Reference Documents	PBN Manual (ICAO Doc 9613) GNSS Manual (ICAO Doc 9849) Annex 10 Vol. I PANS-OPS (ICAO Doc 8168) WGS-84 Manual (Doc 9674) Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

This module complements other airspace and procedures elements (CDO, PBN and Airspace Management) to increase efficiency, safety, access and predictability.

This module describes what is available and can be more widely used now.

1.1.1 Baseline

In the global context, a limited number of GNSS-based PBN compared with conventional procedures. Some States, however, have implemented large numbers of PBN procedures. There are several GBAS demonstration procedures in place

1.1.2 Change brought by the module

Conventional navigation aids (e.g. ILS, VOR, NDB) have limitations in their ability to support the lowest minima to every runway. In the case of ILS, limitations include cost, the availability of suitable sites for ground infrastructure and an inability to support multiple descent paths. VOR and NDB procedures do not support vertical guidance and have relatively high minima that depend on siting considerations. PBN procedures require no aerodrome infrastructure and allow designers complete flexibility in determining the final approach lateral and vertical paths. PBN approach procedures can be seamlessly integrated with PBN arrival procedures, including constant descent operations (CDO), thus reducing aircrew and controller workload and the probability that aircraft will not follow the expected trajectory. GBAS, which is not included in the PBN Manual, requires aerodrome infrastructure but a single station can support approaches to all runways and GBAS offers the same design flexibility as PBN procedures. This flexibility provides benefits when conventional aids are out of service due to system failures or for maintenance.

States can implement GNSS-based PBN approach procedures that provide minima for aircraft equipped with basic GNSS avionics with or without Baro VNAV capability, and for aircraft equipped with SBAS avionics. Regardless of the avionics fit, each aircraft will follow the same lateral path. Such approaches can be designed for runways with or without conventional approaches, thus providing benefits to PBN-capable aircraft, encouraging equipage and supporting the planning for decommissioning of some conventional aids.

The key to realizing maximum benefits from these procedures is aircraft equipage. Aircraft operators make independent decisions about equipage based on the value of incremental benefits and potential savings in fuel and other costs related to flight disruptions. Experience has shown that operators may await fleet renewal rather than equip existing aircraft.

2 Intended Performance Operational Improvement/Metric to determine success

Access and Equity	Increased aerodrome accessibility. Metric: number of runways ends with vertical guidance.
Capacity	This module removes the requirement for sensitive and safety-critical areas on the proposed precision approaches. Metric: Movement rate at airports during LVP operations
Efficiency	Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely-spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds. Metrics: • Number of flight disruptions • Runway capacity
Environment	Environmental benefits through reduced fuel burn Metric: CO_2 savings
Safety	Stabilized approach paths, vertical guidance, elimination of circling procedures. Metric: ratio of vertically-guided to total procedures

CBA	Aircraft operators and ANSPs can quantify the benefits of lower minima by using historical aerodrome weather observations and modelling airport accessibility with existing and new minima. Each aircraft operator can then assess benefits against the cost of any required avionics upgrade. If an operator equips such that all approaches can be made with vertical guidance, that operator can reduce training costs by deleting simulator and flight training modules.
Human Performance	Human performance is reflected in how straightforward it is to successfully perform a specific task consistently, and how much initial and recurrent training is required to achieve safety and consistency. For this module there are clear safety benefits associated with the elimination of circling procedures and approaches without vertical guidance. Metrics: • Ratio of circling to total procedures • Ratio of vertically-guided to total procedures

3 Necessary Procedures (Air & Ground)

The PBN Manual, the GNSS Manual, Annex 10 and PANS-OPS Volume I provide guidance on system performance, procedure design and flight techniques necessary to enable PBN approach procedures. The WGS-84 Manual provides guidance on surveying and data handling requirements. The Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II — Testing of Satellite-based Radio Navigation Systems provides guidance on the testing of GNSS. This testing is designed to confirm the ability of GNSS signals to support flight procedures in accordance with the standards in Annex 10. ANSPs must also assess the suitability of a procedure for publication, as detailed in PANS-OPS, Volume II, Part I, Section 2, Chapter 4, Quality Assurance. The Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5 – Flight Validation of Instrument Flight Procedures provides the required guidance for PBN procedures. Flight validation for PBN procedures is less costly than for conventional aids for two reasons: the aircraft used do not require complex signal measurement and recording systems; and, there is no requirement to check signals periodically.

These documents therefore provide background and implementation guidance for ANS providers, aircraft operators, airport operators and aviation regulators

4 Necessary Technology (Air & Ground)

PBN approach procedures can be flown with basic IFR GNSS avionics that support on board performance monitoring and alerting (e.g. TSO C129 receivers with RAIM); these support LNAV minima. Basic IFR GNSS receivers may be integrated with Baro VNAV functionality to support vertical guidance to LNAV/VNAV minima. In States with defined SBAS service areas, aircraft with SBAS avionics (TSO C145/146) can fly approaches with vertical guidance to LPV minima, which can be as low as ILS Cat I minima when flown to a precision instrument runway, and as low as 250 ft HAT when flown to an instrument runway. SBAS-based procedures do not require any infrastructure at the airport served, but SBAS elements (e.g. reference stations, master stations, GEO satellites) must be in place such that this level of service is supported. The ionosphere is very active in equatorial regions, making it very technically challenging for the current generation of SBAS to provide vertically guided approaches in these regions. Within an SBAS service area, SBAS avionics can provide advisory vertical guidance when flying conventional NDB and VOR procedures, thus providing the safety benefits associated with a stabilized approach. All of the above approach types are described in the PBN Manual. A GBAS station installed at the aerodrome served can support vertically guided Cat I approaches to all runways at that aerodrome. Aircraft require TSO C161/162 avionics to fly GBAS approaches. As of 2011 a draft SARPs amendment for GBAS to support Category II/III approaches is completed and is being validated by States and industry.

5 Implementation and Demonstration Activities

5.1 General

Many States started developing GPS-based RNAV approach procedures after GPS was approved for IFR operations in 1993 and approach-capable avionics meeting TSO C129 appeared the same year. The United States commissioned WAAS (SBAS) in 2003, and supported the integration of stations on Canada and Mexico in 2008. Europe commissioned EGNOS in early 2011. International air carriers have not adopted SBAS because they mainly serve airports already well equipped with ILS, and they generally have Baro VNAV capability, allowing them to fly stabilized approaches. SBAS is more attractive to regional and other domestic air carriers, as well as general aviation aircraft. These operators generally do not have Baro VNAV capability and they serve smaller airports that are less likely to have ILS.

5.2 Current Use

- **United States**

The United States has published over 5,000 PBN approach procedures. Of these, almost 2,500 have LNAV/VNAV and LPV minima, the latter based on WAAS (SBAS). Of the procedures with LPV minima, almost 500 have a 200 ft HAT. Current plans call for all (approximately 5,500) runways in the USA to have LPV minima by 2016. The United States has a demonstration GBAS Cat I procedure at Newark; certification is pending resolution of technical and operational issues.

- **Canada**

Canada has published 596 PBN approach procedures with LNAV minima as of July 2011. Of these, 23 have LNAV/VNAV minima and 52 have LPV minima, the latter based on WAAS (SBAS). Canada plans to add PBN procedures, and to add LNAV/VNAV and LPV minima to those with LNAV-only minima based on demand from aircraft operators. Canada has no GBAS installations.

- **Australia**

Australia has published approximately 500 PBN approach procedures with LNAV minima, and has plans to add LNAV/VNAV minima to these procedures; as of June 2011 there were 60 under development. Only about 5% of aircraft operating in Australia have Baro VNAV capability. Australia does not have SBAS, therefore none of the approaches has LPV minima. Australia has completed a GBAS Cat I trial at Sydney and will be installing a new system for testing leading to full operational approval by late April 2012.

- **France**

France has published 50 PBN procedures with LNAV minima as of June 2011; 3 have LPV minima; none has LNAV/VNAV minima. The estimates for the end of 2011 are: 80 LNAV, 10 LPV and 1 LNAV/VNAV. The objective is to have PBN procedures for 100% of France's IFR runways with LNAV minima by 2016, and 100% with LPV and LNAV/VNAV minima by 2020. France has a single GBAS used to support aircraft certification, but not regular operations. France has no plans for Cat I GBAS.

- **Brazil**

Brazil has published 146 PBN procedures with LNAV minima as of June 2011; 45 have LNAV/VNAV minima. There are 179 procedures being developed, 171 of which will have LNAV/VNAV minima. Plans call for GBAS to be implemented at main airports from 2014. Brazil does not have SBAS due in part to the challenge of providing single-frequency SBAS service in equatorial regions.

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Module N° B0-70: Increased Runway Throughput through Wake Vortex Separation

Summary	Improved throughput on departure and arrival runways through the revision of current ICAO wake vortex separation minima and procedures (re-categorisation, CSPR and WIDAO).	
Main Performance Impact	KPA-02 - Capacity	
Domain / Flight Phases	Arrival and Departure	
Applicability Considerations	Applicable to all approaches and Arrivals/Departures.	
Global Concept Component(s)	CM - Conflict Management, AO – Airport Operations, AUO – Airspace User Operations.	
Global Plan Initiatives (GPI)	GPI 14 – Runway Operations	
Reference Documents	ICAO Doc 9584 Global ATM Operational Concept ICAO Doc 9750 Global Air Navigational Plan	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2013
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	2013
	Operations Approvals	2013

1 Narrative

1.1 General

Refinement of the Air Navigation Service Provider (ANSP) aircraft-to-aircraft wake mitigation processes, procedures and standards will allow increased runway capacity. This Block 0 upgrade is being accomplished without any changes to aircraft equipage or changes to aircraft performance requirements. The upgrade contains three elements that have been or will be implemented by the end of 2013 at selected aerodromes. Element 1 is the revision of the current ICAO wake separation standards to allow more capacity efficient use of aerodrome runways without an increase in risk associated with a wake encounter. Element 2 is increasing, at some aerodromes, the number of arrival operations on closely spaced (runway centre lines spaced closer than 2500 feet apart) parallel runways (CSPR) by modifying how wake separations are applied by the ANSP. Element 3 is increasing, at some aerodromes, the number of departure operations on parallel runways by modifying how wake separations are applied by the ANSP.

1.1.1 Baseline

ANSP applied wake mitigation procedures and associated standards were developed over time, with the last comprehensive review occurring in the early 1990's. These 1990's standards are inherently conservative, in terms of required aircraft-to-aircraft wake separations, to account for inaccuracies in the then existing aircraft wake turbulence transport and decay models and lack of extensive collected data on aircraft wake behaviour.

1.1.2 Improvement brought by the module

This Module will result in a change to an ANSP's applied wake mitigation procedures. Based on the standards developed, safely modifies the separation standards and their application by ANSPs to allow incremental increases to aerodrome runway throughput capacity. The capacity gains by Element 1 (changing wake separation standards) is predicted to be 4% for European capacity constrained aerodromes, 7% for U.S. capacity constrained aerodromes with similar gains in other capacity constrained aerodromes worldwide. Elements 2 (increasing aerodrome arrival operational capacity) and 3 (increasing departure operational capacity) provide runway capacity improvements to aerodromes having runway configurations and aircraft traffic mixes that allow specialized ANSP wake mitigation procedures to enhance the runway throughput capacity. The aerodrome specific specialized procedures have/will result in increased aerodrome arrival capacity (5 to 10 more operations per hour) during instrument landing operations or increased aerodrome departure capacity (2 to 4 more operations per hour)

1.1.3 Other remarks

The work will be the basis for further enhancement in wake mitigation procedures and standards that will occur in B1-18 and B2-23 developments. The Wake Vortex Separation - Refined Module is a progression of steps to have available to global aviation, means to acquire more capacity from existing aerodrome runway structure and to place new aerodrome runways for minimizing wake turbulence landing and departure restrictions. The effort in B0-13 will not provide the major capacity increases needed to meet the overall demand envisioned for the 2025 time frame. However it does provide incremental capacity increases using today's runways and methods of air traffic control. B1-18 and B2-23 will address developing wake mitigation procedures and separation standards that will assure the wake safety of innovations (Trajectory Based, High Density, Flexible Terminal) in air traffic control while at the same time provide the least wake safety constraints on the air traffic control innovation. Some experience has been obtained with the B0-13 changes at Charles de Gaulle Aerodrome, Seattle-Tacoma International Aerodrome, and Memphis International Aerodrome.

2 Element 1: Revision of the Current ICAO Wake Separation Standards

The last full review of wake separation standards used by air traffic control occurred nearly 20 years ago in the early 1990's. Since then, air carrier operations and fleet mix have changed dramatically, aerodrome runway complexes have changed and new aircraft designs (A-380, Boeing 747-8, very light jets, unmanned aircraft systems) have been introduced into the NAS. The 20 year old wake separation standards still provide safe separation of aircraft from each other's wakes but it no longer provides the most capacity efficient spacing and sequencing of aircraft in approach and en-route operations. This loss of efficient spacing is adding to the gap between demand and the capacity the commercial aviation infrastructure can provide.

The work in Element 1 is being accomplished by a joint EUROCONTROL and FAA working group that has reviewed the current required wake mitigation aircraft separations used in both the USA's and Europe's air traffic control processes and has determined the current standards can be safely modified to increase the operational capacity of aerodromes and airspace. In 2010, the working group provided a set of recommendations for ICAO review that focused on changes to the present set of ICAO wake separation standards. To accomplish this, the workgroup developed enhanced analysis tools to link observed wake behaviour to standards and determined safety risk associated with potential new standards relative to existing standards. ICAO, after receiving the ICAO recommendations, formed the Wake Turbulence Study Group to review the FAA/EUROCONTROL working group recommendations along with other recommendations received from ICAO member states. It is expected that by the end of 2012, ICAO will publish wake separation standard changes to its Procedures for Air Navigation Services. Implementation in the U.S. will require changes to its terminal and en-route automation system adaptations to assign the new wake separation spacing to categories of aircraft.

2.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of new wake vortex separation standards, States can use, as appropriate, a combination of the following metrics:

1. Capacity
    a. Aerodrome capacity and departure/arrival rates will increase as the wake categories are reduced from 3 to 6
        i. Aerodrome throughput
        ii. Runway occupancy time
        iii. Arrival/departure rates
2. Flexibility
    a. ANSP have the choice to configure the aerodrome to operate on 3 or 6 categories, depending on demand.
        i. Aerodrome throughput
        ii. Runway occupancy time
        iii. Arrival/departure rates

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2.2 Necessary Procedures (Air & Ground)

The change to the ICAO wake separation standards implemented in the Block 0 -13 timeframe will involve increasing the number of ICAO wake separation aircraft categories from 3 to 6 categories along with the assignment of aircraft types to each of the six wake separation categories. ANSPs will be able to choose how they will implement the revised standards into their operations depending on the capacity needs of the aerodrome. If capacity is not an issue at an aerodrome, the ANSP may elect to use the original 3 categories rather than the 6 category set of standards. It is likely that the ANSP procedures, using the full 6 category set of standards, will need some automation support in providing the wake category assignment of an aircraft to the controller, so the controller will know which wake separation to apply between aircraft.

Implementing Element 1 will not require any changes to air crew flight procedures. However, there will be changes required in how a flight plan is filed in terms of the aircraft's wake category.

2.3 Necessary Technology (Air & Ground)

This element requires no additional technology to be added to the aircraft or additional aircrew certifications. Some ANSPs may develop a decision support tool to aid in the application of the new set of 6 category ICAO wake separates being produced by Element 1. The Element 2 and Element 3 Block 0-13 products vary on their dependency to newly applied technology. For the WTMD implementation, technology is used to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

The product of Element 1 is a recommended set of changes to the ICAO wake separation standards and supporting documentation. The ICAO Air Navigation Bureau has begun its review process for the recommended changes and that process needs to continue to its completion. Once approved, ICAO's revised wake separation standards will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards. ICAO approval is expected in the 2012/13 time frame.

2.5 Business Case specific to the element

This module was developed in response to requests by air carriers and aerodromes to examine the existing ANSP wake vortex mitigation procedures and associated wake separation standards for capacity enhancing opportunities to apply recent advancements in the wake vortex tracking and characterization technology and resulting accumulation of vast wake track data sets. The Elements of this Module are chiefly procedural in nature with some technology applications in the development of wake separation monitoring controller support tools and in the application of crosswind forecasts in the setting of required wake separations. Costs of implementing the Elements are low and include the cost for data analysis, procedure development, procedure approval and implementation, modification of ANSP automation data bases, modification of existing ANSP controller decision support tools and in the case of WTMD, the addition of a personal computer level system and interfaces to weather information inputs. There are no aircraft equipage costs.

Benefits of this Module are to the users of the aerodrome's runways. Overly safety conservative ANSP wake separation procedures and associated separation standards do not allow the maximum utility of an aerodromes runway. One air carrier operating a major hub operation at a U.S. aerodrome has determined a gain of two extra departures per hour from the aerodrome's CSPR during the "rush" has a major beneficial effect in reducing delays in the air carrier's operations.

Element 1's change to the ICAO wake separation standards will yield an average 4% capacity increase for an aerodrome's runways in Europe, 7% in U.S, and between 4 to 7% increase for aerodromes world wide. The 7% increase translates to 2 more landings per hour for a single runway that normally could handle 30 landings per hour. Two extra slots per hour create revenue for the air carrier that fills them and for the aerodrome that handles the extra aircraft operations and passengers.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Not applicable – awaiting ICAO approval of the revised wake vortex separation standards.

2.6.2 Planned or Ongoing Trials

Concurrent with the ICAO approval process, FAA is developing documentation and its automation systems' adaptation changes that will allow implementation of the wake separation standard changes. The ICAO approval is expected in 2012/13.

3 Element 2: Increasing Aerodrome Arrival Operational Capacity

ANSP wake mitigation procedures applied to instrument landing operations on CSPR are designed to protect aircraft for a very wide range of aerodrome parallel runway configurations. Prior to 2008, instrument landing operations conducted to an aerodrome's CSPR had to have the wake separation spacing equivalent to conducting instrument landing operations to a single runway. When an aerodrome using its CSPR for arrival operations had to shift its operations from visual landing procedures to instrument landing procedures, it essentially lost one half of its landing capacity (i.e. from 60 to 30 landing operations per hour).

Extensive wake transport data collection efforts and the resulting analyses indicated that the wakes from aircraft lighter than Boeing 757 and heavier aircraft travelled less than previously thought. Based on this knowledge, high capacity demand aerodromes in the U.S. that used their CSPR for approach operations were studied to see if instrument approach procedures could be developed that provide more landing operations per hour than the single runway rate. A dependent diagonal paired instrument approach procedure (FAA Order 7110.308) was developed and made available for operational use in 2008 for five aerodromes that had CSPR configurations that met the runway layout criteria of the developed procedure. Use of the procedure provided an increase of up to 10 more arrival operations per hour on the aerodrome CSPR. By the end of 2010 the approval to use the procedure was expanded to two additional aerodromes.

Work is continuing to develop variations of the procedure that will allow its application to more aerodrome CSPR with fewer constraints on the type of aircraft that must be the lead aircraft of the paired diagonal dependent approach aircraft. It is expected that by the end of 2012, the procedure will be available in the U.S for use by an additional 6 or more CSPR aerodromes during periods when they use instrument approach landing procedures.

3.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

3. Capacity
    a. Aerodrome capacity and arrival rates will increase as specialized and tailored CSPR procedures for instrument landing operations are developed and implemented in more aerodromes. Current instrument landing procedures reduce aerodrome throughput by 50%. level flight time
        i. level distance time
        ii. fuel burn

3.2 Necessary Procedures (Air & Ground)

The Block 0-13 implementations impacting the use of an aerodrome's CSPR for arrivals, only affect the ANSP procedures for sequencing and segregating aircraft to the CSPR. Element 2 products are additional procedures for use by the ANSP for situations when the aerodrome is operating instrument flight rules and there is a need to land more flights than can be achieved by using only one of its CSPR.

The procedures implemented by Element 2 require no changes to the aircrew's procedures for accomplishing an instrument landing approach to the aerodrome. Sequencing, segregating and separation will remain the responsibility of the ANSP.

3.3 Necessary Technology (Air & Ground)

This element requires no additional technology to be added to the aircraft or additional aircrew certifications. Some ANSPs may develop a decision support tool to aid in the application of the new set of 6 category ICAO wake separates being produced by Element 1. The Element 2 and Element 3 Block 0-13 products vary on their dependency to newly applied technology. For the WTMD implementation, technology is used to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Element 2 products are U.S. aerodrome specific and are approved for use through a national review process to insure proper integration into the air traffic control system. A companion process (FAA Safety Management System) reviews and documents the safety of the product, insuring the safety risk associated with the use of the product is low..

3.5 Business Case specific to the element

See business case in element 1

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

The FAA Order 7110.308 procedure use has been approved for 7 U.S. aerodromes with Seattle-Tacoma and Memphis aerodromes using the procedure during runway maintenance closures. Use at Cleveland is awaiting runway instrumentation changes.

3.6.2 Planned or Ongoing Trials

Work is continuing to develop variations of the FAAA Order 7110.308 procedure that will allow its application to more aerodrome CSPR with fewer constraints on the type of aircraft that must be the lead aircraft of the paired diagonal dependent approach aircraft. It is expected that by the end of 2012, the procedure will be available in the U.S for use by an additional 6 or more CSPR aerodromes during periods when they use instrument approach landing procedures.

4 Element 3: Increasing Aerodrome Departure Operational Capacity

Element 3 is the development of enhanced wake mitigation ANSP departure procedures that safely allow increased departure capacity on aerodrome CSPR. Procedures being developed are aerodrome specific in terms of runway layout weather conditions.

The Wake Independent Departure and Arrival Operation (WIDAO) developed for use on CSPR at Charles de Gaulle aerodrome was developed as a result of an extensive wake turbulence transport measurement campaign at the aerodrome. WIDAO implementation allows the ANSP to use the inner CSPR for departures independent of the arrivals on the outer CSPR where before the ANSP was required to apply a wake mitigation separation between the landing aircraft on the outer CSPR and the aircraft departing on the inner CSPR.

Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required wake mitigation delay of 2 to 3 minutes. WTMD applies a runway cross wind forecast and monitors the current runway crosswind to determine when the WTMD will provide guidance to the controller that the 2 to 3 minute wake mitigation delay can be eliminated and when the delay must again be applied. WTMD is being developed for implementation at 8 to 10 U.S. aerodromes that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757 and heavier aircraft operations. Operational use of WTMD is expected in spring 2011.

4.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

4. Capacity
    a. New procedures will modified the current wake mitigation measures of waiting for 2-3 minutes, and decrease the waiting time required. Aerodrome capacity and departure rates will increase. In addition, runway occupancy time will decrease as a result of this new procedure
        i. Aerodrome throughput
        ii. Runway occupancy time
        iii. Departure time

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4.2 Necessary Procedures (Air & Ground)

Block 0-13 Element 3 implementations only affect the ANSP procedures for departing aircraft on an aerodrome's CSPR. Element 3 products are additional procedures for use by the ANSP for situations when the aerodrome is operating under a heavy departure demand load and the aerodrome will be having a significant number of Boeing 757 and heavier aircraft in the operational mix. The procedures provide for transitioning to and from reduced required separations between aircraft and criteria for when the reduced separations should not be used.

The procedures implemented by Element 3 require no changes to the aircrew's procedures for accomplishing a departure from the aerodrome. When a specialized CSPR departure procedure is being used at an aerodrome, pilots are notified that the special procedure is in use and that they can expect a more immediate departure clearance.

4.3 Necessary Technology (Air & Ground)

This element requires no additional technology to be added to the aircraft or additional aircrew certifications. Some ANSPs may develop a decision support tool to aid in the application of the new set of 6 category ICAO wake separates being produced by Element 1. The Element 2 and Element 3 Block 0-13 products vary on their dependency to newly applied technology. For the WTMD implementation, technology is used to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors.

4.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Element 3's WIDAO has undergone extensive review by the French ANSP and regulator. It is now operational at Charles de Gaulle. WTMD is progressing through the FAA operational use approval process (which includes the Safety Management System process) and is expected to begin its operation at George Bush Intercontinental Houston Airport (IAH) in the spring of 2011.

There is no air approval plan required for the implementation of the Wake Vortex Standards – Refined Module Block 0-13.

4.5 Business Case specific to the element

The following savings are an example of potential savings as a result of CDO implementation. It is important to consider that CDO benefits are heavily dependent on each specific ATM environment.

Nevertheless, if implemented within the ICAO CDO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.

Example of savings after CDO implementation in Los Angeles TMA (KLAX)

- CDOs RIIVR2/SEAVU2/OLDEE1 & 4 ILS'
  - Implemented September 25, 2008, and in use full time at KLAX.
- About 300-400 aircraft per day fly RIIVR2/SEAVU2/OLDEE1 STARs representing approximately half of all jet arrivals into KLAX
  - 50% reduction in radio transmissions.
- Significant fuel savings – average 125 pounds per flight.
  - 300 flights/day * 125 pounds per flight * 365 days = 13.7 million pounds/year
  - More than 2 million gallons/year saved = more than 41 million pounds of CO_2 avoided.

4.6 Implementation and Demonstration Activities

4.6.1 Current Use

The WIDAO relaxation of wake separation constraints at CDG (first and second sets of constraints) were approved in November 2008 and March 2009. The final set of CDG constraints was lifted in 2010

4.6.2 Planned or Ongoing Trials

Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required wake mitigation delay of 2 to 3 minutes. WTMD is being developed for implementation at 8 to 10 U.S. aerodromes that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757 and heavier aircraft operations. First operational use of WTMD is expected in spring 2011.

5 Main Dependencies

Main dependencies are in the area of implementation rather than technical development.

5.1 Element 1: Revision of the Current ICAO Wake Separation Standards

The time when the revised wake separation standards can be globally available for ANSP adaptation and use is dependent on the duration of the ICAO approval process for these revised wake separation standards.

5.2 Element 2: Increasing Aerodrome Arrival Operational Capacity

Major dependency for an aerodrome's use of the CSPR diagonal dependent pairing type of arrival procedures will be modifying its CSPR instrumentation to accommodate the criteria for use of the procedure on its runways.

5.3 Element 3: Increasing Aerodrome Departure Operational Capacity

The implementation dependency at the aerodrome's slated to have WTMD system is the ANSP modification of its departure procedures to assure divergent paths for departures from its CSPR.

Module N° B0-75: Improved Runway Safety (A-SMGCS)

TBC

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Module N° B0-80: Improved Airport Operations through A-CDM

Summary	The object is to achieve Airport operational improvements through the way operational partners at airports work together. A key element will be to improve surface traffic management to reduce delays on movement & manoeuvring areas and enhance safety, efficiency and situational awareness by implementing collaborative applications sharing surface operations data among the different stakeholders on the airport.	
Main Performance Impact	KPA-04 – Efficiency; KPA-05 – Environment; KPA-09 - Predictability	
Domain / Flight Phases	Aerodrome, Terminal	
Applicability Considerations	Local for equipped/capable fleets and already established airport surface infrastructure.	
Global Concept Component(s)	AO – Airport Operations IM – Information Management	
Global Plan Initiatives (GPI)	GPI-8 Collaborative airspace design and management GPI-10 Terminal area design and management GPI-13 Aerodrome design and management	
Reference Documents	ICAO CDM Manual (being finalised) EUROCONTROL A-CDM Programme documentation, including an A-CDM Implementation Manual EUROCAE ED-141 Minimum Technical Specifications for Airport Collaborative Decision Making (Airport-CDM) Systems EUROCAE ED-145 Airport-CDM Interface Specification EC: ETSI DRAFT Community Specification – version – TBD FAA NextGen Implementation Plan 2011	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2013
	Avionics Availability	√
	Infrastructure Availability	2013
	Ground Automation Availability	2013
	Procedures Available	2013
	Operations Approvals	2013

1 Narrative

1.1 General

1.1.1 Baseline

Surface operations, especially for the turnaround phase, involve all operational stakeholders at an airport. They all have their processes that they try to conduct as efficiently as possible. However, by relying on separated systems and not sharing all relevant information, they currently do not perform as efficiently as they could.

The baseline with be operations without airport collaboration tools and operations.

1.1.2 Improvement brought by the module

Implementation of airport collaborative decision making (A-CDM) will enhance surface operations and safety by making airspace users, ATC and airport operations better aware of their respective situation and actions on a given flight.

Airport-CDM is a set of improved processes supported by the interconnection of various airport stakeholders' information systems. Airport-CDM can be a relatively simple, low cost programme.

2 Intended Performance Operational Improvement/Metric to determine success

Capacity	Enhanced use of existing infrastructure of gate and stands (unlock latent capacity) Reduced workload, better organisation of the activities to manage flights Metric: airport throughput increases
Cost Effectiveness	
Efficiency	Increased efficiency of the ATM system for all stakeholders. In particular for aircraft operators: improved situational awareness (aircraft status both home and away), enhanced fleet predictability & punctuality, improved operational efficiency (fleet management) & reduced delay
Environment	• Reduced taxi time • Reduced Fuel and Carbon Emissions • Lower aircraft engine run time
Global Interoperability	Seamless operations from an airport to the next
Participation by the ATM community	By definition of CDM
Predictability	Improved situational awareness among users

CBA	The business case has proven to be positive due to the benefits that flights and the other airport operational stakeholders can obtain. A detailed business case has been produced in support of the EU Regulation which was solidly positive.
Human Performance	Local training required for all involved actors

3 Necessary Procedures (Air & Ground)

Existing procedures, adapted to the collaborative environment.

CDQM has been found to provide reduced taxi times, and resultant reduced fuel usage and emissions, while maintaining full use of departure capacity. Successful operations of the CDQM prototype system has shown in field evaluations to allow ATC personnel and flight operators to avoid excess departure queuing, thereby reducing taxi times and resulting in direct savings to the flight operators. Additional research and development of the Surface CDM Concept of Operations, CDQM and the Collaborative Departure Scheduling concept is being further developed.

4 Necessary Technology (Air & Ground)

No airborne equipment is required.
The difficulty to interconnect ground systems depends on the systems in place locally, but experience proves that industrial solutions/support exist.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Using a standard for A_CDM facilitates the convergence of systems and allows those stakeholders having operations at different airports to participate in A-CDM applications in a consistent and seamless manner..

6 Implementation and Demonstration Activities

6.1 Current Use

Europe

EUROCONTROL Airport CDM has both developed and trialled a number of Airport CDM elements and is currently proactively encouraging European airports to implement Airport CDM locally. Airport CDM is not just a system, hardware or software, meeting or telephone call; it involves culture change, handling of sensitive data, procedural changes and building confidence and understanding of each partners operational processes.

With the help of airport stakeholders the European Airport CDM concept has matured significantly over the years from a high level concept into a process that is delivering real operational benefits. More and more airports are currently implementing Airport CDM and being rewarded by the proven benefits.

With Airport CDM implemented locally at an airport the next steps are to enhance the integration of airports with the Air Traffic Flow & Capacity Management (ATFCM) network and the Central Flow Management Unit (CFMU).

Exchange of real time data between airports and CFMU is operational. The accuracy of this data is proving to be very beneficial to both the CFMU and airports. The airports are receiving very accurate arrival estimates for all flights via the Flight Update Message (FUM). The CFMU is benefiting with enhanced take off time estimates in tactical operations via the Departure Planning Information (DPI) messages. A number of additional airports will enter into the data exchange with the CFMU over the coming months.

Based on the successful implementation of FUM/DPI at Munich airport (operational since June 2007) and the outcome of live trials in Zurich, Brussels, and other airports in close coordination with the CFMU, the objective is to develop incentives for all airport stakeholders to adopt the new procedures and take advantage of the proven benefits.

All information can be found at:

http://www.EUROCONTROL.int/airports/public/standard_page/APR2_ACDM_2.html and http://www.euro-cdm.org/

In October 2008, ACI EUROPE and EUROCONTROL signed a collaboration to increase operational efficiencies at European airports based on the implementation of A-CDM. In 2009-10, the A-CDM programme has made great progress with more than 30 airports engaged in implementing, and the target to have A-CDM fully implemented at 10 airports by the end of 2011.

A formal accreditation to an A-CDM label has been created, already granted to Munich, Brussels and Paris-CDG airports.

United States

TBD.

6.2 Planned or Ongoing Trials

United States

The Collaborative Departure Queue Management CDS concept will be evaluated in field tests by the FAA during the Surface Trajectory Based Operations (STBO) projects in 2011.

To evaluate the Human-in-the-Loop system's feasibility and benefits, five airline dispatchers from American carriers: Continental, Delta, JetBlue, Southwest, and United Airlines used the system to manage a set of flights through several simulated air traffic scenarios. A current FAA air traffic manager set constraints on airspace capacities. Recommendations for future experiments included researching other credit allocation schemes and evaluating alternate constraint resolution methods. The credit assignment software was developed for the U.S. trial at NASA and was integrated into the Federal Aviation Administration's (FAA's) System-wide Enhancements for Versatile Electronic Negotiation (SEVEN) framework. The FAA has planned for SEVEN to become operational in the fall 2011 under the Collaborative Trajectory Options Program.

The FAA has on-going trials with multiple airports and airlines. The FAA is conducting studies at various airports which have different environments.

In 2009, Memphis International Airport in Tennessee began using CDQM with the FedEx operations. The demonstrations are continuing at Memphis where Delta Air Lines has begun using the CDQM program, as well as FedEx. At Memphis, FedEx conducts a massive hub operation overnight, when it is the only carrier operating there. During the day, Delta is the hub airline, with two high-density departure pushes. Delta and its regional affiliates account for nearly 85 percent of passenger-carrier departures at Memphis. Memphis is a test system to reduce departure queues in periods of high demand that involve essentially a single airline. Delta's and FedEx's ramp towers handle their own flights. The Memphis tower handles access for the other airlines at the airport.

In 2010, New York John F. Kennedy International Airport (JFK) underwent a four-month runway resurfacing and widening project in one of the United States' busiest airspaces. The longest runway was expanded to accommodate new, larger aircraft. The construction project also included taxiway improvements and construction of holding pads. In order to minimize disruption during construction, JFK decided to use a collaborative effort using departure queue metering. With CDQM, departing aircraft from JFK's many airlines was allocated a precise departure slot and waited for it at the gate rather than congesting taxiways. The procedures used during the construction project worked so well that they were extended after the runway work was completed.

The FAA plans to expand CDQM to Orlando, Florida International Airport. In 2010 the FAA conducted field evaluations. None of the 39 airlines with service at Orlando conduct hub operations there, Orland must therefore combine the departures of eight of their biggest airlines serving the airport to account for the same percentage of departures as Delta Air Lines in Memphis. At Orlando, the main focus of CDQM has been on automated identification of departure queue management issues involving traffic management initiatives – including flights with new estimated departure control times, flights affected by departure miles-in-trail restrictions and flights needing or already assigned approval requests – as well as extended departure delays related to weather and other disruptions, and surface data integrity.

At JFK and Memphis, sharing surface surveillance data with airlines has reduced taxi times by more than one minute per departure on average. Surface metering techniques demonstrated at these facilities appear to shift an additional minute from the taxiways to the gates, conserving additional fuel. These results suggest that the combined annual savings from increased data sharing and metering could be about 7,000 hours of taxi time at JFK and 5,000 hours at Memphis.

Boston Logan International Airport is hosting a demonstration to study the maximum number of aircraft authorized to push back and enter an airport's active movement area during a set time period. The goal is to feed the runway constantly, without getting into stop-and-go movement of aircraft. In August through September 2010, preliminary findings indicate reductions of nearly 18 hours of taxi-out time, 5,100 gallons of fuel, and 50 tons saved in carbon dioxide emissions.

Module N° B0-15: Improved Traffic Flow through Runway Metering

Summary	This Module includes a brief description of runway sequencing with a focus on high density operations, but it applicable at other locations for improved operational efficiency. The module describes how to manage arrivals and departures to and from a multi-runway aerodrome or locations with multiple dependent runways at closely proximate aerodrome to efficiently utilize the inherent runway capacity. It also introduces time based metering. The module also summarizes the benefits of arrival sequencing and outlines the metrics for the performance measurements.	
Main Performance Impact	KPA-02 – Capacity; KPA-04 – Efficiency ; KPA-06 – Flexibility; KPA-09 - Predictability.	
Domain / Flight Phases	Aerodrome and Terminal	
Applicability Considerations	Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements. The improvement is Least Complex – Runway Sequencing procedures are widely used in aerodromes globally. However, some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this block.	
Global Concept Component(s)	TS – Traffic Synchronization	
Global Plan Initiatives (GPI)	GPI-6 Air Traffic Flow Management	
Reference Documents	European ATM Master Plan, SESAR Definition Phase Deliverable 2 – The Performance Target, SESAR Definition Phase Deliverable 3 – The ATM Target Concept, SESEAR Definition Phase 5 – SESAR Master Plan TBFM Business Case Analysis Report NextGen Midterm Concept of Operations v.2.0 RTCA Trajectory Concept of Use	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2013
	Avionics Availability	√
	Infrastructure Availability	2013
	Ground Automation Availability	2013
	Procedures Available	2013
	Operations Approvals	2013

1 Narrative

1.1 General

NextGen and SESAR share a common strategic objective to introduce operational and technical capabilities that builds toward the future ICAO Global Air Traffic Management Operational Concept. Both efforts seek to implement automation systems and more efficient operational schemes to efficiently utilize runways especially in congested airspace.

Time Based Flow Management (TBFM) concept hinges on the use of metering. Metering is a procedure used to optimise the flow.. This procedure is a time based scheme in which aircrafts are spaced by time in trail rather than distance. TBFM seeks to implement time based metering for all phases of flight. The application of this procedure, along with synchronization of the metering times for each flight phases, is instrumental in traffic synchronization.

In Block 0 (present – 2013), Basic queue management tool such as arrival/departure sequencing systems will provide runway sequencing and metering/scheduling support to the ANSP. In the us the capability is known as Traffic Management Advisor (TMA). TMA is currently being used at 20 ARTCCs in the US. Metering to fixes, arbitrary points in space and to arcs in the airspace are supported by TMA near the terminal area as scheduling entities. These scheduling entities enhance the ability of Air Route Traffic Control Centers (ARTCCs) to conduct time based metering of arrivals over long distances from the arrival aerodromes and to meter en-route traffic flows.

In Europe, Arrival/Departure Management (AMAN)AMAN achieves equivalent functionalities as TMA, (source - SESAR Definition Phase Deliverable 2 – Air Transport Framework: The Performance Target, page 65) and assists ATC personnel in Terminal Manoeuvre Area with sequencing and scheduling. AMAN is deployed at key European aerodromes

1.1.1 Baseline

Traffic Management Advisor (TMA) is the current time based metering and runway sequencing tool in service at all US Air Route Traffic Control Centres (ARTCCs) and the New York Terminal Radar Approach Control (TRACON). AMAN/DMAN deployment in Europe is available at key aerodromes.

1.1.2 Improvement brought by the module

Metering in terminal airspace reduces the uncertainty in airspace and aerodromes demand. Flights are "metered" by Control Time of Arrival (CTAs) and must arrive at the aerodrome by this time. Metering allows ATM to sequence arriving flights such that terminal and aerodrome resources are utilized effectively and efficiently.

While metering automation efforts such as AMAN and TMA/DFM maximizes the use of airspace capacity and to assure full utilization of resources, they have the additional benefit of fuel efficient alternatives to hold stacks in an era in which fuel continues to be a major cost driver and emissions is a high priority. The use of these tools to assure facility of more efficient arrival and departure paths is a main driver in Block 0.

1.1.3 Other remarks

AMAN/DMAN, the European arrival/departure sequencing systems, is implemented at several key airports such as Paris Charles de Gaulle, Frankfurt, Munich, Zurich, and Madrid. Traffic Management Advisor (TMA), the US arrival sequencing and time based metering tool, is implemented in all 20 Air Route Traffic Control Centres (ARTCCs) and N90, the New York Terminal Radar Approach Control (TRACON).

2 Element 1: Time Based Metering

Time based metering is the practice of separation by time rather than distance. Typically, the relevant ATC authorities will assign a time in which a flight must arrive at the aerodrome. This is known as the Control Time of Arrival (CTAs). CTAs are determined based on aerodrome capacity, terminal airspace capacity, aircraft capability, wind and other meteorological factors. Time based metering is the primary mechanism in which arrival sequencing is achieved.

2.1 Intended Performance Operational Improvement/Metric to Determine Success

The following metrics can be used by ANSPs to evaluate the operational improvements as a result of the implementation of Block 0 element 1.

1. Efficiency
    a. Harmonized arriving traffic flow from en-route to Terminal and aerodrome
        i. Runway Throughput
        ii. Arrival rates
2. Capacity
    a. Optimized usage of terminal airspace and runway capacity
        i. Achieved arrival rate
3. Predictability
    a. Decreased uncertainties in aerodrome/terminal demand prediction
        i. Variance between predicted and actual schedule.
4. Flexibility
    a. Arrival and departure sequencing enables dynamic scheduling

2.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing arrival capability consistent with the vision of a performance-oriented ATM System. The US TBFM and EUROCOTROL AMAN/DMAN efforts provide the systems and operational procedures necessary. In particular, procedures for the extension of metering into en-route airspace will be necessary. RNAV/RNP for arrival will also be crucial as well.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

2.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. TBFM, Integrated Arrival and Departure Management represent a major stride toward that vision. The key technological aspects include automation support for the synchronization of arrival sequencing, departure sequencing, and surface information; improve predictability of arrival flow, further hone sector capacity estimates, and management by trajectory. Less congested locations might not required extensive automation support to implement.

Both TBFM and Arrival/Departure Management (AMAN/DMAN) application and existing technologies can be leveraged, but require site adaptation and maintenance. Both efforts will take incremental steps toward the long term capability described in their respective strategic documents.

2.4 Regulatory/Standardisation Needs and Approval Plan (Air & Ground)

This TBFM and AMAN/DMAN implementation will impact ICAO Annex 1, the PANS-ATM document (ICAO Doc 4444), Global Air Navigational Plan (ICAO 9750) and the Global ATM Operational Concepts (ICAO Doc 9584).

2.5 Business Case Specific to the Element

A detailed business case has been built for the Time Based Flow Management program in the US. The business case has proven that the benefit/cost ratio to be positive. Implementation of time based metering can reduced airborne delay. This capability was estimated to provide over 320,000 minutes in delay reduction and $28.37 million in benefits to airspace users and passengers over the evaluation period (source - Exhibit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22).

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Traffic Management Advisor is currently used in the US as the primary time based metering automation. NextGen efforts will field Time Based Flow Management, the augmentation to the Traffic Management Advisor, incrementally. EUROVONTROL will expand the deployment of Arrival and Departure Manager (AMAN/DMAN).

3 Element 2: Departure Management

Departure management, like its arrival counterpart, serves to optimize departure operation to ensure the most efficient utilization of aerodrome and terminal resources. Slots assignment and adjustments will be supported by departure management automations like DMAN or DFM. Dynamic slot allocation will foster smoother integration into overhead streams and help the airspace users better meet metering points and comply with other ATM decisions. Departure management sequences the aircraft, based on the airspace state, wake turbulence, aircraft capability, and user preference, to fit into the overhead en-route streams without disrupting the flow of traffic. This will serve to increase aerodrome throughput and airspace efficiency through compliance with allotted departure time.

3.1 Intended Performance Operational Improvement/Metric to Determine Success

The following metrics can be used by ANSPs to evaluate the operational improvements as a result of the implementation of Block 0.

1. Efficiency
   a. Streamline departure traffic flow and decreased lead time for departure request
      i. Runway Throughput
      ii. Departure rates
      iii. Holding time
2. Capacity
   a. Optimized usage of terminal airspace and runway capacity
      i. Achieved arrival rate
      ii. Sector Throughput
3. Predictability
   a. Decreased uncertainties in aerodrome/terminal demand prediction
      i. Variance between predicted and actual schedule.
4. Flexibility
   a. Arrival and departure sequencing enables dynamic scheduling

3.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing arrival capability consistent with the vision of a performance-oriented ATM System. The US TBFM and EUROCONTROL AMAN/DMAN efforts provide the systems and operational procedures necessary. In particular, procedures for the extension of metering into en-route airspace will be necessary. RNAV/RNP for arrival will also be crucial as well.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM 1System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

3.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. TBFM, Integrated Arrival and Departure Management represent a major stride toward that vision. The key aspects include support for the synchronization of arrival sequencing, departure sequencing, and surface information, improve predictability of arrival flow, further hone sector capacity estimates, and management by trajectory.

Both TBFM and Arrival/Departure Management (AMAN/DMAN) application and existing technologies can be leveraged, but require site adaptation and maintenance. Both efforts will take incremental steps toward the long term capability described in their respective strategic documents.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This TBFM and AMAN/DMAN implementation will impact ICAO Annex 1, the PANS-ATM document (ICAO Doc 4444), Global Air Navigational Plan (ICAO 9750) and the Global ATM Operational Concepts (ICAO Doc 9584).

3.5 Business Case specific to the element

Results from field trials of Departure Flow Management, a departure scheduling tool in the US, have been positive. Compliance rate, a metric use to gauge the conformance to assigned departure time, has increased at field trial sites from 68% to 75%. Likewise, the EUROCONTROL's DMAN has demonstrated positive results. Departure scheduling will streamline flow of aircraft feeding the adjacent center airspace based on that center's constraints. This capability will facilitate more accurate ETAs. This allows for the continuation of metering during heavy traffic, enhanced efficiency in the NAS and fuel efficiencies. This capability is also crucial for extended metering.

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

Departure Flow Management has just undergone an extensive field trial in the US. DMAN is deployed at major European hubs such as Charles de Gaulle.

3.6.2 Planned or Ongoing Trials

DFM will be integrated with extended metering and become part of TBFM in the US. DMAN deployment is expected to cover most major aerodromes in Europe.

4 Main dependencies

Successful implementation of all elements in Block 0 of this module will be hinged largely on the dissemination and adoption of time based metering and departure sequencing automations and operational procedures.

Module N° B0-25: Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration

Summary	Supports the coordination of ground-ground data communication between ATSU based on ATS Interfacility Data Communication (AIDC) supports the coordination between ATSU based on ICAO Doc 9694 . It supports also the transfer of communication in data-link environment in particular for Oceanic ATSU. It is a first step in the ground-ground integration	
Main Performance Impact	KPA-02 – Capacity; KPA-04 – Efficiency; KPA-07 – Global Interoperability; KPA-10 - Safety	
Domain / Flight Phases	All flight phases and all type of ATS units	
Applicability Considerations	Applicable to at least 2 ACCs dealing with en-route and/or TMA airspace. A greater number of consecutive participating ACCs will increase the benefits.	
Global Concept Component(s)	CM - Conflict management IM - Information Management	
Global Plan Initiatives (GPI)	GPI-16 Decision Support Systems	
Reference Documents	• Doc 4444 Appendix 6 - ATS INTERFACILITY DATA COMMUNICATIONS (AIDC) MESSAGES • Doc ATN (Doc 9880). Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols Part II — Ground-Ground Applications — Air Traffic Services Message Handling Services (ATSMHS) • Doc *Manual of Air Traffic Services Data Link Applications* (Doc 9694).part 6 • GOLD *Global Operational Data Link Document (APANPIRG, NAT SPG) June 2010* • *Pan Regional Interface Control Document for Oceanic ATS Interfacility Data Communications (PAN ICD) Coordination Draft Version 0.3 — 31 August 2010* • EUROCONTROL documentation o EUROCONTROL Standard for On-Line Data Interchange (OLDI) o EUROCONTROL Standard for ATS Data Exchange Presentation (ADEXP)	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	No Requirement
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

Flights which are being provided with an ATC service are transferred from one ATC unit to the next in a manner designed to ensure complete safety. In order to accomplish this objective, it is a standard procedure that the passage of each flight across the boundary of the areas of responsibility of the two units is co-ordinated between them beforehand and that the control of the flight is transferred when it is at, or adjacent to, the said boundary.

Where it is carried out by telephone, the passing of data on individual flights as part of the co-ordination process is a major support task at ATC units, particularly at Area Control Centres (ACCs). The operational use of connections between Flight Data Processing Systems (FDPSs) at ACCs replacing phone coordination (On-Line Data Interchange (OLDI)), is already proven in Europe.

This is now fully integrated into the “ATS Interfacility Data Communications” (AIDC) messages in the PANS-ATM, which describes the types of messages and their contents to be used for operational communications between ATS unit computer systems. This type of data transfer (AIDC) will be the basis for migration of data communications to the aeronautical telecommunication network (ATN).

The AIDC module is aimed at improving the flow of traffic by allowing neighbouring air traffic control units to exchange flight data automatically in the form of coordination and transfer messages.

With the greater accuracy of messages based on the updated trajectory information contained in the system and where possible updated by surveillance data, controllers have more reliable information on the conditions at which aircraft will enter in their airspace of jurisdiction with a reduction of the workload associated to flight coordination and transfer. The increased accuracy and data integrity permits the safe application of reduced radar/surveillance based separations.

Combined with data-link application it allows the coordination and transfer of control.

These improvements translate directly into a combination of performance improvements.

Information exchanges between flight data processing systems are established between air traffic control units for the purposes of notification, coordination and transfer of flights and for the purposes of civil-military coordination. These information exchanges rely upon appropriate and harmonised communication protocols to secure their interoperability. They apply to:

(a) communication systems supporting the coordination procedures between air traffic control units using a peer-to-peer communication mechanism and providing services to general air traffic;

(b) communication systems supporting the coordination procedures between air traffic services units and controlling military units, using a peer-to-peer communication mechanism.

1.1.1 Baseline

The baseline for this module is classical coordination by phone and procedural and/or radar distance separations.

Prerequisites being part of the general baseline: an ATC system with flight data plan processing functionality, and a surveillance data processing system connected to the above.

1.1.2 Change brought by the module

The module makes available a set of messages to describe consistent transfer conditions via electronic means across centre boundaries.

1.1.3 Other remarks

This module is a first step towards the more sophisticated 4 D trajectory exchanges between both ground/ground and air/ground according to the ICAO Global ATM Operational Concept.

1.2 Elements

The element consists of Implementation of the set of AIDC messages in the flight data plan processing system (FDPS) of the different ATS units and establishment of LoA to determine the appropriate parameters.

2 Intended Performance Operational Improvement/Metric to determine success

Access and Equity	---
Capacity	Reduced controller workload and increased data integrity supporting reduced separations translating directly to cross sector or boundary capacity flow increases. Metric: Throughput between two ACCs
Cost Effectiveness	
Efficiency	The reduced separation can also be used to offer more frequently to aircraft flight levels closer to the flight optimum; in certain cases, this also translates in reduced en-route holding. Metric: fuel consumption and flight time
Environment	---
Flexibility	---
Global Interoperability	Seamlessness: the use of standardised interfaces reduces the cost of development, allows controller to apply the same procedures at the boundaries of all participating centres and border crossing becomes more transparent to flights. Metric: number AIDC implementation between ACCs
Participation by the ATM community	---
Predictability	---
Safety	Better knowledge of more accurate flight plan information Metric: number of incidents at cross-border
Security	---

CBA	Increase of throughput at ATC unit boundary, reduced ATCo Workload will exceed FDPS software changes cost
Human performance	Appropriate HMI for ATCos Training for best use of the automation support

3 Necessary Procedures (Air & Ground)

Required procedures exist. They need local instantiation on the specific flows; the experience from other regions can be a useful reference.

Means of compliance: EUROCONTROL On Line Data Interchange (OLDI)

4 Necessary Technology (Air & Ground)

Technology is available. It is implemented in Flight Data Processing and could use the ground network standard AFTN-AMHS or ATN. Europe is presently implementing IP Wide Area Networks

There are no specific airborne requirements

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

ICAO material is available (PANS-ATM, ATN).

Regions should consider the possible mandating of AIDC. Means of compliance are also described in EUROCONTROL standards and EU regulations (Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation).)

6 Implementation and Demonstration Activities

6.1 Current Use

Although already implemented in several areas, but there is a need to complete the existing standards to avoid system specific and bilateral protocol.

For oceanic data-link application, NAT and APIRG (cf ISPACG PT/8- WP.02 - GOLD) have defined some common coordination procedures and messages between oceanic centres for data-link application (ADS-C CPDLC).

Implementations in other regions exists.

In Europe it is mandatory for exchange between ATS units.
http://europa.eu/legislation_summaries/transport/air_transport/l24070_en.htm

EUROCONTROL Specification of Interoperability and Performance Requirements for the Flight Message Transfer Protocol (FMTP)

The available set of messages to describe and negotiate consistent transfer conditions via electronic means across centre boundaries have been used for trials in Europe in 2010 in the scope of EUROCONTROL FASTI initiative.

To be completed when the complete picture is defined.

6.2 Planned or Ongoing Trials

Text to be included in next revision.

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Module N° B0-30: Service Improvement through Digital Aeronautical Information Management

Summary	Initial introduction of digital processing and management of information, by the implementation of AIS/AIM making use of AIXM, moving to electronic AIP and better quality and availability of data	
Main Performance Impact	KPA-03 - Cost-Effectiveness; KPA-05 – Environment; KPA-09 – Safety	
Domain / Flight Phases	All phases of flight	
Applicability Considerations	Applicable at State level, with increased benefits as more States participate	
Global Concept Component(s)	IM – Information Management	
Global Plan Initiatives (GPI)	GPI-18 Electronic information services	
Reference Documents	Aeronautical Information Services Manual (Doc 8126) incl AIXM and eAIP as per Edition 3 Aeronautical Chart Manual (Doc 8697) Manuals on AIM quality system and AIM training	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

The subject has been discussed at the 11th ANC which made the following recommendation:

Recommendation 1/8 — Global aeronautical information management and data exchange model

That ICAO:

a) when developing ATM requirements, define corresponding requirements for safe and efficient global aeronautical information management that would support a digital, real-time, accredited and secure aeronautical information environment;

b) urgently adopt a common aeronautical information exchange model, taking into account operational systems or concepts of data interchange, including specifically, AICM/AIXM, and their mutual interoperability; and

c) develop, as a matter of urgency, new specifications for Annexes 4 and 15 that would govern provision, electronic storage, on-line access to and maintenance of aeronautical information and charts.

The long term objective is the establishment of a network-centric information environment, also known as System Wide Information Management (SWIM).

In the short to medium term, the focus is on the definition and harmonised transition from the present Aeronautical Information Services (AIS) to Aeronautical Information Management (AIM). AIM envisages a migration from a focus on products to a data centric environment where aeronautical data will be provided in a digital form and in a managed way. This transition includes both static (AIP) and dynamic (NOTAM) data. This can be regarded as the first stage of SWIM, which is based on common data models and data exchange formats. The next (long term) SWIM level implies the re-thinking of the data services from a “network” perspective, which in the first level remains a centralised State service.

The aeronautical information services must transition to a broader concept of aeronautical information management, with a different method of information provision and management given its data-centric nature as opposed to the product-centric nature of AIS.

The expectations are that the transition to AIM will not involve many changes in terms of the scope of information to be distributed. The major change will be the increased emphasis on data distribution, which should place the future AIM in a position to better serve airspace users and ATM in terms of their information management requirements.

This is the first step towards SWIM. This first step is easier to make because it concerns static or low dynamic information which is being used by other functions but do not use other information, and it generates substantial benefits even for smaller States. It will allow to gain experience before moving to the further steps of SWIM.

1.1.1 Baseline

The baseline is the traditional Aeronautical Information service and processes, based on paper publications and NOTAMs.

AIS information published by the ICAO Member States has traditionally been based on paper documents and text messages (NOTAM) and maintained and distributed as such. In spite of manual verifications, this did not always prevent errors or inconsistencies. In addition, the information had to be recaptured from paper to ground and airborne systems, thus introducing additional risks. Finally, the timeliness and quality of more dynamic information could not always be guaranteed.

1.1.2 Change brought by the module

The module makes AIS move into AIM, with standardised formats based on widely used information technology standards (UML, XML/GML), supported by industrial products and stored on electronics devices. Information quality is increased, as well as that of the management of aeronautical information in general. The AIP moves from paper to electronic support.

2 Intended Performance Operational Improvement/Metric to determine success

Cost Effectiveness	reduced costs in terms of data inputs and checks, paper and post, especially when considering the overall data chain, from originators, through AIS, to the end users Metric: reduced overall cost at equivalent quality of service
Environment	reduced use of paper; also, more dynamic information should allow shorter flight trajectories, based on more accurate information about the current status of the airspace structure Metric: gains in paper volumes and dispatch
Global Interoperability	Essential contribution to interoperability
Safety	Reduction in the number of possible inconsistencies, as the module will allow to reduce the number of manual entries and ensure consistency among data through automatic data checking based on commonly agreed business rules Metric: incident occurrences

CBA	The business case for AIXM has been conducted in Europe and in the United States and has shown to be positive. The initial investment necessary for the provision of digital AIS data may be reduced through regional cooperation and it remains low compared with the cost of other ATM systems. The transition from paper products to digital data is a critical pre-requisite for the implementation of any current or future ATM or air navigation concept that relies on the accuracy, integrity and timeliness of the data.
Human Performance	

3 Necessary Procedures (Air & Ground)

No new procedures for ATC, but a revisited process for AIS. Full benefit requires new procedures for data users in order to retrieve the information digitally. E.g. for Airlines in order to enable the dynamic provision of the digital AIS data in the on-board devices, in particular Electronic Flight Bags.

4 Necessary Technology (Air & Ground)

The AIS data are made available to the AIS service through IT and to external users via either a subscription for an electronic access or physical delivery; the electronic access can be based on internet protocol services. The physical support does not need to be standardised.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

No additional need.

6 Implementation and Demonstration Activities

6.1 Current Use

- **Europe**: the European AIS Database (EAD) became operational in June 2003. Electronic AIP (eAIP), fully digital versions of the paper document and based on a EUROCONTROL eAIP specification have been implemented (on-line or on a CD) in a number of States (e.g. Armenia, Belgium & Luxemburg, Hungary, Latvia, Moldova, Netherlands, Portugal, Slovak Republic, Slovenia, etc.). Both are essential milestones in the realization of the digital environment. The EAD had been developed using the Aeronautical Information Conceptual Model (AICM) and Aeronautical Information Exchange Model (AIXM).
- **United States**: TBC

- Other regions: Azerbaijan, Japan, Taiwan have implemented the eAIP. Mongolia: TBC

AIXM based system recently ordered several countries around the world, including Australia, Canada, South Africa, Brazil, India, Fiji, etc.

6.2 Planned or Ongoing Trials

The current trials in Europe and USA focus on the introduction of Digital NOTAM, which can be automatically generated and used by computer systems and do not require extensive manual processing, as compared with the text NOTAM of today. More information is available on the EUROCONTROL and FAA Web sites: http://www.EUROCONTROL.int/aim/public/standard_page/xnotam.html and http://notams.aim.faa.gov/fnsstart/.

Module N° B0-35: Improved Flow Performance through Planning Based on a Network-Wide View

<table>
<tr><td>Summary</td><td colspan="2">This module implements ATFM services to meet the objectives of balancing demand and capacity, keeping delays to a minimum and avoiding congestion, bottlenecks and overload in a given airspace. CDM applications are introduced in ATFM measures, either as CDM processes in strategic phase or CDM applications such as departure planning information (DPI) which is currently deployed as a result of airport CDM applications.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-01 - Access & Equity; KPA-02 – Capacity; KPA-04 – Efficiency;
KPA-05 – Environment; KPA-09 - Predictability</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">Pre-flight, some action during actual flight.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Region or sub-region</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">DCB – Demand-Capacity Balancing
TS – Traffic Synchronisation
AOM – Airspace Organisation and Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-1 Flexible use of airspace
GPI-6 Air traffic flow management
GPI-8 Collaborative airspace design and management</td></tr>
<tr><td>Reference Documents</td><td colspan="2">ICAO Global Collaborative Decision-Making (CDM) Guidelines (under development)</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">NIL</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>2013</td></tr>
<tr><td>Avionics Availability</td><td>√</td></tr>
<tr><td>Infrastructure Availability</td><td>√</td></tr>
<tr><td>Ground Automation Availability</td><td>2013</td></tr>
<tr><td>Procedures Available</td><td>2013</td></tr>
<tr><td>Operations Approvals</td><td>2013</td></tr>
</table>

1 Narrative

1.1 General

The techniques and procedures brought by this module capture the experience and functionality provided by current ATFM systems which have developed as some States/regions were facing demand-capacity imbalances. Global ATFM seminars and bi-lateral contacts have fostered dissemination of many good practices.

Experience clearly shows the benefits related to managing flows consistently and collaboratively over an area of a sufficient geographical size to obtain network effects. States not yet doing so should consider the benefits to be obtained from a regional approach to ATFM.

System improvements are also about better procedures in these domains, and creating instruments to allow collaboration among the different actors.

Overall, to meet the objectives of balancing demand and capacity, keeping delays to a minimum and avoiding congestion, bottlenecks and overload, ATFM undertakes flow management in three broad phases. Each flight will usually have been subjected to these phases, prior to being handled operationally by ATC.

Strategic ATFM activity takes place during the period from several months until a few days before a flight. During this phase, comparison is made between the expected air traffic demand and the potential ATC capacity. Objectives are set for each ATC unit in order for them to provide the required capacity. These objectives are reviewed monthly in order to minimize the impact on airspace users. In parallel, an assessment of the number and routings of flights which aircraft operators are planning, enables ATFM units to prepare a routing scheme, balancing the air traffic flows in order to ensure maximum use of the airspace and minimize delays.

Pre-tactical ATFM is action taken during the few days before the day of operation. Based on the traffic forecasts, the information received from every ACC covered by the ATFM service, statistical and historical data, the ATFM Notification Message (ANM) for the next day is prepared and agreed through a collaborative process. The ANM defines the tactical plan for the next (operational) day and informs aircraft operators (AOs) and ATC units about the ATFM measures that will be in force on the following day. The purpose of these measures is not to restrict but to manage the flow of traffic in a way that minimises delay and maximises the use of the entire airspace.

Tactical ATFM is the work carried out on the current operational day. Flights taking place on that day receive the benefit of ATFM, which includes the allocation of individual aircraft departure times, re-routings to avoid bottlenecks and alternative flight profiles to maximize efficiency.

ATFM has also progressively been used to address system disruptions and evolves into the notion of management of the performance of the network under its jurisdiction, including management of crises provoked by human or natural phenomena.

1.1.1 Baseline

It is difficult to describe an exact baseline. The need for ATFM has emerged as traffic densities increased, and it took form progressively. It is observed that this need is now spreading progressively over all continents, and that even where overall capacity is not an issue, the efficient management of flows through a given volume of airspace deserves a specific consideration at a scale beyond that of a sector or an ACC, in order to better plan resources, anticipate issues and prevent undesired situations.

1.1.2 Change brought by the module

ATFM has developed progressively over the last 30 years. It is noticeable from the European experience that key steps have been to be able to predict traffic loads for the next day with a good accuracy, to move from measures defined as rate of entry into a given piece of airspace (and not as departure slots) to measures implemented before take-off and taking into account the flows/capacities in a wider area. More recently the importance of proposing alternative routings rather than only a delay diagnosis has been recognized, thereby also preventing over-reservations of capacity. ATFM services offer a range of web-based or B2B services to ATC, airports and aircraft operators, actually implementing a number of CDM applications.

In order to regulate flows, ATFM may take measures of the following nature:

- Departure slots ensuring that a flight will be able to transit the sectors along its path without generating overflows;
- Rate of entry into a given piece of airspace for traffic along a certain axis;
- Requested time at a waypoint or an FIR/sector boundary along the flight;
- Miles-in-trail figures to smooth flows along a certain traffic axis; and/or
- Rerouting of traffic to avoid saturated areas.

These measures are not mutually exclusive. The first one has been the way to resolve the problem of multiple interacting flow regulation measures addressed independently by several ATFM units in Europe before the creation of the CFMU and proved to be more efficient than the second one which pre-existed CFMU.

2 Intended Performance Operational Improvement/Metric to determine success

Access and Equity	Improved access by avoiding disruption of air traffic in periods of demand higher than capacity; ATFM processes address equitable distribution of delays Metric: distribution of delays on airspace user classes or flows
Capacity	Better utilization of available capacity, network-wide; maintaining controller workload within acceptable limits; ability to anticipate difficult situations and mitigate them in advance Metric: amounts of delay and their causes; sector capacity increases
Efficiency	Reduced fuel burn due to better anticipation of flow issues; a positive effect to reduce the impact of inefficiencies in the ATM system or to dimension it at a size that would not always justify its costs (balance between cost of delays and cost of unused capacity); Reduced block times and times with engines on Metric: reduced fuel burn; reduced block times and engine-on times
Environment	Reduced fuel burn as delays are absorbed on the ground, with engines off; reducing the need for longer reroutes unless these provide other operational benefit to the user Metric: reduced fuel burn and emissions (incl. noise at airports)
Participation by the ATM community	Common understanding of operational constraints, capabilities and needs
Predictability	Increased predictability of schedules as the ATFM algorithms tend to limit the number of large delays Metric: reduced block time variability; reduced airline buffer built in schedules
Safety	Reduced occurrences of undesired sector overloads Metric: incident occurrences

CBA	The business case has proven to be positive due to the benefits that flights can obtain in terms of delay reduction.
Human Performance	Controllers are protected from overloads and have a better prediction of their workload.

3 Necessary Procedures (Air & Ground)

Need to expedite the ICAO ATFM guidance manual, but US/Europe experience is enough to initiate application in other regions.

New procedures are required to link ATFM with ATS much closer when using miles-in-trail.

4 Necessary Technology (Air & Ground)

No specific technology apart from current IT. Some vendors propose scalable ATFM systems.

5 Regulatory/standardization needs and Approval Plan (Air & Ground)

Establishing standard ATFM messages in order to ensure common understanding & behaviour for operators flying in several regions and to ensure exchange of ATFM data across regions would be an advantage.

6 Implementation and Demonstration Activities

6.1 Current Use

- **Europe**: Detailed Example – Network Operations Plan (CFMU)

Originated on a regional concept approach to oversee European ATM in a network perspective, where it will be fundamental to maintain an overview of the ATM resources availability required to manage the traffic demand, to support the ATM partners on collaborative decision making. It will provide visibility of the Network demand and capacity situation, the agreements reached, detailed aircraft trajectory information, resource planning information as well as access to simulation tools for scenario modelling, to assist in managing diverse events that may threaten the network in order to restore stability of operations as quickly as possible.

The Network Operations Plan (NOP) is continually accessible to ATM partners and evolves during the planning and execution phases through iterative and collaborative processes enabling the achievement of an agreed Network, stable demand and capacity situation.

The NOP is still under evolution and currently works using web media (portal technology) to present ATM information within European area, increasing a mutual knowledge of the air traffic flow situation in the aviation community from the Strategic phase to the real-time operations contributing to anticipate or react to any events.

The NOP portal was launched in February 2009 and as it exists today is a recognised major step on simplifying the ATM partners access to ATM information. It evolved from a situation where collection of information was disseminated around via multiple web sites and using several applications, towards a fully integrated access, with a single entry point to the European ATM information, contributing for improving decision making at all levels.

The NOP portal through one application provides one single view for all partners of several relevant ATM information like: - a map displaying the air traffic flow information, including the status of the congested areas in Europe and a corresponding forecast for the next three hours; - scenarios and events enriched with context and cross-reference information; - the collaborative process for building the season operations plan is now formalised; - the summary information of the preceding day is now immediately available with access to archive reports.

ATM partners, while waiting for further NOP portal developments are already using it to monitor the ATFM situation, to follow the ATFM situation in unexpected critical circumstances, get online user support, validate flights before filing, to view regulations and airspace restrictions, to evaluate most efficient routes, to accede to pre-tactical forecasts (daily plan, scenarios, etc), plan events, post event analysis, forecast next season, view network forecast and agree adaptations, evaluate performance at network level and for each particular unit, conferencing for collaborative decision making.

- **United States**: Detailed Example – National Playbook (ATCSCC)

Originating from a collaborative workgroup recommendation to enhance common situational awareness, the Air Traffic Control System Command Centre's (ATCSCC) National Playbook is comprised of pre-validated routes for a variety of weather scenarios. It provides common, collaboratively developed options (routes) for stakeholders to standardize reroutes around severe weather conditions. Each option, identified by a specific name is comprised of multiple individual routes addressing different geographical areas. Each named "Play" in the playbook varies in length, complexity and options within it based on the weather scenario it is designed to address. Development, revision, and use of each "play" results from collaboration across the operators and ANSP elements (individual facilities impacted). The routes are available on a designated web site and are updated every 56 days, concurrent with the chart cycle.

The National Playbook is a traffic management tool developed to give all stakeholders a common product for various system wide route scenarios. The purpose is to aid in expediting route coordination during periods of reduced capacity in the ATM System that occur en route or at the destination airport. The playbook contains the most common scenarios that occur each severe weather season. The "play" includes the resource or flow impacted, facilities included, and specific routes for each facility involved. Each scenario in the playbook includes a graphical presentation and has been validated by the individual facilities involved in that scenario. As part of the development of the Playbook each facility develops local procedures in response to the changes each playbook option imposes. For example; weather in an area results in the rerouting of aircraft to a different region of the airspace than usual. ANSP facilities responsible for this area, to which the aircraft have been routed, now need to deal with the "usual" traffic load as well as the addition of the "playbook aircraft". These "local procedures" are critical to the execution of the network management plan and are part of the collaboration between the ANSP and system stakeholders. [Currently, there is an ongoing effort to incorporate the benefits of utilizing the Flight Management System (FMS) waypoints in lieu of land-based navigation fixes in the playbook routes. This will allow increased route options and more flexibility when routing around convective weather.]

A typical example of National Playbook collaboration is during the convective weather season. Early in the day system stakeholders and ANSP facilities become cognizant of severe weather convection that builds across a portion of the system and will impact routes across the country. Various sources of weather information are used in determining which regions of the airspace system will require routing changes to significant flows of aircraft. Based on the anticipated impacts the ANSP (including the overall network management function as well as individual facilities impacted) and airspace users agree on the specific "play" or option to execute. [Note: A separate CDM process describes how various sources of weather information are combined to create a shared view of the expected operational (weather) picture across ATM System stakeholders.]

As the day progresses and the weather conditions either move and/or intensify, playbook routes can be adjusted through a collaborative teleconference and then amended either verbally and/or electronically through TFM tools/technologies.

Playbook options proven to be quite beneficial include those addressing constraints and routes that traverse airspace in a neighbouring ANSP – especially for trans-continental aircraft. The CDM processes used for the cross-ANSP options are essentially the same but include the expanded roster of stakeholders for the affected ANSP(s). Additionally, recently introduced playbook routes that transition through military airspace have been effective in minimizing redundant coordination, increasing standardization, and supporting flexibility for stakeholders to model and plan their operations.

- **Others**:TBC

6.2 Planned or Ongoing Trials

- **Europe:** The following improvement items are being validated or implemented in Europe for 2013 or earlier:

- Enhanced Flight Plan Filing Facilitation
- Use of Free Routing for flight in special Airspace volumes
- Shared Flight Intentions
- Use of Aircraft Derived Data to enhance ATM ground system performance
- Automated Support for Traffic Load Management
- Automated Support for Traffic Complexity Assessment
- Network Performance Assessment
- Moving Airspace Management into day of operation
- Enhanced Real-time Civil-Military Coordination of Airspace Utilisation
- Flexible Sectorisation management
- Modular Sectorisation adapted to Variations in traffic flow
- Enhanced ASM/ATFCM coordination Process
- Short Term ATFCM Measures
- Interactive Network Capacity Planning
- SWIM enabled NOP
- Management of Critical Events
- Collaborative Management of Flight updates
- ATFM Slot Swapping
- Manual User Driven Prioritisation Process

Module N° B0-100: Air Traffic Situational Awareness (ATSA)

<table>
<tr><td>Summary</td><td colspan="2">This module comprises two ATSA (Air Traffic Situational Awareness) applications:
• AIRB (Enhanced Traffic Situational Awareness during Flight Operations)
• VSA (Enhanced Visual Separation on Approach).
These applications will enhance safety and efficiency by providing pilots with the means to achieve quicker visual acquisition of targets.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-04 – Efficiency; KPA-09 – Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">En-route, Terminal and Approach.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">These are cockpit based applications which do not require any support from the ground hence they can be used by any suitably equipped aircraft.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">CM – Conflict Management; TS – Traffic Synchronisation</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-9 Situational Awareness; GPI-15 Match IMC and VMC operating capacity.</td></tr>
<tr><td>Reference Documents</td><td colspan="2">EUROCONTROL Documents – Flight Crew Guidance on Enhanced Traffic Situational Awareness during Flight Operations; Flight Crew Guidance on Enhanced Visual Separation on Approach;

RTCA Document DO-319/EUROCAE Document ED-164, Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness During Flight Operations (ATSA-AIRB)

RTCA Document DO-314/EUROCAE Document ED-160, Safety, Performance and Interoperability Requirements Document for Enhanced Visual Separation on Approach (ATSA-VSA)</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">NIL</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>√</td></tr>
<tr><td>Avionics Availability</td><td>√</td></tr>
<tr><td>Infrastructure Availability</td><td>√</td></tr>
<tr><td>Ground Automation Availability</td><td>√</td></tr>
<tr><td>Procedures Available</td><td>2013</td></tr>
<tr><td>Operations Approvals</td><td>2013</td></tr>
</table>

1 Narrative

1.1 General

This introduction will deal with each of the applications in turn.

Enhanced Traffic Situational Awareness during Flight Operations (ATSA-AIRB), aims at improving flight safety and flight operations by assisting flight crews in building their traffic situational awareness through the provision of an appropriate on-board display of surrounding traffic during all airborne phases of flight. It is expected that flight crews will perform their current tasks more efficiently; both in terms of decision-making and the resulting actions, and thus flight safety and flight operations should be enhanced. The actual benefits will vary depending on the airspace and operational flight rules.

Approaches flown where flight crews maintain own separation from the preceding aircraft may increase landing capacity and/or increase the number of movements achievable at many airports compared to rates obtained when ATC separation is applied. Through the use of an airborne traffic display, the “Enhanced Visual Separation on Approach” application (ATSA-VSA) will enhance this type of operation by providing improved and reliable visual acquisition of preceding aircraft and by extending the use of own separation clearances on approach.

1.1.1 Baseline

As these applications are under development there is no existing baseline.

1.1.2 Improvement brought by the module

This module provides various efficiency benefits at all stages of flight. ATSA-AIRB applies to all phases of flight, ATSA-VSA applies to the approach phase of flight, Although each provides capacity and efficiency improvements, the mechanism for each is different.

ATSA-AIRB is the most basic Aircraft Surveillance (AS) application and is used as the foundation for all the other applications described in this document. The application uses a cockpit display to provide the flight crew with a graphical depiction of traffic using relative range and bearing, supplemented by altitude, flight ID and other information. It is used to assist the out-the-window visual acquisition of airborne traffic for enhancing flight crew situational awareness and air traffic safety.

Flight crews using the AIRB application will refer to the display during the instrument scan to supplement their visual scan. The display enables detection of traffic by the flight crew and aids in making positive identification of traffic advised by ATC. The information provided on the display also reduces the need for repeated air traffic advisories and is expected to increase operational efficiencies.

The objective of the ATSA-VSA application is to support the flight crew to acquire and maintain own separation from the preceding aircraft when performing a visual approach procedure. By making it easier and more reliable for flight crews to visually acquire the preceding aircraft and by supporting them in maintaining own separation from the preceding aircraft, this application will improve efficiency and regularity of arrival traffic at airports. In addition to the traffic information provided by the controller, the traffic display will support the flight crew in the visual search for the preceding aircraft whenever this one is equipped with ADS B OUT. Additionally, the traffic display will provide up to date information that will support the flight crews to visually maintain a safe and not unnecessarily large distance and to detect unexpected speed reductions of the preceding aircraft. In these situations, the flight crew will be able to manoeuvre by adjusting own speed more precisely whilst maintaining the preceding aircraft in sight. The objective is not to reduce the distance between the two aircraft in comparison with current operations when own separation is applied but it is to avoid that this distance becomes too low due to a late detection of unexpected closing situation. The use of the traffic display is expected to support improved and reliable visual acquisition of preceding aircraft, and extend the use of own separation clearances on approach.

Voice communications associated with traffic information are expected to be reduced. Safety of operations improvement is expected as it is anticipated that this procedure will decrease the likelihood of wake turbulence encounters. Some efficiency benefits are also expected to be derived when the preceding and succeeding aircraft are approaching the same runway because of a reduction in the number of missed approaches.

1.1.3 Other remarks
NIL

1.2 Element 1: ATSA-AIRB
ATSA-AIRB application can be used in all types of aircraft fitted with certified equipment. (ADS-B IN and a traffic display). The details are provided below.

ATSA-AIRB application can be used in all types of airspaces, from class A to class G. The use of this application is independent of the type of ATC surveillance (if any) and of the type of air traffic services provided in the airspace in which the flight is conducted.

1.3 Element 2: ATSA-VSA
The application is mainly intended for air transport aircraft arriving into capacity limited airport but it can be used by all suitably equipped aircraft during approach to any airports where own separation is used.

2 Intended Performance Operational Improvement/Metric to determine success
For KPA-04 Efficiency, the improvement/metric will be reduced fuel burn. For KPA-09 Safety, the improvement/metric will be fewer breakdowns of separation.

3 Necessary Procedures (Air & Ground)
Flight Crew Guidance already exists however it has to be determined whether specific procedures will be needed.

4 Necessary Technology (Air & Ground)
The necessary aircraft technology for AIRB and VSA is an ADS-B in capability and a suitable CDTI. No technology is required on the ground.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)
TBD.

6 Business Case specific to the module
TBC

7 Implementation and Demonstration Activities

7.1 Current Use
TBC

7.2 Planned or Ongoing Trials
TBC

8 Main dependencies
NIL

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Module N° B0-05: Improved Flexibility and Efficiency in Descent Profiles (CDOs)

Summary	Flight operations in many terminal areas precipitate the majority of current airspace delays in many states. Opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb and descent profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term. The core capabilities that should be leveraged are RNAV; RNP where needed; continuous descent operations (CDO); where possible, increased efficiencies in terminal separation rules in airspace; effective airspace design and classification; and ATC, flow. Opportunities to reduce emissions and aircraft noise impacts should also be leveraged where possible.	
Main Performance Impact	KPA-03 – Cost-effectiveness; KPA-04 – Efficiency; KPA-09 - Predictability	
Domain / Flight Phases	Approach and Arrivals.	
Applicability Considerations	Regions, States or individual locations most in need of these improvements. For simplicity and implementation success, complexity can be divided into three tiers: 1. Least Complex – Regional/States/Locations with some foundational PBN operational experience that could capitalize on near term enhancements, which include integrating procedures and optimizing performance. 2. More Complex – Regional/States/Locations that may or may not possess PBN experience, but would benefit from introducing new or enhanced procedures. However, many of these locations may have environmental and operational challenges that will add to the complexities of procedure development and implementation. 3. Most Complex – Regional/States/Locations in this tier will be the most challenging and complex to introduce integrated and optimized PBN operations. Traffic volume and airspace constraints are added complexities that must be confronted. Operational changes to these areas can have a profound effect on the entire State, Region or location.	
Global Concept Component(s)	AUO, TS, AOM	
Global Plan Initiatives (GPI)	**GPI-1-** Flexible Use of Airspace; **GPI 5-** RNAV/RNP (Perf. Based Nav); **GPI-11-** RNP and RNAV SIDs and STARs; **GPI-8-** Collaborative Airspace Design and Management; **GPI-10**- Terminal Area Design and Management; **GPI-11**- RNP and RNAV Standard instrument Departures (SIDS)and Standard Terminal Arrivals (STARS); **GPI-12**- Functional integration of Ground systems with Airborne Systems; **GPI-16-** Decision Support Systems and Alerting Systems; **GPI-21-** Navigation Systems	
Reference Documents	Various ICAO and Industry Standards	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

This module integrates with other airspace and procedures (CDO, PBN and Airspace Management) to increase efficiency, safety, access and predictability.

As traffic demand increases, the challenges in terminal areas centre around volume, convective weather, reduced-visibility conditions, adjacent airports and special activity airspace in close proximity whose procedures utilize the same airspace, and policies that limit capacity, throughput, and efficiency.

Traffic flow and loading (across ingress and egress routes) are not always well-metered, balanced or predictable. Obstacle and airspace avoidance (in the form of separation standards and criteria), noise abatement procedures, as well as wake encounter risk mitigation, tend to result in operational inefficiencies (e.g., added time or distance flown, thus more fuel).

Inefficient routing can also cause under-use of available airfield and airspace capacity. Finally, challenges are presented to States by serving multiple customers (international and domestic with various capabilities): the intermingling of commercial, business, general aviation and many times military traffic destined to airports within a terminal area that interact and at times inhibit each other's operations.

1.1.1 Baseline

The baseline for this module may vary from one State, Region or location to the next. Noted is the fact that some aspects of the movement to PBN have already been the subject of local improvements in many areas; these areas and users are already realizing benefits.

The lack of an ICAO PBN operational approval guidance material is slowing down implementation and is perceived as one of the main roadblocks for harmonization.

There is still some work to be done to harmonize PBN nomenclature, especially in charts and States/Regional regulations (e.g. most of European regulations still mention B-RNAV and P-RNAV).

1.1.2 Improvement brought by the module

Flight operations in many terminal areas precipitate the majority of current airspace delays in many states. Opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb and descent profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term.

The core capabilities that should be leveraged are RNAV; RNP where needed; continuous descent operations (CDO); where possible, increased efficiencies in terminal separation rules in airspace; effective airspace design and classification; and ATC, flow. Opportunities to reduce emissions and aircraft noise impacts should also be leveraged where possible.

1.1.3 Other remarks

This module must be a first step towards harmonization and a more optimized organization and management of the airspace. Many States will require knowledgeable assistance to achieve implementation. Initial implementation of PBN, RNAV for example, takes advantage of existing ground technology and avionics and allows extended collaboration of ANSPs with partners: military, airspace users, neighbouring States. Taking small and required steps, and only performing what is needed or required allows States to rapidly exploit PBN.

2 Element 1: Continuous Descent Operations

Continuous Descent is one of several tools available to aircraft operators and ANSPs to benefit from existing aircraft capabilities and reduce noise, fuel burn and the emission of greenhouse gases. Over the years, different route models have been developed to facilitate CDO and several attempts have been made to strike a balance between the ideal of environmentally friendly procedures and the requirements of a specific airport or airspace.

Future developments in this field are expected to allow different means of realizing the performance potential of CDO without compromising the optimal Airport Arrival Rate (AAR).

CDO is enabled by airspace design, procedure design and facilitation by ATC, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix/final approach point (FAF/FAP). An optimum CDO starts from the top-of-descent (TOD) and uses descent profiles that reduce controller-pilot communications and segments of level flight.

Furthermore it provides for a reduction in noise, fuel burn and emissions, while increasing flight stability and the predictability of flight path to both controllers and pilots.

2.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

5. Efficiency / Environment
    a. cost savings and environmental benefits through reduced fuel burn
        i. level flight time
        ii. level distance time
        iii. fuel burn
    b. authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted
        i. number of operations
    c. reduction in the number of required radio transmissions
        i. number of radio transmissions
6. Safety
    a. more consistent flight paths and stabilized approach paths
        i. number of unstable approaches
        ii. number of inconsistent flight paths
    b. reduction in the incidence of controlled flight into terrain (CFIT)
        i. number of CFIT

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2.2 Necessary Procedures (Air & Ground)

The ICAO Continuous Descent Operations (CDO) Manual (ICAO Document 9931) provides guidance on the airspace design, instrument flight procedures, ATC facilitation and flight techniques necessary to enable continuous descent profiles.

It therefore provides background and implementation guidance for:

a) air navigation service providers;
b) aircraft operators;
c) airport operators; and
d) aviation regulators.

2.3 Necessary Technology (Air & Ground)

CDO is an aircraft operating technique aided by appropriate airspace and procedure design and appropriate ATC clearances enabling the execution of a flight profile optimized to the operating capability of the aircraft, with low engine thrust settings and, where possible, a low drag configuration, thereby reducing fuel burn and emissions during descent.

The optimum vertical profile takes the form of a continuously descending path, with a minimum of level flight segments only as needed to decelerate and configure the aircraft or to establish on a landing guidance system (e.g. ILS).

The optimum vertical path angle will vary depending on the type of aircraft, its actual weight, the wind, air temperature, atmospheric pressure, icing conditions and other dynamic considerations.

A CDO can be flown with or without the support of a computer-generated vertical flight path (i.e. the vertical navigation (VNAV) function of the flight management system (FMS)) and with or without a fixed lateral path. However, the maximum benefit for an individual flight is achieved by keeping the aircraft as high as possible until it reaches the optimum descent point. This is most readily determined by the onboard FMS.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Understanding the policy context is important for making the case for local CDO implementation and ensuring high levels of participation. CDO may be a strategic objective at international, State, or local level, and as such, may trigger a review of airspace structure.

For example, noise contour production may already assume a 3-degree continuous descent final approach. Thus, even if noise performance is improved in some areas around the airport, it may not affect existing noise contours. Similarly, CDO may not affect flight performance within the area of the most significant noise contours, i.e., those depicting noise levels upon which decision-making is based.

In addition to a safety assessment, a transparent assessment of the impact of CDO on other air traffic operations and the environment should be developed and made available to all interested parties.

2.5 Business Case specific to the element

The following savings are an example of potential savings as a result of CDO implementation. It is important to consider that CDO benefits are heavily dependent on each specific ATM environment.

Nevertheless, if implemented within the ICAO CDO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.

Example of savings after CDO implementation in Los Angeles TMA (KLAX)

- CDOs RIIVR2/SEAVU2/OLDEE1 & 4 ILS'
  - Implemented September 25, 2008, and in use full time at KLAX.
- About 300-400 aircraft per day fly RIIVR2/SEAVU2/OLDEE1 STARs representing approximately half of all jet arrivals into KLAX
  - 50% reduction in radio transmissions.
- Significant fuel savings – average 125 pounds per flight.
  - 300 flights/day * 125 pounds per flight * 365 days = 13.7 million pounds/year
  - More than 2 million gallons/year saved = more than 41 million pounds of CO_2 avoided.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Description of (examples of) where the module is already operational or being implemented and how it is used (e.g. which elements, length of experience, etc).

2.6.2 Planned or Ongoing Trials

Short description of the nature of the demonstrations, the programme/context/date where they are planned to take place or have been executed. Main results and references where available. Description related to the module or to some of its elements.

3 Element 2: Performance Based Navigation

Performance-based navigation (PBN) is a global set of area navigation standards, defined by ICAO, based on performance requirements for aircraft navigating on departure, arrival, approach or en-route.

These performance requirements are expressed as navigation specifications in terms of accuracy, integrity, continuity, availability and functionality required for a particular airspace or airport.

PBN will eliminate the regional differences of various Required Navigation Performance (RNP) and Area Navigation (RNAV) specifications that exist today. The PBN concept encompasses two types of navigation specifications:

- RNAV specification: navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, e.g. RNAV 5, RNAV 1.

- RNP specification: navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, e.g. RNP 4.

3.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of PBN, States can use, as appropriate, a combination of the following metrics:

1. Efficiency / Environment
    a. cost savings and environmental benefits through reduced fuel burn
        i. level flight time
        ii. level distance time
        iii. fuel burn
    b. authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted
        i. number of operations

2. Safety
    a. more consistent flight paths and stabilized approach paths
        i. number of unstable approaches
        ii. number of inconsistent flight paths
    b. reduction in the incidence of controlled flight into terrain (CFIT)
        i. number of CFIT

3.2 Necessary Procedures (Air & Ground)

The ICAO Performance-based Navigation Manual (ICAO Document 9613) provides general guidance on PBN implementation.

This manual identifies the relationship between RNAV and RNP applications and the advantages and limitations of choosing one or the other as the navigation requirement for an airspace concept.

It also aims at providing practical guidance to States, air navigation service providers and airspace users on how to implement RNAV and RNP applications, and how to ensure that the performance requirements are appropriate for the planned application.

3.3 Necessary Technology (Air & Ground)

Within an airspace concept, PBN requirements will be affected by the communication, surveillance and ATM environments, the navaid infrastructure, and the functional and operational capabilities needed to meet the ATM application.

PBN performance requirements also depend on what reversionary, non-RNAV means of navigation are available and what degree of redundancy is required to ensure adequate continuity of functions. Evaluate PBN implementation requirements in the ATC Automated Systems (e.g. flight plan requirements in Amendment 1, PANS/ATM v15 (ICAO Doc 4444).

The decision to plan for RNAV or RNP has to be decided on a case by case basis in consultation with the airspace user. Some areas need only a simple RNAV to maximize the benefits, while other areas such as nearby steep terrain or dense air traffic may require the most stringent RNP.

Since RNP AR Approaches require significant investment and training, ANSPs should work closely with airlines to determine where RNP AR Approach should be implemented. In all cases PBN implementation needs to be an agreement between the airspace user, the ANSP and the regulatory authorities.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

International public standards for PBN are still evolving. International PBN is not widespread. For example, outside the U.S. in 2009, there were only RNP AR procedures in only 11 countries and only 4 have “public” RNP AR procedures. All the rest are “specials” or “restricted.” There are a few RNP transitions” to RNP AR approaches and RNP “departures” in Australia and Canada but no designated RNP STARs or RNP SIDs. These few procedures in the world are primarily driven by terrain and lack of ground infrastructure.

According to the ICAO/IATA Global PBN Task Force, International Air Traffic Management (ATM) and State flight standards rules and regulations lag behind airborne capability.

States are having a difficult time determining the benefits of RNP over conventional procedures and basic RNAV procedures. The cost of authorizing aircraft for RNP AR and the associated crew and controller training and data integrity requirements overwhelms many States and their national airlines. Other than some terrain challenged airports, RNP is not required to continue to operate.

The few countries with RNP procedures have little or no standardization between them. Despite ICAO PBN AR documents, there is a scarcity of common regulations within each of the States and doubts continue about the integrity of the criteria/data used to design RNP procedures. U.S. criteria is considered too restrictive by many States. There is a growing need for worldwide harmonization of RNP requirements, standards, procedures and practices. Air Traffic Controllers throughout the world desire common Flight Management System functionality for predictable and repeatable RNP procedures.

Despite some advanced airborne capability in international fleets there continues to be a need for forward fit and retrofit requirements including a higher percentage of GNSS equipped aircraft. These requirements should be harmonized or the airlines, as well as ATC, may continue to fail to buy into RNP.

As PBN implementation progresses, standardized international requirements should be set for fixed radius transitions, radius-to-fix legs, Required Time of Arrival (RTA), parallel offset, vertical containment, 4D control, ADS-B, datalink, etc.

SMS must be part of any development process, and each one manifests itself differently for each of the PBN processes. For production development, SMS should be addressed through an ISO 9000-compliant production process, workflow, automation improvements, and data management. The production process is monitored for defect control and workflow. For air traffic developed procedures, a Safety Risk Management Document (SRMD) may be required for every new or amended procedure. That requirement will extend the time required to implement new procedures, especially PBN-based flight procedures.

Progress should be measured against the key performance indicators recommended by the Working Group(s), as approved. PBN does not:

1. add new navigation philosophy, but just is a pragmatic tool to implement navigation procedures for aircraft capability that exists for more than 30 years!
2. require States to completely overhaul navigation infrastructure, but can be implemented step-by-step
3. require States to implement the most advanced navspec, only needs to accommodate the operational needs

3.5 Business Case specific to the element

The advantage of PBN to the ANSP is that PBN avoids the need to purchase and deploy navigation aids for each new route or instrument procedure. The advantage to everyone is that PBN clarifies how area navigation systems are used and facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

The safety benefits to PBN are significant, as even airports located in the poorest areas of the world can have runway aligned approaches with horizontal and vertical guidance to any runway end without having to install, calibrate and monitor expensive ground based navigation aids. Therefore, with PBN all airports can have a stabilized instrument approach that will allow aircraft to land into the wind, as opposed to a tail wind landing.

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

TBD, however, many trials and actual implementation have already occurred globally, with Lessons Learned and Best Practices documented. PBN should be demonstrated as part of other demonstrations and trials and not a standalone demonstration

3.6.2 Planned or Ongoing Trials

Short description of the nature of the demonstrations, the programme/context/date where they are planned to take place or have been executed. Main results and references where available. Description related to the module or to some of its elements.

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Module N° B0-40: Improved Safety and Efficiency through the Initial Application of Data Link En-Route

<table>
<tr><td>Summary</td><td colspan="2">The implementation of a first set of air-ground data link capabilities which have been the subject of development in the last decades. It provides controller pilot data link communications (CPDLC) and automatic dependent surveillance (ADS-C) over oceanic and remote areas. These data link applications enable controllers to provide more efficient and safe ATS by providing capabilities to controllers to monitor the accurate positions of aircrafts and communicate accurately and clearly in real time with pilots where radar systems are not available. This enhanced traffic situation awareness, the improved quality of air-ground communications and the reduced workload generated by voice communications will increase capacity</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 – Capacity, KPA-04 – Efficiency; KPA-10 – Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">En-route flight phases, especially areas where surveillance systems cannot be installed such as remote or oceanic airspace.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those equipped. Benefits increase with the proportion of equipped aircraft.

Not applicable to light aircraft.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">IM – Information Management

SDM – Service Delivery Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-9 Situational awareness

GPI-17 Implementation of data link applications

GPI-18 Electronic information services</td></tr>
<tr><td>Reference Documents</td><td colspan="2">Manual of Air Traffic Services Data Link Applications (Doc 9694)

OPLINK GOLD Manual (under development)

EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">NIL</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>√</td></tr>
<tr><td>Avionics Availability</td><td>√</td></tr>
<tr><td>Infrastructure Availability</td><td>√</td></tr>
<tr><td>Ground Automation Availability</td><td>√</td></tr>
<tr><td>Procedures Available</td><td>√</td></tr>
<tr><td>Operations Approvals</td><td>√</td></tr>
</table>

1 Narrative

1.1 General

Air-ground data exchanges have been the subject of decades of research and standardisation work and are an essential ingredient of the future operational concepts since they can carry reliably richer information than what can be exchanged over radio. Many technologies exist and have been implemented now widely in aircraft, often motivated by AOC and AAC reasons as well. Since a few years a number of applications have started to become a reality for ATM, but they are not completely deployed. In addition, there are ongoing further efforts to ensure that the applications are interoperable to diverse a/c fits, a task being addressed with priority by the OPLINK panel. This module covers what is available and can be more widely used now.

One element of the module is the transmission of aircraft position information, forming the Automatic Dependent Surveillance (ADS-C) service, principally for use over oceanic and remote areas where radar cannot be deployed for physical or economical reasons.

A second element is a first set of data link applications allowing pilots and controllers to exchange ATC messages.

1.2 Baseline

Prior to this module, air-ground communications use voice radio (VHF or HF depending on the airspace), known for its limitations in terms of quality, bandwidth and security. There are also wide portions of the globe with no radar surveillance. ATC instructions, position reports and various information have to be transmitted through HF radios where voice quality is really bad most of the times, leading to significant workload to controllers and pilots (including HF radio operators), poor knowledge of the traffic situation outside radar coverage, large separation minima, and misunderstandings.

1.3 Change brought by the module

The module concerns the implementation of a first package of data link applications, covering ADS-C, CPDLC and other FANS1/A and LINK applications for ATC. These applications provide significant improvement in the way ATS is provided as described in the next section.

1.4 Element 1: ADS-C

ADS-C provides an automatic dependent surveillance service over oceanic and remote areas, through the exploitation of position messages sent automatically by aircraft over data link at specified time intervals (ADS-Contract). This improved situational awareness (in combination with appropriate PBN levels) is improving safety in general and allows reducing separations between aircraft and progressively moving away from pure procedural modes of control.

1.5 Element 2: CPDLC, FANS1/A, Link

The applications allow pilots and controllers to exchange messages with a better quality of transmission. In particular, they provide a way to alert the pilot when its microphone is stuck and a complementary means of communication.

Over dense continental airspace, they can significantly reduce the communication load, allowing the controller to better organise its tasks, in particular by not to having to interrupt immediately to answer radio. They provide more reliability on the transmission and understanding of frequency changes, flight levels and flight information etc., thereby increasing safety and reducing the number of misunderstandings and repetitions.

Oceanic (FANS1/A) and continental (ICAO ATN based) data link implementations today are based on different standards, technology and operational procedures although there are many similarities. An important goal of the global ATM concept within the area of data link is to harmonise the regional implementations and to come to a common technical and operational definition, applicable to all flight regions in the world.

Today, the existing Data Link implementations are based on two sets of ATS Data link services: FANS 1/A and ATN B1, both will exist. FANS1/A is deployed in Oceanic and Remote regions whilst ATN B1 is being implemented in Europe according to European Commission legislation (EC Reg. No. 29/2009) – the Datalink Services Implementing Rule.

These two packages are different from the operational, safety and performance standpoint and do not share the same technology but there are many similarities and can be accommodated together, thanks to the resolution of the operational and technical issues through workaround solutions, such as accommodation of FANS 1/A aircraft implementations by ATN B1 ground systems and dual stack (FANS 1/A and ATN B1) implementations in the aircraft.

2 Intended Performance Operational Improvement/Metric to determine success

2.1 Element 1: ADS-C

Capacity	A better localisation of traffic and reduced separations allow to increase the offered capacity. Metric: applied horizontal separation minima
Efficiency	Routes/tracks and flights can be separated by reduced minima, allowing to apply flexible routings and vertical profiles closer to the user-preferred ones. Metric: deviations from user-preferred profiles
Flexibility	ADS-C permits to make route changes easier Metric: number of permitted reroutings compared to non-ADS-C situation
Safety	Increased situational awareness; better support to SAR Metric: proportion of traffic with known position

CBA	The business case has proven to be positive due to the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts). To be noted, the need to synchronise ground and airborne deployments to ensure that services are provided by the ground when aircraft are equipped, and that a minimum proportion of flights in the airspace under consideration are suitably equipped.
Human Performance	ADS-C is a means to provide the air traffic controller with a direct representation of the traffic situation, and reduces the task of controllers or radio operators to collate position reports.

2.2 Element 2: CPDLC, FANS1/A, Link

Capacity	Reduced communication workload and better real-time organisation of tasks allow to increase sector capacity Metric: sector capacity increases
Safety	Increased situational awareness; reduced occurrences of misunderstandings; solution to stuck mike situations Metric: incident occurrences

CBA	The business case has proven to be positive due to the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts). A detailed business case has been produced in support of the EU Regulation which was solidly positive. To be noted, the need to synchronise ground and airborne deployments to ensure that services are provided by the ground when aircraft are equipped, and that a minimum proportion of flights in the airspace under consideration are suitably equipped.
Human Performance	In addition to providing another channel of communications, the data link applications allow in particular air traffic controllers to better organise their tactical tasks. Both pilots and controllers benefit from a reduced risk of misunderstanding of voice transmissions.

3 Necessary Procedures (Air & Ground)

Procedures have been described and are available in ICAO documents.

4 Necessary Technology (Air & Ground)

Standards for the enabling technology are available in ICAO documents.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Specifications are already available in RTCA and EUROCAE documents.

6 Implementation and Demonstration Activities

6.1 Current Use

- **Remote & Oceanic areas**: ADS-C is used primarily over remote and oceanic areas. Dependent surveillance (ADS-C) is already successfully used in a number of regions of the world, for example in the CAR/SAM region (COSESNA, Brazil, etc) or in the South Pacific for FANS 1/A aircraft in combination with CPDLC messages. Also, in the NOPAC (NOrth PACific) route system it has allowed a reduction of separation minima.
- In March 2011, NAV CANADA and NATS implemented Reduced Longitudinal Separation Minima (RLongSM) of five minutes for properly equipped aircraft on tracks across the Atlantic. RLongSM requires aircraft to be equipped with GNSS, ADS-C and CPDLC. Along with other procedural improvements, this will allow more aircraft to access optimal altitudes. The expected result is an estimated $1 million in customer fuel savings in the first year, along with 3,000 metric tons of emissions savings.
- **Europe**: data link services are being implemented, namely Data Link Communications Initiation Capability (DLIC), ATC Communications Management service (ACM), ATC Clearances and Information service (ACL) and ATC Microphone Check service (AMC). To support them, the ATN B1 package is currently being deployed in 32 European Flight Information Regions and Upper Flight Information Regions above FL285 (known as the LINK2000+ service deployment). European Commission legislation

(EC Reg. No. 29/2009) – the Datalink Services Implementing Rule - mandates implementation of a compliant solution:

- From Feb 2013, in core European ground systems and
- From Feb2015, in the whole of Europe.
- From Jan 2011, on newly produced aircraft intending to fly in Europe above FL285
- From Feb 2015, retrofitted on all aircraft flying in Europe above FL285,

Note: Aircraft fitted with FANS1/A prior to 2014 for Oceanic operations are exempt from the regulation. In an effort to promote technical compatibility with the existing FANS 1/A+ fleet, a Mixed Interoperability document (ED154/DO305) was created that allows ATN B1 ground systems to provide ATS Datalink service to FANS 1/A+ aircraft. So far 7 out of 32 Flight Information Regions and Upper Flight Information Regions have indicated they will accommodate FANS 1/A+ aircraft.

Note: data link is operational at the Maastricht UAC since 2003. The PETAL II project extension finalised the validation of the ATN B1 applications by executing a pre-operational phase where aircraft equipped with certified avionics conducted daily operations with controllers in Maastricht Upper Airspace. The results were documented in the PETAL II Final Report and lead to the creation of the LINK 2000+ Programme to co-ordinate full scale European Implementation.

Note: The decision of implementation is accompanied by an economic appraisal, business case and other guidance material available at the following address:

http://www.EUROCONTROL.int/link2000/public/site_preferences/display_library_list_public.html#6 .

- **US**: Domestic Airspace: Beginning in 2014 Departure Clearance Services will be deployed using FANS-1/A+. In 2017, En-route Services will begin deployment to domestic en-route airspace. TBC
- **Australia**: TBC

6.2 Planned or Ongoing Trials

- **Africa, ACAC:** TBC

Module N° B0-20: Improved Flexibility and Efficiency in Departure Profiles

Summary	Flight operations in many terminal areas precipitate the majority of current airspace delays in many states. Opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term. The core capabilities that should be leveraged are RNAV; RNP where possible and needed; continuous descent operations (CDO); continuous climb operations (CCO); increased efficiencies in terminal separation rules; effective airspace design and classification; and Air Traffic flow. Opportunities to reduce fuel/emissions and aircraft noise impacts should also be leveraged where possible.	
Main Performance Impact	KPA-04 – Efficiency; KPA-05 – Environment; KPA-09 - Predictability	
Domain / Flight Phases	Departure and En-Route	
Applicability Considerations	Regions, States or individual Locations most in need of these improvements. For simplicity and implementation success, complexity can be divided into three tiers: 1. Least Complex – Regional/States/Locations with some foundational PBN operational experience that could capitalize on near term enhancements, which include integrating procedures and optimizing performance. 2. More Complex – Regional/States/Locations that may or may not possess PBN experience, but would benefit from introducing new or enhanced procedures. However, many of these locations may have environmental and operational challenges that will add to the complexities of procedure development and implementation. 3. Most Complex – Regional/States/Locations in this tier will be the most challenging and complex to introduce integrated and optimized PBN operations. Traffic volume and airspace constraints are added complexities that must be confronted. Operational changes to these areas can have a profound effect on the entire State, Region or location.	
Global Concept Component(s)	AUO – Airspace user operations TS – Traffic synchronization AOM – Airspace organization and management	
Global Plan Initiatives (GPI)	GPI 5- RNAV/RNP (Performance. Based Navigation) GPI-10- Terminal Area Design and Management GPI-11- RNP and RNAV SIDs and STARs	
Reference Documents	ICAO Doc xxxx, *Continuous Climb Operations (CCO) Manual – under development* ICAO Doc 9613, *Performance-based Navigation (PBN) Manual* ICAO Doc 4444, *PANS-ATM*	
Main Dependencies	NIL	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

This module integrates with other airspace and procedures (PBN, CDO, and Airspace Management) to increase efficiency, safety, access and predictability; and minimise fuel use, emissions, and noise.

As traffic demand increases, the challenges in terminal areas center around volume, convective weather, reduced-visibility conditions, adjacent airports and special activity airspace in close proximity whose procedures utilize the same airspace, and policies that limit capacity, throughput, and efficiency.

Environmental requirements must be taken into account. Apart from emissions, noise contours related to land planning requirements is part of the route design process laterally and vertically.

Traffic flow and loading (across ingress and egress routes) are not always well metered, balanced or predictable. Obstacle and airspace avoidance (in the form of separation standards and criteria), noise abatement procedures and noise sensitive areas, as well as wake encounter risk mitigation, tend to result in operational inefficiencies (e.g., added time or distance flown, thus more fuel).

Inefficient routing can also cause under-use of available airfield and airspace capacity. Finally, challenges are presented to States by serving multiple customers (international and domestic with various capabilities): the intermingling of commercial, business, general aviation and many times military traffic destined to airports within a terminal area that interact and at times inhibit each other's operations.

1.2 Baseline

Flight operations in many terminal areas precipitate the majority of current airspace delays in many states. Opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb and descent profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term.

The baseline for this module may vary from one State, Region or location to the next. Noted is the fact that some aspects of the movement to PBN have already been the subject of local improvements in many areas; these areas and users are already realizing benefits.

The lack of an ICAO PBN operational approval guidance material and subsequently the emergence of States or regional approval material, which may differ or be even more demanding than intended, is slowing down implementation and is perceived as one of the main roadblocks for harmonization.

There is still some work to be done to harmonize PBN nomenclature, especially in charts and States/Regional regulations (e.g. most of European regulations still make use of B-RNAV and P-RNAV).

Efficiency of climb profiles may be compromised by level off segments, vectoring, and an additional overload of radio transmissions between pilots and air traffic controllers. Existing procedure design techniques do not cater for current FMS capability to manage the most efficient climb profiles. There is also excessive use of radio transmissions due to the need to vector aircraft in an attempt to accommodate their preferred trajectories.

1.3 Change Brought by the Module

The core capabilities that should be leveraged are RNAV; RNP where possible and needed; continuous climb operations (CCO), increased efficiencies in terminal separation rules; effective airspace design and classification; and Air Traffic flow. Opportunities to reduce flight block times, fuel/emissions and aircraft noise impacts should also be leveraged where possible.

This module is a first step towards harmonization and a more optimized organization and management of the airspace. Many States will require knowledgeable assistance to achieve implementation. Initial implementation of PBN, RNAV for example, takes advantage of existing ground technology and avionics and allows extended collaboration of ANSPs with partners: military, airspace users, and neighbouring States. Taking small and required steps, and only performing what is needed or required allows States to rapidly exploit PBN.

1.4 Continuous Climb Operations (CCO)

Operating at the optimum flight level is a key driver to improve flight fuel efficiency and minimising atmospheric emissions. A large proportion of fuel burn occurs in the climb phase and for a given route length, taking into account aircraft mass and the meteorological conditions for the flight, there will be an optimum flight level, which gradually increases as the fuel on-board is used up and aircraft mass therefore reduces. Enabling the aircraft to reach and maintain its optimum flight level without interruption will therefore help to optimise flight fuel efficiency and reduce emissions.

CCO can provide for a reduction in noise, fuel burn and emissions, while increasing flight stability and the predictability of flight path to both controllers and pilots.

CCO is an aircraft operating technique aided by appropriate airspace and procedure design and appropriate ATC clearances enabling the execution of a flight profile optimized to the operating capability of the aircraft, thereby reducing fuel burn and emissions during the climb portion of flight.

The optimum vertical profile takes the form of a continuously climbing path, with a minimum of level flight segments only as needed to accelerate and configure the aircraft.

The optimum vertical path angle will vary depending on the type of aircraft, its actual weight, the wind, air temperature, atmospheric pressure, icing conditions and other dynamic considerations.

A CCO can be flown with or without the support of a computer-generated vertical flight path (i.e. the vertical navigation (VNAV) function of the flight management system (FMS)) and with or without a fixed lateral path. The maximum benefit for an individual flight is achieved by allowing the aircraft to climb on the most efficient climb profile along the shortest total flight distance possible.

2 Intended Performance Operational Improvement/Metric to determine success

Efficiency	Cost savings through reduced fuel burn and efficient aircraft operating profiles. Reduction in the number of required radio transmissions. Metrics: • Level flight distance at low altitude • Fuel burn to flight level • Flight block time • Number of radio transmissions
Environment	Authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted. Environmental benefits through reduced emissions. Metrics: • Number of operations • CO_2 savings
Safety	More consistent flight paths. Reduction in the number of required radio transmissions. Lower pilot and Air Traffic Control workload. Metrics: • Number of flights receiving radar vectors • Number of radio transmissions • Number of miscommunications (readback/hearback) • Number of altitude errors (flight level busts)
Cost Benefit Analysis	It is important to consider that CCO benefits are heavily dependent on each specific ATM environment. Nevertheless, if implemented within the ICAO CCO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.
Human Performance	Human performance or human factors are reflected in how easy it is to successfully perform a specific task consistently. For this module it can be broken down to: o Complexity of task o Time allocated for task o Predictability of outcome once task is complete Metrics: • Number of CCO procedures issued • Number of times pilot is cleared for CCO prior to departure • Percentage of time that pilot is left on complete CCO (i.e. not vectored off of procedure or issued additional level off restrictions)

3 Necessary Procedures (Air & Ground)

The ICAO Performance-based Navigation Manual (ICAO Document 9613) provides general guidance on PBN implementation.

This manual identifies the relationship between RNAV and RNP applications and the advantages and limitations of choosing one or the other as the navigation requirement for an airspace concept.

It also aims at providing practical guidance to States, air navigation service providers and airspace users on how to implement RNAV and RNP applications, and how to ensure that the performance requirements are appropriate for the planned application.

The ICAO *Continuous Climb Operations (CCO)* Manual (Doc xxxx) provides guidance on the airspace design, instrument flight procedures, ATC facilitation and flight techniques necessary to enable continuous descent profiles.

It therefore provides background and implementation guidance for:

a) air navigation service providers;
b) aircraft operators;
c) airport operators; and
d) aviation regulators.

4 Necessary Technology (Air & Ground)

CCO does not require a specific air or ground technology. It is an aircraft operating technique aided by appropriate airspace and procedure design, and appropriate ATC clearances enabling the execution of a flight profile optimized to the operating capability of the aircraft, in which the aircraft can attain cruise altitude flying at optimum air speed with climb engine thrust settings set throughout the climb, thereby reducing total fuel burn and emissions during the whole flight. Reaching cruise flight levels sooner where higher ground speeds are attained can also reduce total flight block times. This may allow a reduced initial fuel upload with further fuel, noise and emissions reduction benefits.

The optimum vertical profile takes the form of a continuously climbing path. Any level or non-optimal reduced climb rate segments during the climb to meet aircraft separation requirements should be avoided. Achieving this whilst also enabling Continuous Descent Operations (CDO) is critically dependent upon the airspace design and the height windows applied in the instrument flight procedure. Such designs need an understanding of the optimum profiles for aircraft operating at the airport to ensure that the height windows avoid, to greatest extent possible, the need to resolve potential conflicts between the arriving and departing traffic flows through ATC height or speed constraints.

5 Regulatory/Standardisation Needs and Approval Plan (Air & Ground)

Understanding the policy context is important for making the case for local CCO implementation and ensuring high levels of participation. CCO may be a strategic objective at international, State, or local level, and as such, may trigger a review of airspace structure when combined with CDO.

For example, noise contour production may be based on a specific departure procedure (NADP1 or NADP2-type). Noise performance can be improved in some areas around the airport, but it may affect existing noise contours elsewhere. Similarly CCO can enable several specific strategic objectives to be met and should therefore be considered for inclusion within any airspace concept or redesign. Guidance on airspace concepts and strategic objectives is contained in Doc 9613. Objectives are usually collaboratively identified by airspace users, ANSPs, airport operators as well as by government policy. Where a change could have an impact on the environment, the development of an airspace concept may involve local communities, planning authorities and local government and may require formal impact assessment under regulations. Such involvement may also be the case in the setting of the strategic objectives for airspace. It is the function of the airspace concept and the concept of operations to respond to these requirements in a balanced, forward-looking manner, addressing the needs of all stakeholders and not of one of the stakeholders only (e.g. the environment). Doc 9613, Part B, Implementation Guidance, details the need for effective collaboration among these entities

Contrary to a CDO, where noise benefits are an intrinsic positive element, in case of a CCO, the choice of a departure procedure (NADP1 or NADP2-type), requires a decision of the dispersion of the noise.

In addition to a safety assessment, a transparent assessment of the impact of CCO on other air traffic operations and the environment should be developed and made available to all interested parties.

6 Implementation and Demonstration Activities

TBD

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BLOCK 1

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Module N° B1-65: Optimised Airport Accessibility

<table>
<tr><td rowspan="1">Summary</td><td colspan="2">This is the further transition in the universal implementation of GNSS-based approaches.
PBN and GLS (CAT II/III) procedures enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency. Key aspects included:
• Increased availability and reliability through Mutli-Frequency/Constellation use of GNSS
• GNSS-based CAT II/III approach capability
Curved/segmented approaches with RNP to XLS transition</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-04 – Efficiency; KPA-05 – Environment; KPA-10 - Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">Approach and landing</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">This module is applicable to all instrument and precision instrument runway ends, and to a limited extent, non-instrument runway ends</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">AUO – Airspace User Operations
AO – Aerodrome Operations</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-5 RNAV and RNP (PBN)
GPI-11 PBN and SIDS/STARS
GPI-14 Runway Operations
GPI-20 WGS84
GPI-21 Navigation Systems</td></tr>
<tr><td>Reference Documents</td><td colspan="2">PBN Manual (ICAO Doc 9613)
GNSS Manual (ICAO Doc 9849)
Annex 10
PANS-OPS
WGS-84 Manual (Doc 9674)
Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II
Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">B0-65</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>√</td></tr>
<tr><td>Avionics Availability</td><td>2018</td></tr>
<tr><td>Infrastructure Availability</td><td>√</td></tr>
<tr><td>Ground Automation Availability</td><td>√</td></tr>
<tr><td>Procedures Available</td><td>√</td></tr>
<tr><td>Operations Approvals</td><td>2018</td></tr>
</table>

1 Narrative

1.1 General

This module complements other airspace and procedures elements (CDO, PBN and Airspace Management) to increase efficiency, safety, access and predictability.

This module proposes to take advantage of the lowest available minima through the extension of GNSS-based approaches from CAT-I capability to category CAT II/III capability at a limited number of airports. It also harnesses the potential integration of the PBN STARS directly to all approaches with vertical guidance. This capability allows for both curved approaches and segmented approaches in an integrated system. The emergence of multi-frequency/constellation GNSS may start to be developed to enhance approach procedures.

This module describes what technology is expected to be available in 2018, and what operations are likely to be supported.

1.1.1 Baseline

Module B0-65 provided the first step toward universal implementation of GNSS-based approaches. It is likely that many States will have a significant number of GNSS-based PBN approaches, and in some States virtually all runways will be served by PBN procedures. Where GBAS and/or SBAS are available, precision instrument runways will have Cat I minima.

1.1.2 Change brought by the module

As more PBN and GBAS procedures become available, and as more aircraft are equipped with the required avionics, application of this module will result in some rationalisation of the navigation infrastructure.

Increased aerodrome accessibility via lower approach minima to more runways, which will be reflected in fewer fight disruptions, reduced fuel burn and reduced greenhouse gas emissions. The more widespread availability of SBAS and GBAS procedures will enhance safety via vertical guidance.

As described in Module B0-65, conventional navigation aids (e.g. ILS, VOR, NDB) have limitations in their ability to support the most efficient and cost-effective approach procedures. PBN procedures require no aerodrome infrastructure and allow designers complete flexibility in determining the final approach lateral and vertical paths. PBN approach procedures can be seamlessly integrated with PBN arrival procedures, including constant descent operations (CDO), thus reducing aircrew and controller workload and the probability that aircraft will not follow the expected trajectory. GBAS, which is not included in the PBN Manual, requires aerodrome infrastructure, but a single station can support approaches to all runways, and GBAS offers the same design flexibility as PBN procedures. This flexibility provides benefits when conventional aids are out of service due to system failures or for maintenance.

States can implement a single GNSS-based PBN approach procedure that provides minima for aircraft equipped with basic GNSS avionics with or without Baro VNAV capability, and for aircraft equipped with SBAS avionics. Regardless of the avionics fit, each aircraft will follow the same lateral path. Such approaches can be designed for runways with or without conventional approaches, thus providing benefits to PBN-capable aircraft, encouraging equipage and supporting the planning for decommissioning of some conventional aids.

Aircraft equipage is the key to realizing maximum benefits from increased numbers of PBN and GBAS procedures. Aircraft operators make independent decisions about equipage based on the value of incremental benefits and potential savings in fuel and other costs related to flight disruptions. Experience has shown that operators may await fleet renewal rather than equipping existing aircraft.

2 Intended Performance Operational Improvement/Metric to determine success

Efficiency	Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely-spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds. Metrics: i. Number of flight disruptions ii. Runway capacity
Environment	Environmental benefits through reduced fuel burn Metric: CO_2 savings
Safety	Stabilized approach paths. Metric: ratio of vertically-guided to total procedures

CBA	Aircraft operators and ANSPs can quantify the benefits of lower minima by modelling airport accessibility with existing and new minima. Operators can then assess benefits against avionics and other costs. The GBAS Cat II/III business case needs to consider the cost of retaining ILS or MLS to allow continued operations during an interference event. The potential for increased runway capacity benefits with GBAS is complicated at airports where a significant proportion of aircraft are not equipped with GBAS avionics.
Human Performance	Human performance is reflected in how straightforward it is to successfully perform a specific task consistently, and how much initial and recurrent training is required to achieve safety and consistency. For this module there are clear safety benefits associated with the elimination of circling procedures and approaches without vertical guidance. Metrics: iii. Ratio of circling to total procedures v. Ratio of vertically-guided to total procedures

3 Necessary Procedures (Air & Ground)

The PBN Manual, the GNSS Manual, Annex 10 and PANS-OPS Volume I provide guidance on system performance, procedure design and flight techniques necessary to enable PBN approach procedures. The WGS-84 Manual provides guidance on surveying and data handling requirements. The Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II — Testing of Satellite-based Radio Navigation Systems provides guidance on the testing of GNSS. This testing is designed to confirm the ability of GNSS signals to support flight procedures in accordance with the standards in Annex 10. ANSPs must also assess the suitability of a procedure for publication, as detailed in PANS-OPS, Volume II, Part I, Section 2, Chapter 4, Quality Assurance. The Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5 – Flight Validation of Instrument Flight Procedures provides the required guidance for PBN procedures. Flight validation for PBN procedures is less costly than for conventional aids for two reasons: the aircraft used do not require complex signal measurement and recording systems; and, there is no requirement to check signals periodically.

These documents therefore provide background and implementation guidance for ANS providers, aircraft operators, airport operators and aviation regulators.

4 Necessary Technology (Air & Ground)

Module B0-65 describes the avionics required to fly PBN approach procedures, and explains the requirements for, benefits and limitations of SBAS based on single-frequency GPS. It is expected that standards will exist for Cat II/III GBAS in 2018, that some ground stations will be in place in some States and that there may be avionics available to support Cat II/III GBAS operationally. There will likely be some expansion of operational Cat I GBAS operations in some States.

The majority of operations globally will continue to be based on single-frequency GPS, although in some regions (e.g. Russia) avionics will integrate GLONASS and GPS signals. It is expected that GPS will provide signals on two frequencies for civilian use by 2018, and there are similar plans for GLONASS. It is possible that the emerging core constellations Galileo and Compass/Beidou will be operational in 2018 and that these constellations will be standardized in Annex 10; both are designed to be interoperable with GPS and will also provide service on two civilian frequencies. The availability of avionics and the extent of operational use of multi-constellation, multi-frequency GNSS will be determined by incremental benefits; it is not certain that there will be standards for such avionics by 2018. The availability of multiple frequencies could be exploited to eliminate ionospheric errors and support a simplified SBAS that could provide approaches with vertical guidance. The availability of multi-constellation GNSS offers robustness in the presence of severe ionospheric disturbances and could allow expansion of SBAS to equatorial regions. It not expected multiple frequencies and constellations will exploited to any degree globally in 2018

5 Expected Implementation and Demonstration Activities

- **United States**

By 2016 all runways (approximately 5,500) in the United States will be served by PBN procedures with LNAV, LNAV/VNAV and LPV minima. Precision instrument runways will likely all have 200 ft HAT LPV minima based on WAAS (SBAS). The United States has determined that acquisition of GBAS is not affordable due to lack of resources through 2014, but will continue research and development activities. It is therefore unlikely that there will be GBAS Cat II/III procedures available and being flown by scheduled operators in 2018.

- **Canada**

By 2018 Canada expects to expand PBN approach service based on demand from aircraft operators. As of 2011 Canada does not have plans to implement GBAS.

- **Australia**

By 2018 Australia expects a considerable expansion of PBN approach service. Subject to the successful introduction of the CAT 1 GBAS service into Sydney, Airservices will further validate GBAS operational benefits in consultation with key airline customers with a view to expanding the network beyond Sydney in the period 2013 to 2018. Other activities to be considered in relation to the expansion and development of the GBAS capability in Australia include development of a CAT II/III capability during the 3 years following 2011.

- **France**

The objective is to have PBN procedures for 100% of France's IFR runways with LNAV minima by 2016, and 100% with LPV and LNAV/VNAV minima by 2020. France has no plans for Cat I GBAS and it is unlikely that there will be Cat II/III GBAS in France by 2018 because there is not a clear business case.

- **Brazil**

By 2018 Brazil expects a considerable expansion of PBN procedures. Plans call for GBAS to be implemented at main airports from 2014.

Module N° B1-70: Increased Runway Throughput through Dynamic Wake Vortex Separation

Summary	Wake Vortex Separation - Refined: This ICAO ATM System Block Upgrade addresses the capacity enabling revisions to the Air Navigation Service Provider (ANSP) applied aircraft-to-aircraft wake separation standards and associated changes to the procedures the ANSP uses to apply the wake separation standards.	
Main Performance Impact	KPA-02 – Capacity; KPA-10 – Safety.	
Domain / Flight Phases	Aerodrome	
Applicability Considerations	Least Complex – Implementation of re-categorized wake turbulence is mainly procedural. No changes to automation systems are needed.	
Global Concept Component(s)	CM - Conflict Management	
Global Plan Initiatives (GPI)	GPI-13 - Aerodrome Design; GPI 14 – Runway Operations	
Reference Documents	ICAO Doc 9584 Global ATM Operational Concept, ICAO Doc 9750 Global Air Navigational Plan.	
Main Dependencies	B0-70	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2018
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

Refinement of the Air Navigation Service Provider (ANSP) aircraft-to-aircraft wake mitigation processes, procedures and standards will allow increased runway capacity with the same or increased level of safety. Block 1 upgrade will be accomplished without any required changes to aircraft equipage or changes to aircraft performance requirements. Full benefit from the upgrade would require significantly more aircraft/crews being able to conduct RNP based approaches and aircraft broadcasting their aircraft based weather observations during their airport approach and departure operations. The upgrade contains three elements that will be implemented by ANSP by the end of 2018. Element 1 is the establishment of wake vortex mitigation separation minima based on the wake generation and wake upset tolerance of individual aircraft types rather than ICAO standards based on 6 broad categories of aircraft. Element 2 is increasing, at some airports, the number of arrival operations on closely spaced (runway centre lines spaced closer than 2500 feet apart) parallel runways (CSPR) and on single runways taking into account the winds present along the approach corridor in modifying how wake separations are applied by the ANSP. Element 3 is increasing, at selected additional airports, the number of departure operations on parallel runways by modifying how wake separations are applied by the ANSP.

1.1.1 Baseline

ANSP applied wake mitigation procedures and associated standards were developed over time, with the last comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved 6 category wake vortex separation standards. The ICAO 2013 standards allow greater runway utilization than the prior 1990's inherently conservative wake separation standards; however, the 2013 standards can be enhanced to define safe, runway capacity efficient wake vortex separations for typical aircraft operating at an airport. By the end of 2013, some airports were approved to use modified ANSP wake separation procedures on their CSPR, if certain runway layout and instrumentation criteria were met. Also by the end of 2013, some airports will be using ANSP wake separation CSPR departure procedures based on predicted and monitored crosswinds.

1.1.2 Improvement brought by the module

This Module (B1–70) represents an expansion on the wake separation standards and ANSP wake mitigation procedures upgrade accomplished in Block 0. Block 1 represents technology being applied to make available further runway capacity savings by enhancing the efficiency of wake vortex separation standards and the ease by which they can be applied by the ANSP. Element 1's expansion of the 6 category wake separation standards to a Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings), is expected to yield an average increased airport capacity of 4% above that which was obtained by the Block 0 upgrade to the ICAO 6 category wake separation standards. Element 2 expands the use of specialized ANSP wake mitigation separation procedures to more airports by using airport wind information (predicted and monitored) to adjust the needed wake mitigation separations between aircraft on approach. Element 3 uses the same wind prediction/monitoring technology as Element 2 and will allow greater number of airports to increase their departure runway operations if airport winds are favourable. The estimated capacity gains by Element 1 (changing to Leader/Follower - Pair Wise Static wake separations) will be for European, U.S. and other capacity constrained airports worldwide. Elements 2 (increasing airport arrival operational capacity) and 3 (increasing departure operational capacity) provide runway capacity improvements to a wider range of airports than the upgrades of Block 0 could deliver. These Element 2 and 3 technology aided airport specific specialized procedures will provide for additional airports increased airport arrival capacity (5 to 10 more operations per hour) during instrument landing operations and increased airport departure capacity (2 to 4 more operations per hour) during favourable airport wind conditions.

1.1.3 Other remarks

The work accomplished in Block 1 builds on the upgrades of Block 0 and will be the basis for further enhancement in wake mitigation procedures and standards that will occur in Block 2 developments. The Wake Vortex Separation - Refined Module is a progression of steps to have available to global aviation, means to acquire more capacity from existing airport runway structure and to place new airport runways for minimizing wake turbulence landing and departure restrictions. The effort in Block 1 will not provide the major capacity increases needed to meet the overall demand envisioned for the 2025 time frame. However it does provide incremental capacity increases using today's runways and minor modifications to air traffic control procedures. Block 1 and subsequent Block 2 will address developing wake mitigation procedures and separation standards that will assure the wake safety of innovations (Trajectory Based, High Density, Flexible Terminal) in air traffic control while at the same time provide the least wake safety constraints on the air traffic control innovation. The upgrades of Block 1 will incorporate the experience obtained with the Block 0 upgrades.

2 Element 1: Implement Leader/Follower - Pair Wise Static Matrix Wake Separation Standards

The work in Element 1 is being accomplished by a joint EUROCONTROL and FAA working group that in Block 0 reviewed the wake mitigation aircraft separations used in both the USA's and Europe's air traffic control processes and determined the standards can be safely modified to increase the operational capacity of airports and airspace. A 6 category wake separation standard recommendation was developed by the working group and provided to ICAO. It is expected that by the end of 2012, ICAO will publish the recommendation as changes to its Procedures for Air Navigation Services.

Block 1 Element 1 work will again be accomplished by the joint EUROCONTROL and FAA working group. It will take the analysis tools developed for its 6 category wake separation standard recommendation and enhance them to investigate the added airport capacity that could be obtained if wake separations were tailored to the performance characteristics of the aircraft generating the wake vortex and the performance characteristics of the aircraft that might encounter the generated wake vortex. Preliminary estimates have indicated that an additional 3 to 5% increase to airport capacity could be obtained from this more complex Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings. Depending on the majority of aircraft types operating at an airport, the ANSP would use the associated paired wake separation standards for operations involving those aircraft types. For all other aircraft types, a more general wake separation would be applied. It is planned that the Leader/Follower - Pair Wise Static Matrix wake separation standards recommendation will be provided to ICAO at the end of 2014 and ICAO will approve ANSP use of the matrix in 2016. Modifications to the ANSP ATC systems will likely be required to support effective use of the Leader/Follower - Pair Wise Static Matrix wake separation standards.

2.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

7. Capacity
    a. Aerodrome capacity and departure/arrival rates will increase as aircraft pairings are optimized. In addition, runway occupancy time will decrease as the result
        i. Aerodrome throughput
        ii. Runway occupancy time
        iii. Arrival/departure rate
8. Flexibility
    a. Dynamic Scheduling. ANSPs have the choice of optimizing the arrival/departure schedule via pairing.number of unstable approaches
        i. Arrival/departure rate
        ii. Runway occupancy time

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2.2 Necessary Procedures (Air & Ground)

The change to the ICAO wake separation standards implemented in the Block 1 timeframe will add potentially 60 or more individual aircraft-to-aircraft Leader/Follower Pair-Wise Static wake separations that ANSPs can choose to apply in their airport operations. ANSPs will be able to choose how they will implement the additional standards into their operations depending on the capacity needs of the airport. If capacity is not an issue at an airport, the ANSP may elect to use the original 3 categories in place before the Block 0 upgrade or the 6 Category standards put in place by Block 0. The ANSP procedures, using the Leader/Follow Pair-Wise Static set of standards, will need automation support in providing the required aircraft-to-aircraft wake separations to its air traffic controllers.

Implementing Element 1 will not require any changes to air crew flight procedures. However, there will be changes required in how a flight plan is filed in terms of the aircraft's wake classification.

2.3 Necessary Technology (Air & Ground)

Module 70, Block 1 upgrade requires no additional technology to be added to the aircraft or additional aircrew certifications. Block 1 upgrades will utilize aircraft avionics enhancements that are expected to occur during that timeframe from other Modules (i.e. ADS-B). ANSPs, if they choose to use the Leader/Follower Pair-Wise Static wake separation standards Element 1 upgrade will develop a decision support tool to support in the application the standards. The Element 2 and Element 3 Block 1 upgrades require the ANSP, if the ANSP chooses to use the reduced wake separations on its CSPR, add the capability to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

The product of Element 1 is a recommended set of Leader/Follower Pair-Wise Static additional wake separation changes to the ICAO wake separation standards and supporting documentation. Once approved, ICAO's revised wake separation standards will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards. ICAO approval of the Leader/Follower Pair-Wise Static wake separation standards is estimated to occur in the 2015/16 time frame.

2.5 Business Case specific to the element

Element 1's change to the ICAO wake separation standards will yield an average 4% additional capacity increase for an airport's runways in Europe, U.S, and other airports world wide. The 4% increase translates to 1 more landing per hour for a single runway that normally could handle 30 landings per hour. One extra slot per hour creates revenue for the air carrier that fills them and for the airport that handles the extra aircraft operations and passengers.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Not applicable

2.6.2 Planned or Ongoing Trials

Concurrent with the ICAO approval process, FAA is developing documentation and its automation systems' adaptation changes that will allow implementation of the wake separation standard changes. The ICAO approval is expected in 2015/16.

3 Element 2: Increasing Airport Arrival Operational Capacity at Additional Airports

ANSP wake mitigation procedures applied to instrument landing operations on CSPR are designed to protect aircraft for a very wide range of airport parallel runway configurations. Prior to 2008, instrument landing operations conducted to an airport's CSPR had to have the wake separation spacing equivalent to conducting instrument landing operations to a single runway. When an airport using its CSPR for arrival operations had to shift its operations from visual landing procedures to instrument landing procedures, it essentially lost one half of its landing capacity (i.e. from 60 to 30 landing operations per hour).

Block 0 Element 2 upgrade provided a dependent diagonal paired instrument approach wake separation procedure (FAA Order 7110.308) for operational use in 2008 at five airports that had CSPR configurations meeting the runway layout criteria of the developed procedure. Use of the procedure provided an increase of up to 10 more arrival operations per hour on the airport CSPR during airport operations requiring instrument approaches. By the end of 2010 the approval to use the procedure was expanded to two additional airports. An enhanced version of FAA Order 7110.308 will be approved in 2012 for use by up to 6 more U.S. airports who use their CSPR for arrival operations.

Block 1 work will expand the use of the dependent instrument landing approach procedure to capacity constrained airports that use their CSPR for arrival operations but do not have the runway configuration to satisfy the constraints of FAA Order 7110.308. The mechanism for this expansion is the Wake Turbulence

Mitigation for Arrivals (WTMA) capability that will be added to FAA ATC systems. WTMA relies on predicted and monitored winds along the airport approach path to determine if wakes of arriving aircraft will be prevented by cross winds from moving into the path of aircraft following on the adjacent CSPR. The WTMA capability maybe expanded during Block 1 to include predicting when steady crosswinds would blow wakes out of the way of aircraft following directly behind the generating aircraft – allowing the ANSP to safely reduce the wake separation between aircraft approaching a single runway. It is expected that by the end of 2018, the WTMA capability will be in use at an additional 6 or more CSPR airports whose physical layout precluded use of the non-wind dependent 7110.308 Block 0 developed procedure.

Critical component of the WTMA capability is wind information along the airport's approach corridor. Use of WTMA will be limited by the timely availability of this information. During Block 1 time frame, it is expected that aircraft wind information observed and transmitted during their approach to the airport will be incorporated into the WTMA wind prediction model as a replacement for the much more latten National Weather Service forecasted winds information. Use of aircraft wind data will significantly increase WTMA's capability to forecast and monitor wind changes, allowing WTMA wake separations to used during times when before, due to uncertainty of wind information, use of the reduced wake separations was precluded.

3.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

9. Capacity
    a. Better wind information will around the aerodrome to enact reduced wake mitigation measures in a timely manner. Aerodrome capacity and arrival rates will increase as the result of reduced wake mitigation measures.
        i. Aerodrome throughput
        ii. Runway occupancy time
        iii. Arrival/departure rate

3.2 Necessary Procedures (Air & Ground)

The Block 0 implementations impacting the use of an airport's CSPR for arrivals, only affect the ANSP procedures for sequencing and segregating aircraft to the CSPR. Block 1 upgrade adds procedures for applying reduced wake separations between pairs of aircraft during arrivals to an airport's CSPR when crosswinds along the approach path are favourable for the reduced separations. Use of Block 1 procedures requires the addition to the ANSP automation platforms the capability to predict and monitor the crosswind and to display to the air traffic controller the required wake separation between aircraft arriving on the CSPR.

The procedures implemented by Element 2 require no changes to the air crew's procedures for accomplishing an instrument landing approach to the airport. Sequencing, segregating and separation will remain the responsibility of the ANSP.

3.3 Necessary Technology (Air & Ground)

Module 70, Block 1 upgrade requires no additional technology to be added to the aircraft or additional aircrew certifications. Block 1 upgrades will utilize aircraft avionics enhancements that are expected to occur during that timeframe from other Modules (i.e. ADS-B). ANSPs, if they choose to use the Leader/Follower Pair-Wise Static wake separation standards Element 1 upgrade will develop a decision support tool to support in the application the standards. The Element 2 and Element 3 Block 1 upgrades require the ANSP, if the ANSP chooses to use the reduced wake separations on its CSPR, add the capability to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors. This capability will be provided by a combination of X-band radar and Lidar scanner technology.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Element 2 and 3 products are U.S. airport specific and are approved for use through a national review process to insure proper integration into the air traffic control system. A companion process (FAA Safety Management System) reviews and documents the safety of the product, insuring the safety risk associated with the use of the product is low.

There is no air approval plan required for the implementation of the Wake Vortex Standards – Refined Module Block 1.

3.5 Business Case specific to the element

The impact of the Element 2 upgrade is the reduced time that an airport, due to weather conditions, must operate its CSPR as a single runway. Element 2 upgrade allows more airports to better utilize their CSPR when they are conducting instrument flight rules operations – resulting in 8 to 10 more airport arrivals per hour when crosswinds are favourable for WTMA reduced wake separations. For the Element 2 upgrade, the addition of a crosswind prediction and monitoring capability to the ANSP automation is required. For the Element 2 and 3 upgrades, additional downlink and real time processing of aircraft observed wind information will be required. There are no aircraft equipage costs besides costs incurred for other Module upgrades.

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

Not applicable

3.6.2 Planned or Ongoing Trials

Work is continuing on developing crosswind based wake separation procedures and technology upgrades for arrival operations to and airport's CSPR. Human-in-the-loop simulations using the procedures and the associated controller display support will be conducted in 2012. Depending on the outcome of the simulations, the development of the capability may continue.

4 Element 3: Increasing Airport Departure Operational Capacity at Additional Airports

Element 3 is the development of technology aided enhanced wake mitigation ANSP departure procedures that safely allow increased departure capacity on an airport's CSPR.

Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that allows, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required wake mitigation delay of 2 to 3 minutes. WTMD applies a runway cross wind forecast and monitors the current runway crosswind to determine when the WTMD will provide guidance to the controller that the 2 to 3 minute wake mitigation delay can be eliminated and when the delay must again be applied. WTMD was developed for implementation at 8 to 10 U.S. airports that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757 and heavier aircraft operations. Operational use of WTMD began in 2011.

Block 1 will enhance the WTMD capability to predict when crosswinds will be sufficient to prevent the wake of a departing aircraft from transporting into the path of an aircraft departing on the adjacent CSPR. WTMD will be modified to receive and process aircraft wind information observed during their departure from the airport, as a replacement for the much more latten National Weather Service forecasted winds information. Use of aircraft wind data will significantly increase WTMD's capability to forecast and monitor wind changes, allowing WTMD wake separations to used during times when before, due to uncertainty of wind information, use of the reduced wake separations was precluded.

4.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

b. Efficiency / Environment
c. Changes brought by this element will enable more accurate crosswind prediction.
d. Aerodrome throughput
e. Runway occupancy time
f. Arrival/departure rate

.

4.2 Necessary Procedures (Air & Ground)

Block 1 Element 3 implementations only affect the ANSP procedures for departing aircraft on an airport's CSPR. Element 3 products are additional procedures for use by the ANSP for situations when the airport is operating under a heavy departure demand load and the airport will be having a significant number of Boeing 757 and heavier aircraft in the operational mix. The procedures provide for transitioning to and from reduced required separations between aircraft and criteria for when the reduced separations should not be used. Block 1 upgrade does not change these procedures, it only increases the frequency and duration that the procedures can be applied

The procedures implemented by Element 3 require no changes to the aircrew's procedures for accomplishing a departure from the airport. When a specialized CSPR departure procedure is being used at an airport, pilots are notified that the special procedure is in use and that they can expect a more immediate departure clearance.

4.3 Necessary Technology (Air & Ground)

Module 70, Block 1 upgrade requires no additional technology to be added to the aircraft or additional aircrew certifications. Block 1 upgrades will utilize aircraft avionics enhancements that are expected to occur during that timeframe from other Modules (i.e. ADS-B). ANSPs, if they choose to use the Leader/Follower Pair-Wise Static wake separation standards Element 1 upgrade will develop a decision support tool to support in the application the standards. The Element 2 and Element 3 Block 1 upgrades require the ANSP, if the ANSP chooses to use the reduced wake separations on its CSPR, add the capability to predict crosswind strength and direction and to display that information to the ANSP controllers and supervisors.

4.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Element 2 and 3 products are U.S. airport specific and are approved for use through a national review process to insure proper integration into the air traffic control system. A companion process (FAA Safety Management System) reviews and documents the safety of the product, insuring the safety risk associated with the use of the product is low.

There is no air approval plan required for the implementation of the Wake Vortex Standards – Refined Module Block 1.

4.5 Business Case specific to the element

Impact of the Element 3 upgrade is reduced time that an airport must space departures on its CSPR two to three minutes apart, depending on runway configuration. Element 3 upgrade will provide more time periods that an airport's ANSP can safely use WTMD reduced wake separations on their CSPR. The airport's departure capacity increases 4 to 8 more departure operations per hour when WTMD reduced separations can be used. Downlink and real time processing of aircraft observed wind information will be required. There are no aircraft equipage costs besides costs incurred for other Module upgrades.

4.6 Implementation and Demonstration Activities

4.6.1 Current Use

The WTMD system will be operationally demonstrated at three U.S. airports beginning in 2011.

4.6.2 Planned or Ongoing Trials

Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required wake mitigation delay of 2 to 3 minutes. WTMD is being developed for implementation at 8 to 10 U.S. airports that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757 and heavier aircraft operations. First operational use of WTMD is expected in spring 2011.

5 Main Dependencies

Block 1 implementation is depended on the successful adoption and implementation of the predecessor block B0-70.

Module N° B1-75: Enhanced Safety and Efficiency of Surface Operations (A-SMGCS/ATSA-SURF)

Summary	This block provides enhancements to surface situational awareness, including both cockpit and ground elements, in the interest of runway and taxiway safety, and surface movement efficiency. Cockpit improvements including the use of Surface Moving Maps with Traffic Information, basic runway safety alerting logic, and Enhanced Vision Systems (EVS) for low visibility taxi operations. Ground improvements include the use of surface surveillance to track aircraft and ground vehicles, combined with safety logic to detect potential runway incursions.	
Main Performance Impact	KPA-02 – Capacity; KPA-04 – Efficiency; KPA-10 -Safety	
Domain / Flight Phases	Aerodrome	
Applicability Considerations	Small through large aerodromes and all classes of aircraft; cockpit capabilities will work independently of ground infrastructure or other aircraft equipage, but other aircraft equipage and/or ground surveillance broadcast will improve benefit.	
Global Concept Component(s)	AO - Aerodrome Operations CM - Conflict Management	
Global Plan Initiatives (GPI)	GPI-9 Situational Awareness GPI-13 Aerodrome Design and Management GPI-16 Decision Support Systems and Alerting Systems	
Reference Documents	ICAO Surveillance Multilateration Manual (Draft), ICAO Airborne Surveillance Manual (Draft), Doc 9830 Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual. FAA Advisory Circulars AC120-86 Aircraft Surveillance Systems and Applications, AC120-28D Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout, AC120-57A Surface Movement Guidance and Control System. FAA NextGen Implementation Plan; EUROCONTROL Doc - Flight Crew Guidance on Enhanced Situational Awareness on the Airport Surface; RTCA Document DO-322/EUROCAE Document ED-163, Safety, Performance and Interoperability Requirements Document for ATSA-SURF Application	
Main Dependencies	B0-75:	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2012
	Avionics Availability	2013
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

The aerodrome surface operation is perhaps ironically the phase of operations where surveillance and situational awareness of aircraft is least robust. Surface operations historically have been managed by use of visual scanning by both ANSP personnel and flight crew, both as the basis for taxi management as well as aircraft navigation and separation. These operations are significantly impeded during periods of reduced visibility (weather obscuration, night) and high demand, e.g. when a large proportion of aircraft are from the same operator and/or of the same aircraft type. In addition, remote areas of the aerodrome surface are difficult to manage if out of direct visual surveillance. As a result, efficiency can be significantly degraded, and safety services are unevenly provided.

This block is focused on improving the baseline case (completion of B0-75 Runway Safety), by the introduction of new capabilities which will enhance surface situational awareness and surface movement capabilities:

- Enhanced ANSP Surface Surveillance capability with Safety Logic
- Enhanced Cockpit Surface Surveillance capability with Indications and Alerts
- Enhanced Vision Systems for Taxi Operations

1.1.1 Baseline

The baseline case, which is based upon the completion of Block 0 (B0-75 Runway Safety), comprises the use of an aerodrome surface primary radar system and display. This permits the surveillance of all aircraft and ground vehicles without any need for cooperative surveillance equipment installed on the aircraft/vehicles. This improvement allows ANSP personnel to better maintain awareness of ground operations during periods of low visibility. In addition, the presence of safety logic allows for limited detection of runway incursions.

1.1.2 Change brought by the module

The following capabilities are added to the aerodrome primary surveillance capability by Block 1:

- Cooperative surveillance provides a means to identify surveillance targets with specific flight identification. This is a significant improvement to the identification and correction of unsafe conditions such as runway incursion, and reduces the degradation of surveillance due to clutter, multipath, shadowing and heavy precipitation.
- Cockpit operations receive a display of the surface map, with "ownship" and other traffic depicted. This enhances visual scanning, especially during low-visibility conditions and in cases where the aerodrome is unfamiliar to the flight crew.
- Cockpit visual scanning is further improved by the addition of Enhanced Vision Systems (EVS), which provides better visual awareness of surroundings during periods of reduced visibility (e.g. night, weather obscuration).

1.1.3 Other remarks

The capabilities in this block are intended to provide the foundation for improving surface operations in all weather conditions, through improved management of taxiways and departures, and via integration of surface operations with arrival and departure flow operations. These capabilities will be addressed in Block B2-75 A-SMGCS Level 3/4 with Synthetic Vision Systems.

2 Element 1: Enhanced ANSP Surface Surveillance Capability with Safety Logic

This element of the block enhances the primary radar surface surveillance with the addition of at least one cooperative surface surveillance systems. These systems include (1) aerodrome multilateration secondary surveillance, and (2) Automatic Dependent Surveillance – Broadcast (ADS-B). As with TMA and En Route secondary surveillance/ADS-B, the cooperative aspect of the surveillance allows for matching of equipped surveillance targets with flight data, and also reduces clutter and degraded operation associated with primary surveillance.

2.1 Intended Performance Operational Improvement/Metric to Determine Success

The addition of cooperative surveillance has a significant positive benefit to the performance of safety logic, as the tracking and short term trajectory projection capabilities are improved with the higher quality surveillance. Alerting with flight identification information also improves the ANSP personnel response to safety situations. Also, this capability provides for a marginal improvement in routine management of taxi operations and more efficient sequencing of aircraft departures.

a. Safety
b. Reduced number of runway incursion incidents
c. Improved response times to correction of unsafe surface situations
d. Efficiency
e. Reduced Taxi Times
f. Improved handling of runway sequencing

2.2 Necessary Procedures (Air & Ground)

As this capability is largely intended to enhance situational awareness of ANSP personnel, while specific procedures are needed for use of the new equipment, they do not significantly change surface operating practices.

An exception to this is ANSP personnel response to safety logic alerting; detailed procedures on proper response to alerts must be incorporated into training and operations.

2.3 Necessary Technology (Air & Ground)

This element requires the following ground technology:

a. Aerodrome Multilateration System
b. Automatic Dependent Surveillance – Broadcast ground station
c. Aircraft transponder *or* ADS-B out avionics
d. Aerodrome Safety Logic

2.4 Regulatory/Standardisation Needs and Approval Plan (Air & Ground)

Standards for Element 1 require those for Aerodrome Multilateration systems, ADS-B ground systems, and Safety Logic, which have been approved for operational use in the US and other member states. Guidance on these systems can be found in the ICAO Surveillance Multilateration Manual. Guidance on cockpit systems is given in the ICAO Airborne Surveillance Manual.

2.5 Business Case Specific to the Element

The business case for this element is largely made around safety. Currently, the aerodrome surface is often the regime of flight which has the most risk for the failure of aircraft separation, due to the lack of good surveillance on the ground acting in redundancy with cockpit capabilities. Efficiency gains are expected to be marginal and modest in nature. (Details TBD)

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Many aerodromes around the world already use Multilateration techniques. For example, the US Federal Aviation Administration has completed initial deployment of operational Multilateration systems (2010), and is in the process of deploying operational Automatic Dependent Surveillance-Broadcast surveillance systems to aerodromes, including the enhanced safety logic, for ANSP use in aerodrome control towers. These systems are operational at 35+ aerodromes in the US, and similar systems are being deployed world-wide.

Deployment to additional aerodromes, using differing combinations of surveillance technology, is planned through 2018 and beyond.

2.6.2 Planned or Ongoing Trials

The US NextGen and EUROCONTROL Multilateration Task Force (MLTF) programs are supporting deployment of Element 1 capability to additional aerodromes, using various combinations of primary and secondary surveillance. This includes low cost ground surveillance programs, which may unite a more affordable primary radar system with ADS-B. Within SESAR programme a dedicated project on “Enhanced surveillance function” has been set up. . The intended scope of the project is to define , verify and validate in field, enhanced techniques of multi-sensor data fusion taking into considerations the availability of new sensors (ADS-B, Multilateration, video cameras) and new data directly extracted from aircraft and the intrinsic variability of meteorological conditions.

In initial operational capabilities should be in the 2012-2016 timeframe.

3 Element 2: Enhanced Cockpit Surface Surveillance Capability with Indications and Alerts (ATSA-SURF)

This element of the block introduces surface moving map capabilities in the aircraft cockpit, to assist the flight crew with navigation and traffic situational awareness:

- Basic capability is provided by the addition of an electronic display which can depict the aerodrome chart. This basic capability is essentially a replacement of paper charts with an electronic presentation.
- Initial enhancements include the ability to depict the ownship aircraft location on the aerodrome chart, based on Area Navigation avionics (e.g. Global Navigation Satellite System) installed on the aircraft.
- Additional enhancements allow for other aerodrome traffic to be depicted on the display. This information may be direct aircraft-to-aircraft (e.g., via ADS-B In avionics on the own ship combined with ADS-B Out avionics on other aircraft), or may be provided via a Traffic Information Service-Broadcast (TIS-B) from the ANSP based on ANSP surveillance.
- The final enhancement to cockpit capability is the addition of safety logic to the avionics, which allows for detection of potential unsafe situations (e.g. runway already occupied) independent of any ground system, the presentation of these situations (e.g., by highlighting the occupied runway), and by providing a visual and aural alert.

3.1 Intended Performance Operational Improvement/Metric to Determine Success

The addition of cockpit electronic maps, with aerodrome and traffic depictions, further enhanced by safety logic, provides enhanced redundancy for the detection of potentially unsafe situations on the aerodrome surface. Also, this capability provides for a marginal improvement surface efficiency, as there will be improved situational awareness of taxi routes, especially at aerodromes unfamiliar to the flight crew.

a. Safety
b. Fewer navigation errors
c. Reduced number of runway incursions
d. Improved response times to correction of unsafe surface situations
e. Efficiency
f. Reduced Taxi Times
g. Fewer navigation errors requiring correction by ANSP

3.2 Necessary Procedures (Air & Ground)

This element requires adherence to Aircraft Flight Manual approved procedures for the use of the equipment. These procedures outline limitations to the use of the equipment and the proper incorporation of new capabilities into the existing taxi procedures and techniques (e.g. appropriate heads-up and heads-down times, integration with effective Cockpit Resource Management, etc.). Flight crew response to alerting capabilities requires incorporation into appropriate initial and recurrent training modules. An example of guidance to operators can be found in FAA Advisory Circular AC120-86 Aircraft Surveillance Systems and Applications.

3.3 Necessary Technology (Air & Ground)

This element requires aircraft technology:

a. Aerodrome Moving Map
b. Area Navigation position source (e.g. Global Navigation Satellite System)
c. ADS-B/TIS-B receiver
d. Cockpit Safety Logic

3.4 Regulatory/Standardisation Needs and Approval Plan (Air & Ground)

Avionics standards developed by RTCA SC-186/Eurocae WG-51 for ADS-B, and aerodrome map standards developed by RTCA SC-217/Eurocae WG-44, are needed for this element.

3.5 Business Case Specific to the Element

The business case for this element is largely made around safety. Currently, the aerodrome surface is often the regime of flight which has the most risk for the failure of aircraft separation, which can be addressed by augmented visual scanning in the cockpit, acting in conjunction with ANSP capabilities. Efficiency gains are expected to be marginal and modest in nature. (Details TBD)

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

The US and Europe are also in the process of defining avionics standards for the cockpit capabilities, with operational capabilities expected to be phased in now through 2017. Standards are also being developed for ground vehicle equipment to allow them to be “seen” via ADS-B.

3.6.2 Planned or Ongoing Trials

No specific trials in the US or Europe are identified at this time.

4 Element 3: Enhanced Vision Systems for Taxi Operations

This element of the block provides for additional avionics which add electromagnetic sensors outside the visible light spectrum (e.g. infrared cameras, Millimeter Wave Radar). These sensors will allow for improved navigation by visual reference, even during conditions of low-light or weather obscuration such as fog. Presentation to the flight crew may be through an instrument panel display (Liquid Crystal Display or Cathode Ray Tube) or via Heads-Up Display (HUD), etc..

4.1 Intended Performance Operational Improvement/Metric to Determine Success

The addition of cockpit enhanced vision capabilities will improve flight crew awareness of ownship position, and reduce navigation errors during periods of reduced visibility. In addition, improved situational awareness of aircraft position will allow for more confidence by the flight crew in the conduct of the taxi operation during periods of reduced visibility.

a. Safety
b. Fewer navigation errors
c. Reduced number of runway incursions
d. Improved response times to correction of unsafe surface situations
e. Efficiency
f. Reduced Taxi Times
g. Fewer navigation errors requiring correction by ANSP

4.2 Necessary Procedures (Air & Ground)

This element requires adherence to Aircraft Flight Manual approved procedures for the use of the equipment. These procedures outline limitations to the use of the equipment and the proper incorporation of new capabilities into the existing taxi procedures and techniques (e.g. appropriate heads-up and heads-down times, integration with effective Cockpit Resource Management, etc.)

4.3 Necessary Technology (Air & Ground)

This element requires an Enhanced Flight Vision System in the aircraft. Some technologies may require compatible runway/taxiway lighting on the aerodrome surface.

4.4 Regulatory/Standardisation Needs and Approval Plan (Air & Ground)

Avionics standards developed by RTCA SC-213/Eurocae WG-79 for Enhanced Vision Systems are needed by this element.

4.5 Business Case Specific to the Element

Currently, improving flight crew situational awareness of ownship position during periods of reduced visibility will reduce errors in the conduct of taxi operations, which lead to both safety and efficiency gains. (Details TBD)

4.6 Implementation and Demonstration Activities

4.6.1 Current Use

Certification of Enhanced Flight Vision Systems for aerodrome surface operations have been accomplished for several aircraft types by several member States as of this writing (e.g. Dassault Falcon 7X, Gulfstream GVI, Bombardier Global Express).

4.6.2 Planned or Ongoing Trials

No specific trials in the US or Europe are identified at this time

5 Main Dependencies

Successor of: B0-75

Module N° B1-80: Optimised Airport Operations through A-CDM

TBC

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Module N° B1-81: Remotely Operated Aerodrome Control Tower

<table>
<tr><td>Summary</td><td colspan="2">Remotely Operated Aerodrome Control concerns the provision of ATS to aerodrome(s) from a facility which is not local to the aerodrome itself. The direct Out The Window (OTW) view is replaced by other information sources relayed to the remote facility e.g. visual reproduction via cameras, virtual reproduction using surveillance information and/or synthetic models etc. The ability to enhance the situational awareness of the aerodrome traffic picture and for one ATCO/AFISO to provide ATS to more than one aerodrome at a time is also anticipated, as is application in Contingency Situations.

The performance objective is to provide a safe and cost effective ATS to aerodromes where dedicated, local ATS is no longer sustainable or cost effective, but there is a local economic and social benefit from aviation.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-03 - Cost Effectiveness, KPA-04 – Efficiency, KPA-10 - Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">TMA, Descent, Airport Surface, Climb Out.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">The main target for the Single and Multiple Remote Tower Services are small rural airports, which today are struggling with low business margins. Both ATC and AFIS aerodromes are expected to benefit.

The main targets for the Contingency Tower solution are medium to large airports – those that are large enough to require a contingency solution, but who require an alternative to A-SMGCS based “heads down” solutions or where maintaining a visual view is required.

Although some cost benefits are possible with remote provision of ATS to a single aerodrome, maximum benefit is expected with the remote of ATS to multiple aerodromes.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">CM: Conflict Management

AO: Airport Operations</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-13 Aerodrome design and management

GPI-15 Match IMC and VMC operating capacity

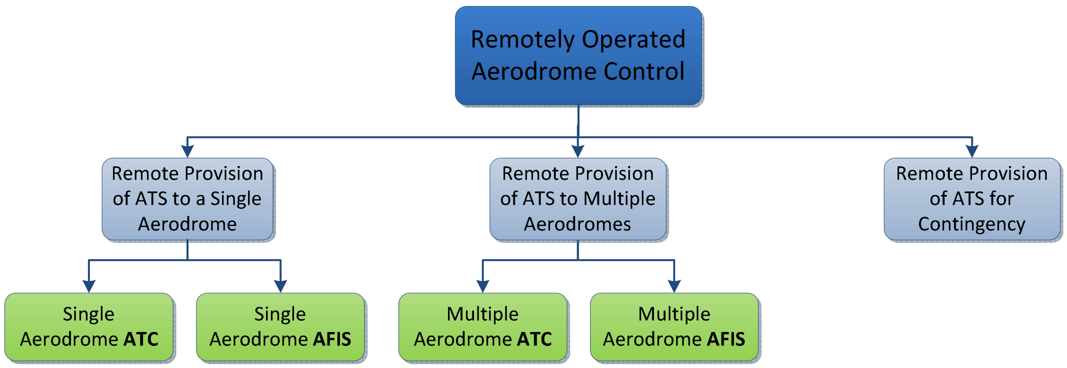
GPI-9 Situational awareness</td></tr>
<tr><td>Reference Documents</td><td colspan="2"></td></tr>
<tr><td>Main Dependencies</td><td colspan="2">None</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (indicate ready with a tick or input date)</td></tr>
<tr><td>Standards Readiness</td><td>2018</td></tr>
<tr><td>Avionics Availability</td><td>N/A</td></tr>
<tr><td>Infrastructure Availability</td><td>2018</td></tr>
<tr><td>Ground Automation Availability</td><td>2018</td></tr>
<tr><td>Procedures Available</td><td>2018</td></tr>
<tr><td>Operations Approvals</td><td>2018</td></tr>
</table>

1 Narrative

1.1 General

Remotely Operated Aerodrome Control concerns the provision of ATS to aerodrome(s) from a facility which is not located at the aerodrome itself.

Remotely Operated Aerodrome Control can be applied for a single aerodrome (either ATC or AFIS) where the local tower can be replaced by a remote facility; for multiple aerodromes where the local towers of several aerodromes can be replaced by a single remote facility; or for larger single aerodromes that require a facility to be used in contingency situations. This is illustrated in the figure overleaf.



The concept does not seek to change the air traffic services provided to airspace users or change the levels of those services. Instead it changes the way those same services will be provided through the introduction of new technologies and working methods.

The visual surveillance will be provided by a reproduction of the Out of The Window (OTW) view, by using visual information capture and/or other sensors. The visual reproduction can be overlaid with information from additional sources if available, for example, surface movement radar, surveillance radar, multilateration or other positioning and surveillance implementations providing the positions of moving object within the airport movement area and vicinity. The collected data, either from a single source or combined, is reproduced for the ATCO/AFISO on data/monitor screens, projectors or similar technical solutions.

The provision of ATS from a local tower building (as in today's operations) has some constraints at some airports due to the single operational viewpoint from a central, high up perspective, and subject to prevailing viewing conditions at the time (e.g. clear, foggy). This can create some minor limitations in capability, which is accepted in 'traditional' air traffic control. With the use of reproduced visual views, these limitations can potentially be eliminated. Visual information capture and reproduction can still be done in order to replicate the operational viewpoint obtained from a traditional tower view and this may ease the transition from current operations to remote operations and also provide some common reference points. Alternatively, several operational viewpoints may be based on information captured from a range of different positions, not necessarily limited to the original tower position. This may provide an enhanced situational awareness and/or a progressive operational viewpoint. In all cases, the visual reproduction shall enable visual surveillance of the airport surface and surrounding area.

With the digitisation, or computer generation of the relayed information, visual enhancements are possible. These can be used to enhance situational awareness in all visibilities.

With the removal or decommissioning of individual local towers, disparate systems and procedures can be standardised to a greater level in a shared uniform facility.

With many aerodromes operating from a shared facility using common systems, the possibility to share system wide information can increase.

The ATCO/AFISO will not have the ability to perform any tasks that are external to the control facility e.g. physical runway inspection. The aim is that that they primarily will focus on the pure ATS tasks, and other tasks will be secondary and/or performed by personnel local to the aerodrome.

Although it is not necessary, it will be possible to remove the local control tower as it will no longer be used for the provision of air traffic services. The need to have a single, tall tower building at the aerodrome will disappear. The infrastructure (service, maintenance etc.) that goes along with maintaining such a building will also become redundant. Instead, a local installation consisting of systems/sensors will be maintained (perhaps less frequently) by central maintenance teams. The remote facility will also require maintenance, but it is expected that a more 'traditional' building using common systems and components will lead to a reduction in overall maintenance costs.

1.1.1 Baseline

Remotely Operated Aerodrome Control will be built on today's local aerodrome operations and services.

The Single Tower services will be implemented first (2012 onwards), thereby acting as a baseline for the Multiple Tower services. Contingency services are already in initial service and will evolve with the capabilities developed for Remotely Operated Aerodrome Control.

Specifically, the Out of the Window component of this solution will enhance existing contingency solutions e.g. London Heathrow Virtual Contingency Facility.

1.1.2 Change brought by the module

The main improvements will be:

- Safety;
- Lower operating costs for the aerodrome;
- Lower cost of providing ATS to the airspace users;
- More efficient use of staff resources;
- Higher levels of standardisation/interoperability across remote aerodrome systems and procedures;
- Higher situational awareness in low visibility conditions using visual enhancements;
- Greater capacity in low visibility conditions;
- Greater capacity in contingency situations.

1.2 Element 1: Remote Provision of ATS for Single Aerodromes

The objective of Remote Provision for a Single Aerodrome is to provide the ATS defined in ICAO Documents 4444, 9426 and EUROCONTROL's Manual for AFIS for one aerodrome from a remote location. The full range of ATS should be offered in such a way that the airspace users are not negatively impacted (and possibly benefit) compared to local provision of ATS. The overall ATS will remain broadly classified into either of the two main service subsets of TWR or AFIS.

The main change is that the ATCO or AFISO will no longer be located at the aerodrome. They will be re-located to Remote Tower facility or a Remote Tower Centre (RTC).

It is likely that an RTC will contain several remote tower modules, similar to sector positions in an ACC/ATCC. Each tower module will be remotely connected to (at least) one airport and consist of one or several Controller Working Positions (CWP), dependent on the size of the connected airport. The ATCO will be able to perform all ATS tasks from this CWP.

1.3 Element 2: Remote Provision of ATS for Multiple Aerodromes

The objective of Remote Provision for Multiple Aerodromes is to provide aerodrome ATS for more than one aerodrome, by a single ATCO/AFISO, from a remote location i.e. not from individual control towers local to the individual aerodromes. As with Single Aerodromes, the full range of ATS should be offered in such a way that the airspace users are not negatively impacted (and possibly benefit) compared to local provision of ATS and the overall ATS will remain broadly classified into either of the two main service subsets of TWR or AFIS.

The Remote Provision of ATS to Multiple Aerodromes can be operated in a number of ways depending on several factors. The common, general principle is that a single ATCO/AFISO will provide ATS for a number of aerodromes. A number of staff resources (ATS personnel) and a number of CWP will be co-located in an RTC which may be a separate facility located far from any airport, or an additional facility co-located with a local facility at an aerodrome.

The additional factors to be considered for remote ATS to multiple Aerodromes include:

- Resource Management – balancing of shift size according to the number of aerodromes, traffic demand, and the number of aerodromes a single ATCO/AFISO can provide service to;
- Controller Working Positions – the number and configuration of CWP in the RTC. A single CWP may serve one aerodrome, several aerodromes, or share service provision to the same aerodrome with other CWP (larger aerodromes only);
- Operating Methods – it is expected that the ATCO/AFISO will be able to provide ATS to more aerodromes when there are no current aircraft movements at those aerodromes yet the airspace is Established and provision of ATS is required. As traffic increases, the maximum number of aerodromes per single ATCO/AFISO will decrease;
- Air Traffic Management – The ability to accommodate both IFR and VFR traffic requires management – demand and capacity balance. Slot coordination and traffic synchronisation across multiple aerodromes will help extract maximum benefit from Multiple Tower by reducing the occasions when several aerodromes have simultaneous aircraft movements;
- Aerodrome clustering – the selection of which aerodromes can be operated in parallel by a single ATCO/AFISO;
- Approach Control – whether the approach control is also provided by the multiple aerodrome ATCO/AFISO, whether it is provided by a dedicated APP controller, or a combination of both;

Each factor contains several options and it is the combination of these options for a given set of aerodromes that determines the make-up of an RTC.

1.4 Element 3: Remote Provision of ATS for Contingency Situations

The objective of this service is to apply the principles used for Remote ATS in order to establish standby installations and a contingency solution for medium to high density airports, to assist in cases where the primary (local) tower is out of service and contingency is required.

A Remotely Operated Aerodrome Control facility can be used to provide alternative facilities, and the Remote Tower can provide alternative services, without compromising safety and at a reasonable cost, in cases where:

- Visual operations are required;
- Radar coverage is not available;
- Systems such as A-SMGCS are not available.

This service provides a cost effective alternative to the systems used at many large airports (e.g. A-SMGCS based). This may enable also the small and medium size airports (i.e. those without ‘traditional’ contingency solutions) to fulfil or improve upon their obligations with respect to European SES regulation CR §8.2 “An ANSP shall have in place contingency plans for all services it provides in cases of events which result in the significant degradation or interruption of its services”.

2 Intended Performance Operational Improvement/Metric to determine success

Remotely Operated Aerodrome Control is aimed at providing benefits in three main areas – Safety, Cost Effectiveness and Efficiency. In addition, it is necessary for the concept to maintain performance at least as good as current operations in other Key Performance Areas (KPA).

Access and Equity	As above, the implementation of the concept, and the Multiple Aerodrome applications in particular, should not affect the levels of access each type of airspace user has to the aerodrome.
Capacity	Capacity should not be reduced through the removal of local facilities, or through the sharing of resources across multiple aerodromes. It may even be increased through the use of digital enhancements in low visibility
Cost Effectiveness	This is the main benefit delivered by the Remote Tower. The benefit is expected through provision of air traffic services from remote facilities. For single aerodromes these facilities will be cheaper to maintain, able to operate for longer periods and enable lower staffing costs (through centralised training and resource pools). For multiple aerodrome additional cost effectiveness benefits can be achieved through the ability to control a greater number of aerodromes with fewer individual facilities and controllers.
Efficiency	Efficiency benefits are provided in three main areas. The first is the cost effectiveness benefits described above, centred around using assets and resources more efficiently thus leading to a more cost effective service. The second is the ability to exploit the use of technology in the provision of the services. Digital enhancements can be used to maintain throughput in low visibility conditions, thus making a more efficient use of available capacity
Flexibility	The implementation of the concept, especially the Multiple Aerodrome service must not affect the ability to provide a flexible service to the airspace users. It may even be increased through a greater possibility to extend opening hours when through remote operations
Safety	Safety is the number one concern for air traffic. The provision of air traffic services (facilities and staff) from a remote location should provide the same, or greater if possible, levels of safety as if the services were provided locally. The use of the digital visual technologies used in the RVT may provide some safety enhancements in low visibility.

CBA	Cost Benefit Assessments for previous remote tower research programs have shown a cost benefit to exist in the target environment. Since there are no current operational remote towers these CBA were necessarily based on some assumptions. However, these assumptions were developed by a working group of subject matter experts and considered reasonable working assumptions. There are costs associated with remote tower implementation including the costs of procurement and installation of equipment. There are additional capital costs in terms of new hardware and adaptation of buildings. New operating costs are incurred in the form of facilities leases, repairs and maintenance and communication links. There are then short term transition costs such as staff re-training, re-deployment and relocation costs. Against this, savings are derived from remote tower implementation. A significant portion of these result from savings in employment costs due to reduction in shift size. Previous CBA indicated a reduction in staff costs of 10% to 35% depending on the scenario. Other savings arise from reduced capital costs, particularly savings from not having to replace and maintain tower facilities and equipment and from a reduction in tower operating costs. The CBA concluded that remote tower does produce positive financial benefits for ANSP. Further Assessment of Costs and Benefits (ACB) will be conducted during 2012 and 2013 using a range of implementation scenarios (Single, Multiple, Contingency).

3 Necessary Procedures (Air & Ground)

The concept aims to maintain as many current air and ground procedures as possible. The services provided remain the same and there should be no impact on airspace users.

Some new operating methods may be required for tasks which are external to the current aerodrome tower. The ATCO/AFISO will not have the ability to perform any tasks that are external to the control facility e.g. physical runway inspection. The aim is that that they primarily will focus on the pure ATS tasks, and other tasks will be secondary and/or performed by personnel local to the aerodrome.

New fallback procedures are required in case of full or partial failure of the RTC. In cases of complete failure, there is no possibility for reduced operations. All ATS will be suspended until the system can be at least partially restored and traffic may be re-routed to other aerodromes in the meantime

In cases of partial failure, it is expected that the failure scenario can be mapped to existing procedures. For example, loss of visual reproduction when operating remotely can be likened to low visibility when operating from a local tower. Therefore 'local' LVP could be adapted for use under visual reproduction failure. However, this will only apply when contingency procedures do not require a local solution.

4 Necessary Technology (Air & Ground)

For Remotely Operated Aerodrome Control the main technology is the development of camera-based solutions. Camera and display technologies aimed at user acceptance are focused at creating a uniform visual view which is perceived as smooth and delivers the level of quality and information required to provide safe and efficient ATS. Other CWP and HMI technologies are focused on creating an acceptable method for interaction with the remote tower systems and controller working position as a whole.

Situational awareness is addressed by looking at placement of visual surveillance sensors, to enhance the visual view by means of night vision and image enhancement, and extend it with graphical overlay such as tracking information, weather data, visual range values and ground light status etc.

Except implementation of sensors and facilities on the airport, suitable communication capabilities between the airports and the RTC is required.

For Remotely Operated Aerodrome Control, Virtual Tower technology must fuse heterogeneous data sources such as surveillance data, map data, terrain models, 3D satellite data, Computer Aided Design (CAD) models, aerial laser scans (LIDAR), and potentially others. These must then be consolidated into a coherent representative model usable by at ATCO/AFISO to provide a real time service. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Specification are already available in RTCA and EUROCAE documents.

Material for provision of ATS in Contingency situations already exists, but not for the solutions delivered by this concept. However, no regulatory or standardisation material exists for the remote provision of ATS. It will therefore need assessment, development and approval as appropriate before operations.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

TBD

6 Implementation and Demonstration Activities

6.1 Current Use

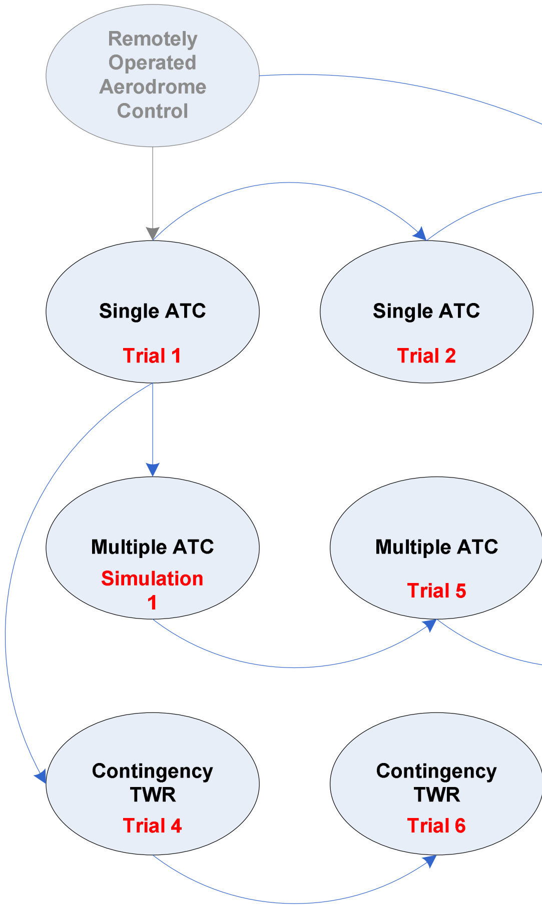
There is no current operational use of Remotely Operated Aerodrome Control in normal operations. Some aerodromes have contingency facilities, but none that include an OTW view.

An implementation project in Sweden began in 2011 for Sundsvall and Örnsköldsvik aerodromes. The system, jointly developed by Saab and LFV, is expected to be installed and tested in 2012 and to become operational in 2012/2013. Air traffic at Sundsvall and Örnsköldsvik airports will then be controlled from a joint air traffic control centre located in Sundsvall.

6.2 Planned or Ongoing Trials

In support of ongoing implementations and further developments, several trials are planned during the 2011 to 2014 period. A range of candidate operational environments in Sweden (ATC) Norway (AFIS) and

Australia will be selected. Trial and environment specific methods and procedures will be developed. The set of trials is shown in the figure below.



Shadow Mode trials for the Single Tower service will take place in 2011 and 2012.

A Real Time Simulation for the Multiple Tower service will be conducted in 2012, followed by Shadow Mode trials in 2013 and 2014.

Shadow Mode trials for the Contingency Service will take place in 2013 and 2014.

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Module N° B1-15: Improved Approach and Departure Management through Integration

Summary	This module includes a brief description of integrated surface management and departure sequencing. The module also summarizes the benefits of departure sequencing and its integration with surface management.
Main Performance Impact	KPA-02 – Capacity; KPA-03 – Cost Effectiveness; KPA-04 – Efficiency; KPA-05 – Environment; KPA-06 – Flexibility; KPA-09 - Predictability;
Domain / Flight Phases	Aerodrome and Terminal
Applicability Considerations	Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements. Complexity in implementation of this block depends on several factors. Some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this block. Infrastructure for RNAV/RNP routes need to be in place.
Global Concept Component(s)	TS – Traffic Synchronization
Global Plan Initiatives (GPI)	GPI-6 Air Traffic Flow Management
Reference Documents	European ATM Master Plan, SESAR Definition Phase Deliverable 2 – The Performance Target, SESAR Definition Phase Deliverable 3 – The ATM Target Concept, SESEAR Definition Phase 5 – SESAR Master Plan TBFM Business Case Analysis Report NextGen Midterm Concept of Operations v.2.0 RTCA Trajectory Concept of Use
Main Dependencies	B0-15

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	2018
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

NextGen and SESAR share a common strategic objective to introduce operational and technical capabilities that builds toward the future ICAO Global Air Traffic Management Operational Concept. Both efforts seek to implement automation systems and more efficient operational schemes to better utilize congested airspace.

In Block 1 (2018), departure management will be integrated with surface management. The augmented surface surveillance information can be tapped to provide more precise departure traffic planning and timely updates. In addition, enhanced surface management will increase aerodrome throughput without compromising wake separation and other safety protocols. Aerodrome capacity and throughput is closely tied to surface surveillance and management. Precise surface movement and guidance in all weather conditions and reduced runway occupancy time will immensely improve the efficiency of surface operations. In particular, improved surface surveillance and management will facilitate the optimal use of movement areas.

The synergy of precise surface management and departure sequencing will further hone the predictability and accuracy of departure times assigned to flights. It will enable departure dynamic spacing and sequencing, leading to a higher departure rate. Departure and arrival patterns can be adjusted to lessen the impact separation procedures posed. Flights can be sequenced such that the effect of natural phenomena (i.e. wake vortex) can be mitigated. . Wake vortex effects can be minimized by putting a series of heavy aircrafts behind light aircrafts, as wake vortex generated by light aircrafts dissipates quickly. The coupling of surface and departure management enables greater flexibility in runway balancing. Runway can be re-configured to adapt and support the ever changing arrival and departure scenarios. The runway usecan be configured such that wake vortex effects can be circumvented, e.g. dedicated runways for heavies and light aircrafts that diverge into different directions.

Expansion of time base metering into adjacent en-route airspace and more prevalent use of performance based procedures, such as RNAV/RNP, will further optimise resource utilisation in high density areas. The linkage will improve predictability, flexibility, and optimized departure and surface operations.

The expansion of time based metering into the adjacent en-route domain is also crucial part of Block 1. Extending metering enables adjacent ATC authorities to collaborate with each other and manage and reconcile traffic flows more effectively. Coordination between ATC authorities will require common situational awareness and consistent execution of ATM decisions. The coordination requires consistent trajectory, weather, and surveillance information exchange across Flight Information Regions (FIRs). Information such as CTAs, position, and convective weather must be uniformed and their interpretation consistent.

Block 1 also seeks to increase the utilisation of performance based navigation procedures such as RNAV/RNP procedures in high density areas by linking the procedures to metering to support successful execution. RNAV/RNP procedures can efficiently direct flights into arrival and departure metering fixes and beyond. This will further optimize both aerodrome and terminal resource allocation.

The TBFM program in the US seeks to augment TMA (Trajectory Management Advisor) and strive to close the performance gaps in TMA. Generally, TBFM aims to improve and optimise the sequencing to maximize airspace utilization. In addition, TBFM will extend metering and sequencing to other domains and incorporate delay information imposed on flights by TMIs (Traffic Management Initiatives). Similarly, AMAN/DMAN works toward integrated, synchronized sequencing of all flight phases. The aims of the US and European efforts are congruous.

1.1.1 Baseline

Block 0 introduced time based metering, arrival and departure management automation. These automations work independently, with the ATC personnel serving as the integrator of information generated by these systems.

Metering in terminal airspace reduced the uncertainty in airspace and aerodrome demand. Flights are controlled via Control Time of Arrival. The CTA dictates the time in which the flight must arrive or risk losing the slot. This enables ATM to predict, with reasonable accuracy, the future demand for terminal airspace and aerodrome. Terminal ATC authority can now adjust the arrival sequence to better utilise limited resources in the terminal domain.

Department management automation provides departure scheduling. Departure scheduling will optimise the sequence in which the flow is fed to the adjacent ATC authorities. Departure is sequenced based on flights' arrival flow constraints. Departure management also provides automated disseminations and communication of departure restriction, clearance, and other relevant information.

Arrival and departure metering automation efforts maximizes the use of capacity and to assure full utilization of resources by assuring ATC authorities of more efficient arrival and departure paths. They have the secondary benefit of fuel efficient alternatives to hold stacks in an era in which fuel continues to be a major cost driver and emissions is a high priority.

1.1.2 Improvement brought by the module

This module will enable surface management, extended metering, and departure/surface integration. Departure management automation will eliminate conflicts and provide smoother departure operations and streamlined synchronization with adjacent ATC authority. Enhanced surface movement tracking and control will decrease each flight's runway occupancy time on the aerodrome surface, thus boosting aerodrome throughput. In addition, integrated surface and departure management enable more flexible runway balancing, further increase aerodrome throughput. This integration will also facilitate more efficient and flexible departure operations and ensure optimized resource allocation both on the aerodrome surface and in the terminal airspace.

Extended metering will foster greater accuracy and consistency in Control Time of Arrival (CTAs). Errors in CTAs in long range metering are inevitable, but can be mitigated via coordination between different ATC authorities. Coordination will lead to reconciliation of trajectory, weather, surveillance, and other relevant information for ATM. This coordination will eliminate misunderstanding and misinterpretation of ATM decisions. Delays will be contained in the en-route domain, where the airspace users can accommodate such delays in an economical manner.

Performance based procedures such as RNAV/RNP in high density areas will lead to more optimal utilisation of airspace. In addition to optimal airspace utilisation, RNAV/RNP routes are more fuel efficient. The RNAV/RNP procedures streamlines and un-tangled the arrival and departure flows to ensure continuous streams. These procedures lessen the negative impacts and transition time for modifying the configuration of the runways and their associated approach fixes. Time based metering enables the continuous application of PBN procedures in high density operations.

2 Element 1: Surface Management

Enhanced surface management includes improvements in the precision of surface movement tracking, conflict detection and control. Surface management manages runway demand and sequences the flights on the ground to support departure operations. Surface management optimizes the sequence to the departure threshold and ensure streamline operations. Such streamlined surface operations facilitate a more robust departure rates by decreasing each flight's time on the aerodrome surface. In addition, surface management provides taxi routing support. Taxi routes are devised based on the location of the aircraft, runway configuration, and user preferences.

2.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of Surface Management, States can use, as appropriate, a combination of the following metrics:

a) Efficiency
   i. Surface Management decreases runway occupancy time, more robust departure rates, and enables dynamic runway rebalancing and re-configuration.
   ii. Runway Occupancy Time
   iii. Runway Throughput
   iv. Achieved Arrival Rate
   v. Departure Rate

b) Capacity
   i. Leads to greater runway capacity
   ii. Runway Throughput
   iii. Sector Throughput

c) Safety
    i. Greater precision in surface movement tracking
    ii. Number of Runway Incursions
d) Predictability
    i. Decreased uncertainties in aerodrome/terminal demand prediction
    ii. Variance between actual and predicted schedule

2.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing surface management consistent with the vision of a performance-oriented ATM System. The TBFM and AMAN/DMAN efforts, along with other surface initiatives, provide the systems and operational procedures necessary.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM 1System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

2.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. Surface management requires more precise surface movement tracking. Mechanism to share surface information effectively and in a timely manner is essential to this element and also fosters greater common situational awareness between all users of the aerodrome surface.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Surface management will entail policies on surface information sharing, roles and responsibilities of all users of the aerodrome surface, and mutual understanding/acceptance of operational procedures. A framework, similar to A-CDM in Europe and surface CDM in the US, should be establish to serve as a forum for all stakeholders to discuss relevant issues and concerns.

2.5 Business Case specific to the element

Surface management streamlines traffic flow on the aerodrome surface and facilitate more efficient use of runways and increase runway capacity. In addition, surface management optimizes departure flow and provide more predictable and gate-arrival times. Greater precision in surface movement tracking can reduce runway incursions and ensure aerodrome user’s safety. Surface management also offers environmental benefits in fuel burn and noise abatement in some aerodromes.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

Surface movement tracking and navigational systems, such as the ASDE-X in the US and initial ASMGCS (Advanced Surface Movement Guidance and Control System) in Europe, are deployed to support tracking, guidance, routing and planning of surface operations.

2.6.2 Planned or Ongoing Trials

SMAN (Surface Manager) will be introduced as the go-to surface management tool in Europe. Similarly, TFDM will be introduced in the US to fulfil the same role. SMAN is a function in the ASMGCS tool to maintain a safe and efficient traffic flow on the surface. Enhanced surveillance will be defined, verified and in-field validated within the SESAR programme in the 2010-2015 time frame.

3 Element 2: Departure and Surface Integration

The integration of departure sequencing and surface management will foster greater predictability and flexibility in surface and departure operations. This integration will facilitate greater assigned departure time compliance, as enhanced surface movement tracking and control will improve the accuracy of the estimated slot time. Furthermore, surface and departure linkage enables dynamic sequencing and runway balancing. Flights can be sequenced to mitigate the effects of undesirable natural phenomena and restrictions. Runway and taxiway assignments will be tied to the projected runway demand, surface traffic level, gate location, and user preferences. Improved runway balancing will ensure that the “meet” time in the airspace and the slot time on the surface are coordinated. These measures serve to increase aerodrome throughput and departure rates.

3.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of departure/surface management integration, States can use, as appropriate, a combination of the following metrics:

a. Efficiency
   i. Departure/Surface integration enables dynamic runway rebalancing to better accommodate arrival and departure patterns.
   ii. Runway Throughput
   iii. Achieved Arrival Rate
   iv. Departure Rate

b. Capacity
   i. Greater terminal capacity via optimized utilization
   ii. Runway Throughput
   iii. Sector Throughput

c. Flexibility
   i. Dynamic sequencing

d. Predictability
   i. Increased compliance with assigned departure time
   ii. Variance between actual and predicted schedule

3.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing integrated departure and surface management consistent with the vision of a performance-oriented ATM System. The IDAC portion of TBFM and AMAN/DMAN efforts, along with other initiatives, provide the systems and operational procedures necessary.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM 1System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

3.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. Integrated departure and surface management entail the synchronization of associate automation. Synchronization and exchange mechanism is needed for such function as well.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Integrated surface and departure management will entail policies and mutual understanding/acceptance of optimized operational procedures for automated surface movement planning/guidance and departure operations. Coordination of meet time and slot time should be managed as part of the optimized operational procedures as well.

3.5 Business Case specific to the element

Integrated surface and departure management streamlines traffic flow on the aerodrome surface and facilitate more efficient use of runways and increase departure rates. This integration improves runway sequencing. Linked surface and departure management offers greater efficiency by synchronizing departure and surface operations. This synchronization ensures that departure activities in the terminal airspace are coordinated with runway state and activities. Surface and departure harmonization will also foster greater accuracy and consistency in runway and departure operations

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

Departure and surface management synchronization is currently achieved mostly through human coordination.

3.6.2 Planned or Ongoing Trials

Departure and surface management synchronization is a crucial component in the TBFM and AMAN/DMAN/SMAN efforts in the US and Europe. Departure and surface management harmonization will be implemented as these capabilities mature.

4 Element 3: Extended Metering

Extended metering will enhance predictability and ATM decision compliance. The ATC authorities meter across FIR boundaries. Extended metering enables ATC authorities to continue efficient time-based metering during high volume traffic and improve overall aerodrome metering accuracy. This will also facilitate synchronization between adjacent en-route ATM authorities/FIRs. With extended metering, delay can be shifted to higher attitudes, where it can be more efficiently absorb by incoming flights. In addition, synchronization will foster a common method and message set among ATC authorities.

4.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of extended metering, States can use, as appropriate, a combination of the following metrics:

1. Efficiency
    a. Traffic flow synchronization between en-route and terminal domain.
        i. Runway Throughput
        ii. Achieved Arrival Rate
        iii. Departure Rate

    b. Reduction in airborne delay/holding
        i. Airborne delay (in minutes)

2. Capacity
    a. Greater terminal capacity via optimized utilization
        i. Runway Throughput
        ii. Sector Throughput

3. Flexibility
    a. Dynamic sequencing

4. Predictability
    a. More accurate assigned arrival time and greater compliance
        i. Variance between actual and predicted schedule

4.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing extended metering consistent with the vision of a performance-oriented ATM System. Extended metering procedures required the coordination of the terminal and adjacent en-route ATM authorities. Some regions may already have such procedures in place.

4.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. Extended metering may be implemented with existing metering automation tools. However, coordination and synchronization between metering and en-route automation is required.

4.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Operational procedures and standards for extended metering exist in different manifestations depending on region. Extended metering might required the modification or the addition of metering points. Approvals might be needed for such revision.

4.5 Business Case specific to the element

Extended metering enables adjacent ATM authorities coordinate departure scheduling and streamline flows to satisfy both sides' constraints. Departure sequencing can be adjusted to fit adjacent centre's arrival constraints. Coordination between two ATM authorities entails the coupling of metering points. Coupled metering points reduce the error in long range metering and reduces the need of Miles-In-Trail restrictions. In addition, the coupled metering points can serve to de-conflict traffic flow. Extended metering also reduces airborne delay by propagating any delay to domain where higher altitudes, where it can be absorb more effectively.

4.6 Implementation and Demonstration Activities

4.6.1 Current Use

Extended metering is in used the US and elsewhere to varying degrees.

4.6.2 Planned or Ongoing Trials

Extended metering will be a crucial component in the TBFM and AMAN/DMAN/SMAN efforts in the US and Europe. Extended metering will be implemented along with these capabilities as they mature.

5 Element 5: Utilization of RNAV/RNP routes

While performance based navigation procedures provide the most fuel efficient and lowest emission paths to the runway, high demand conditions can make these procedures difficult to support at the meter fix. In order to service the demand and maintain individual flight efficiency, linking the RNAV/RNP procedures to the AMAN scheduler will allow sequencing of aircraft so they can funnel efficiently and directly to the metering fix from their Top of Descent (TOD) and enable the execution of PBN procedures such as Optimized Profile Descent (OPD). Time-based metering can sequence the incoming traffic via Controlled Time of Arrival (CTA) and RNAV/RNP assignment. Sequencing by CTA ensures the flight will arrive at the Top of Descent and enable the utilization of Optimize Profile Descent and other RNAV/RNP procedures to a specific waypoint. Time-based metering allows the continuous utilization RNAV/RNP procedures during periods of high traffic volume.

5.1 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of RNAV/RNP routes, States can use, as appropriate, a combination of the following metrics:

1. Efficiency
    a. RNAV/RNP procedures will optimize aerodrome/terminal resource utilization.
        i. Runway Throughput
        ii. Achieved Arrival Rate
        iii. Departure Rate

    b. Higher sector throughput
        i. Sector throughput

    c. Enables more precise routes that are efficient and minimize conflicts (OPD)
        i. Airborne delay (in minutes)

2. Environmental
    a. Reduction in fuel burn and environment impact (emission and noise)
        i. Fuel burn
        ii. Carbon and NO_x emission
        iii. EPNdB level

3. Predictability
    a. More predictable and orderly flow into metering points
    b. Greater compliance to Controlled Time of Arrival (CTA)
        i. Variance between actual and predicted schedule

5.2 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing RNAV/RNP routes consistent with the vision of a performance-oriented ATM System. RNAV/RNP procedures are well-established in the US and Europe. RNAV/RNP procedures can be modified for global adoption.

5.3 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System.

5.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Operational procedures and standards, along with performance requirements for RNAV/RNP routes are needed for its implementation.

5.5 Business Case specific to the element

RNAV/RNP routes represent the most efficient and precise routes. Utilization of RNAV/RNP routes and other PBN procedures provide more reliable, repeatable, predictable, and efficient routing to metering fixes. Delays are reduced via improved trajectory prediction and schedule accuracy. More efficient routing brings about more robust throughput. RNAV/RNP routes are crucial components of the AMAN/DMAN metroplex. In addition to improvement to operational efficiency, RNAV/RNP routes contribute to better fuel efficiency and noise/emission reduction. Improvement in arrival management via CTA will increase the application and utilization of these procedures.

5.6 Implementation and Demonstration Activities

5.6.1 Current Use

RNAV/RNP routes are implemented at the all most metroplex across the US.

6 Main dependencies

Block 1 implementation is depended on the successful adoption and implementation of the predecessor block B0-15. Elements such as RNAV/RNP, surface integration, and extended metering, hinges on sound information sharing and exchange mechanisms and information management.

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Module N° B1-25: Increased Interoperability, Efficiency and Capacity though FF-ICE/1 application before Departure

Summary	Introduction of FF-ICE step 1, to implement ground-ground exchanges using common flight information reference model, FIXM, XML and the flight object used before departure	
Main Performance Impact	KPA-02 – Capacity; KPA-04 Efficiency; KPA-06 Flexibility; KPA-07 Interoperability; KPA-10 Safety,	
Domain / Flight Phases	All flight phases and all types of ATS units Planning phase for FF-ICE/1	
Applicability Considerations	Applicable to at least 2 ACCs dealing with en-route and/or TMA airspace. A greater number of consecutive participating ACCs will increase the benefits. Airspace user and airport	
Global Concept Component(s)	DCB – Demand capacity Balancing CM - Conflict management IM - Information Management	
Global Plan Initiatives (GPI)	GPI-6 ATFM GPI-7 Dynamic and flexible route management GPI-16 Decision Support Systems	
Reference Documents	• Same as B0-25 + • EUROCONTROL OLDI V4.2 • Eurocae ED-133 June 09 Flight Object Interoperability Specification • FF-ICE concept document	
Main Dependencies	B0-25 and B0-30	
Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	2016
	Avionics Availability	No requirement
	Infrastructure Availability	2017
	Ground Automation Availability	2017
	Procedures Available	2017
	Operations Approvals	2017

1 Narrative

1.1 General

The use of FF-ICE/1 permits a better sharing of Flight information before departure for improved Flight planning submission, pre-flight ATFM by facilitating the flight information sharing between all stakeholders (Airspace users, airport and ASP).

1.1.1 Baseline

The baseline for this module is automated standard through a set of messages and limited need for direct speech coordination and present process for submission of FPL through ICAO standardized FPL/2012 messages .

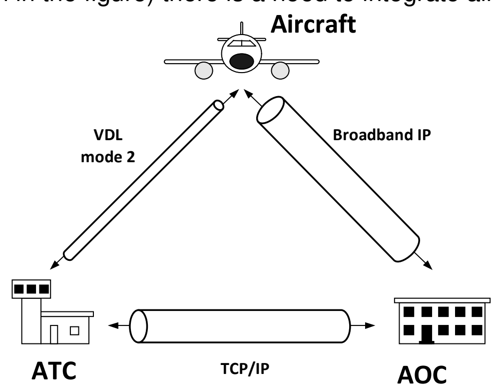
1.1.2 Change brought by the module

1.2 Element 1: FF-ICE/1 before departure

ICAO SARPs for FF-ICE/1 is being developed by ICAO groups between 2012-2015 after endorsement of Flight and Flow Information for a Collaborative Environment (FF-ICE) – A Concept at 12th ANC. It will facilitate the exchange of information associated to Flight plan, allowing more flexibility for flight data submission and publishing.

(Extract from Ref ATMRPP WP470) "The objective of FF-ICE/1 is to establish the basis for transition towards a full FF-ICE deployment. This basis consists of:

- Introduction of Unique Global Flight Identification: introduction of the GUFI
- Introduction of common data format i.e. FIXM in the context of the overall transition to XML for aeronautical information as shown in the following picture:
- Introduction of basic roles, rules and procedures for submission and maintenance of FF-ICE information including provisions for the early sharing of trajectory information.
- Systematic introduction of "Triangle" (Aircraft, AOC, ATC) recognising the constraint that the bandwidth between ATC and aircraft does not allow for (frequent) exchange of 4D trajectory information as foreseen in the FF-ICE concept. The figure below assumes a high bandwidth connection between AOC and aircraft. This may be the case for some operators but not for all. In addition (not shown in the figure) there is a need to integrate airports in the environment for



information sharing.

The Flight Object (FO) concept has been developed to specify the information on environments, flights and flows managed by and exchanged between FDPSs. FF-ICE is a subset of FO but includes, at conceptual level, the interface with the Airspace User (AOC and a/c). FO will be deployed in the target period of FF-ICE/1. FF-ICE/1 standards should therefore be consistent with the evolving standards for FO and especially compliment them with standards on the ground-ground interactions with the Air Space Users."

List of changes included in FF-ICE/1

1. Support for early provision of flight intention information.
2. Support for exchange of 4D Trajectory information between the AOC and the ANSP

3. New format for flight and flow information 5internet protocol and XML
4. Globally Unique Flight Identifier (GUFI)
5. FF-ICE/1 Information Elements (first list of Information elements)

1.3 Other remarks

This module is a second step towards the more sophisticated 4D trajectory for both ground/ground and air/ground exchanges according to the ICAO Global ATM Operational Concept.

2 Intended Performance Operational Improvement/Metric to determine success

Element 1: FF-ICE step1

Access and Equity	
Capacity	
Cost Effectiveness	
Efficiency	Better knowledge of aircraft capabilities allows trajectories closer to Airspace user preferred trajectories and better planning Metrics: fuel consumption and flight time
Environment	
Flexibility	
Global Interoperability	The use of new mechanism for FPL filling and information sharing will facilitate the Flight data sharing among the actors. Metric: number of implementation of FF-ICE-1 by ANSP, AU and AO.
Participation by the ATM community	FF-ICE/1 for Ground-Ground application will facilitate CDM, the implementation or the systems interconnection for Information sharing, trajectory or slot negotiation before departure providing better use of capacity and better flight efficiency.. Metric: number of implementation of FF-ICE-1 by ANSP, AU and AO.
Predictability	
Safety	
Security	

CBA	
Human performance	

3 Necessary Procedures (Air & Ground)

Required procedures exist. They need local instantiation on the specific flows; the experience from other regions can be a useful reference.

Means of compliance: EUROCONTROL OnLine Data Interchange (OLDI) standard

FF-ICE/1 Manual, SARPS and concept of use to be developed.

4 Necessary Technology (Air & Ground)

There are no specific airborne requirements.

FF-ICE/1 SARPS, FIXM and Interface need to be used and require further development in ground systems. Flight Object industrial standards will be implemented in FDPSs.

Airspace users systems will need to be modified to support the provision of FF-ICE to ANSPs

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

For advanced AIDC, ICAO material is available (PANS-ATM, ATN).

Regions should consider the possible mandating of AIDC. Means of compliance are also described in EUROCONTROL OLDI standard and EU regulations: i.e. Implementing Rule on Coordination and Transfer (CE 1032/2006).

For FF-ICE/1 SARPS should be developed and validated

6 Implementation and Demonstration Activities

6.1 Current Use

6.2 Planned or Ongoing Trials

For Element 1: Flight Object validation is taking place in the frame of the SESAR projects 10.2.5 et 4.3 and is planned between 2011 and 2013.

FF-ICE/1 could be considered as part of SESAR WP8 and WP14 in the development of AIRM.

Module N° B1-30: Service Improvement through Integration of all Digital ATM Information

Summary	Implementation of the ATM Information Reference Model (AIRM) integrating all ATM information using UML and enabling XML data representations and data exchange based on internet protocols. Second step of implementation of digital IM, with the WXXM for meteorological information.	
Main Performance Impact	KPA-01 Access & Equity; KPA-03 Cost-Effectiveness; KPA-10 Safety	
Domain / Flight Phases	All phases of flight	
Applicability Considerations	Applicable at State level, with increased benefits as more States participate	
Global Concept Component(s)	IM – Information Management	
Global Plan Initiatives (GPI)	GPI-18 Electronic information services	
Reference Documents	WXXM available in 2012	
Main Dependencies	B0-30, B0-60	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2018
	Avionics Availability	NA
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	√
	Operations Approvals	2018

1 Narrative

1.1 General

The module captures two main actions which capitalise on the advances made in the previous block on the same subject. The module will implement the ATM Information Reference Model (AIRM) capturing all the types of information used by ATM in a consistent set of data and service models (using UML, GML/XML) and that can be accessed via internet protocol based tools. The module also implements a second step of digital information management, with the WXXM for meteorological information and possible flight and flow exchange data models. The further standardisation of aircraft performance data is also to be considered.

1.1.1 Baseline

The baseline at the implementation level is the use of AIXM for AIS data, resulting from module B0-30. The AIXM, the WXXM, and any other xxXM models are compatible with the AIRM.

1.1.2 Change brought by the module

This module expands the approach pioneered by AIXM to the other forms of information by providing the overall reference model framework, allowing each type of data to fit into a consistent picture, the implementation of AIXM providing the foundation for many data that refer to AIM data. It also proceeds with the additional capability to manage, distribute and proceed the weather, possibly flight & flow and aircraft performance related data. In addition to interoperable data, the module starts to provide interoperable information services as part of the transition to a Service Oriented Architecture.

2 Intended Performance Operational Improvement/Metric to determine success

Access and Equity	greater and more timely access to up-to-date information by a wider set of users
Cost Effectiveness	reduction of time to process a new piece of information; reduced use of paper; higher agility of the system to create new applications through the availability of standardised data Metric: reduction of service costs
Efficiency	
Environment	
Flexibility	
Global Interoperability	Essential for global interoperability
Participation by the ATM community	
Predictability	
Safety	reduced probability of error or inconsistency in/across data; reduced possibility to introduce additional errors by subsequent manual inputs Metric: incident occurrences
Security	

CBA	Business case to be established in the course of the projects defining the models and their possible implementation.
Human Performance	

3 Necessary Procedures (Air & Ground)

No new procedures for ATC, but a revisited process for management of information.

4 Necessary Technology (Air & Ground)

All users/producers of the information need to implement AIRM in support of their exchanges with other members of the ATM community.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

The diverse elements of AIRM will be the subject of ICAO standards.

6 Implementation and Demonstration Activities

6.1 Current Use

None identified

6.2 Planned or Ongoing Trials

- **Europe**: SESAR is currently defining and validating the ATM Information Reference Model (AIRM) & Information Service Reference Model (ISRM) including the specific data models Weather Exchange model (WXXM), Flight Information Exchange Model (FIXM),…
- **US:** This is covered through the EA OV-7 and associated service model activities of the NextGen programme.
- US-Europe cooperation is in place on the joint development and maintenance of the data models AIXM/WXXM/FIXM

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Module N° B1-31: Performance Improvement through the Application of System Wide Information Management (SWIM)

Summary	Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximise interoperability. With this module the right, up-to-date and accurate data is timely available to the right user with the required performance and quality. This is an enabler of the most advanced functionalities of the Global Operational Concept.	
Main Performance Impact	KPA-03 Cost-Effectiveness; KPA-05 Environment; KPA-10 Safety	
Domain / Flight Phases	All phases of flight	
Applicability Considerations	Applicable at State level, with increased benefits as more States participate	
Global Concept Component(s)	IM – Information Management	
Global Plan Initiatives (GPI)	GPI-18 Electronic information services	
Reference Documents	ICAO Global Concept	
Main Dependencies	B0-30, B0-60	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2018
	Avionics Availability	NA
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

The goal is a net-centric operation where the ATM network is considered as a series of nodes, including the aircraft, providing or using information. Aircraft operators with operational control centre facilities will share information while the individual user will be able to do the same via applications running on any suitable personal device. The support provided by the ATM network will in all cases be tailored to the needs of the user concerned.

The sharing of information of the required quality and timeliness in a secure environment is an essential enabler to the ATM Target Concept. The scope extends to all information that is of potential interest to ATM including trajectories, surveillance data, aeronautical information of all types, meteorological data etc. In particular, all partners in the ATM network will share trajectory information in real time to the extent required from the trajectory development phase through operations and post-operation activities. ATM planning, collaborative decision making processes and tactical operations will always be based on the latest and most accurate trajectory data. The individual trajectories will be managed through the provision of a set of ATM services tailored to meet their specific needs, acknowledging that not all aircraft will (or will need to) be able to attain the same level of capability at the same time.

SWIM is an essential enabler for ATM applications which provides an appropriate infrastructure and ensures the availability of the information needed by the applications run by the users. The related geo / time enabled, seamless and open interoperable data exchange relies on the use of common methodology and the use of a suitable technology and compliant system interfaces. The availability of SWIM will make possible the deployment of advance end-user applications as it will provide extensive information sharing and the capability to find the right information wherever the provider is.

The phased approach to the deployment of SWIM has been developed to ensure that benefits start of be realised at the earliest possible time by integrating simple end-user applications first. The deployment of SWIM is not dependent on the deployment of ATM changes, benefits can be achieved in largely legacy environments though regulations might be required notably concerning the liability aspects of data provision.

At each stage, the phased implementation of SWIM will consider the three inter-related dimensions (applications, information, infrastructure):

- Applications represent the user side of SWIM. They will be addressed through the identification of “communities of interest” gathering stakeholders that have to share information to serve their interests. The partners in the community know the information they need to share with what quality of service and for effective collaboration they require a common understanding of the information and the information has to be available in a commonly agreed structure. Initially the communities will comprise a core of airports and aircraft operators evolving to include more complex collaborations across the whole ATM business chain.
- Information covers both the semantic and syntactic aspects of data composing information and the Information Management functions. The former is dealt with by modelling activities which aim to use and or define common standards while the latter include mainly distribution, quality, maintenance, user identity and profile to enable data exchange and sharing within a community of interest and between communities independently of the underlying communication infrastructure.
- Infrastructure will be concerned mainly by the connectivity aspects: It will be built on existing legacy infrastructure as far as practicable until an IP based network communications is available. The air/ground segment is an example of SWIM connectivity that is intended to be added at a later stage as aircraft are integrated into the communities of interest (see B1-40).

The combination of the above three areas at particular stages of their common evolution constitute the ATM Capability Levels for Information Management.

1.1.1 Baseline

Module B0-30 will have created a nucleus of modern information management and provided experience to move forward in domains other than AIM. Module B1-30 will in parallel allow ATM information to be structured and managed in fully digital and consistent manner, using the same standards for their description. B0-30 remained a traditional environment where information needed to be requested or was the subject of distribution via classical subscriptions. It was not adapted to the fully dynamic environment that ATM is about, and therefore is started with information not considered as safety critical and/or integrated with other data.

1.1.2 Change brought by the module

This module allows, thanks to the notion of SWIM, to ensure that the right, up-to-date and accurate data is timely available to the right user with the required performance and quality. It represents the achievement of a significant paradigm shift in ATM and is the enabler, together with the appropriate telecommunication infrastructure, of the most advanced features of the Global concept, in particular seamless trajectory based operations.

2 Intended Performance Operational Improvement/Metric to determine success

Cost Effectiveness	further reduction of costs; all information can be managed consistently across the network, limiting bespoke developments, flexible to adapt to state-of-the-art industrial products and making use of scale economies for the exchanged volumes Metric: reduction of costs at equivalent service
Efficiency	(indirect) Using better information allows operators and service providers to plan and execute better trajectories
Environment	further reduction of paper usage (indirect) more cost-efficient flights as the most up to data is available to all stakeholders in the ATM system
Safety	access protocols and data quality will be designed to reduce current limitations in these area Metric: incident occurrences
Security	access protocols and data quality will be designed to reduce current limitations in these area

CBA	The business case is to be considered in the full light of other modules of this block and the next one. Pure SWIM aspects unlock ATM information management issues; operational benefits are more indirect
Human Performance	

3 Necessary Procedures (Air & Ground)

SWIM implies new procedures regarding access to and delivery of information. While most of them should be transparent to tactical ATC functions, there will be a need to be able to distinguish, at least during a transition period, those flights/operators which will have been to acquire information via SWIM from those which still need less advanced information modes.

4 Necessary Technology (Air & Ground)

The ground SWIM infrastructure and its oversight functions to allow the progressive connection of ATM stakeholder systems while meeting the necessary safety, security and reliability requirements.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Standards will be needed in terms of information management, addressing all aspects.

6 Implementation and Demonstration Activities

6.1 Current Use

- **Europe**: use of PENS as backbone for IP ground-ground communications, but currently with no SWIM application. Use of CFMU NOP Portal Web services and EAD AIM services.
- **US**: TBC

6.2 Planned or Ongoing Trials

- **Europe:**
  - SWIM Step1 infrastructure demonstration by the end of 2011
  - Planned Release 2 V&V SWIM-enabled exercises :
    - EXE-04.03-VP-022/ EXE-04.03-VP-026 "IOP Validation" : Support of part of the actual ATC-ATC Coordination by means of a new mechanism based in the Flight Object"
    - EXE-07.06.04-VP-538 "Slot Swapping" : DMEAN implemented improvement (slot swapping). Prototype of enhanced slot swapping function to cover the following requirements: extension to all flights departing from (or arriving to) the same airport (slot swapping between flights from different AOs)
    - EXE-07.06.04-VP-539 "UDPP extension to 4D BT FTS" : Extension to full 4D business/mission trajectory. Different alternative exchange models for collaborative prioritization of flights (compensation value, auction...). UDPP extended to en-route congestion. Fast time model implementing decision tools including different models for priority rules and collaborative prioritization (e.g. auction models, prioritization models, etc).
    - EXE-13.02.02-VP-460 "AIMQuick win (Step1)" : Validate the new ways of publishing complex up-to-date aeronautical information based on the Digital NOTAM concept with its particular temporality data representation.
  - SESAR trials in 2013-16 for SWIM protocols and prototype
- **US:** TBC

Module N° B1-10: Improved Operations through Dynamic ATS Routing

<table>
<tr><td>Summary</td><td colspan="2">Introduction of free routing in defined airspace, where the flight plan is not defined as segments of a published route network or track system to facilitate adherence to the user-preferred profile.

The benefits are primarily in terms of adherence to the user-preferred profile. ATC may need to be provided with the necessary tools to ensure flight progress monitoring and coordination activities, and conflict prediction. The use of dynamic ATS routes can be restricted in some cases, in particular when/where its use would induce concentrations of traffic which consume capacity to the detriment of the overall flow.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 Capacity, KPA-04 Efficiency, KPA-05 Environment</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">En-route, TMA, incl. Oceanic & Remote areas</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Region or sub-region: the geographical extent of the airspace of application should be large enough; significant benefits arise when the dynamic routes can apply across FIR boundaries rather than imposing traffic to cross boundaries at fixed pre-defined points.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">AOM – Airspace Organisation and Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-1 Flexible use of airspace

GPI-8 Collaborative airspace design and management</td></tr>
<tr><td>Reference Documents</td><td colspan="2"></td></tr>
<tr><td>Main Dependencies</td><td colspan="2">B0-10</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>√</td></tr>
<tr><td>Avionics Availability</td><td>√</td></tr>
<tr><td>Infrastructure Availability</td><td>√</td></tr>
<tr><td>Ground Automation Availability</td><td>2018</td></tr>
<tr><td>Procedures Available</td><td>2018</td></tr>
<tr><td>Operations Approvals</td><td>2018</td></tr>
</table>

1 Narrative

1.1 General

1.1.1 Baseline

The baseline is the use of published routes; some of them possibly defined flexibly as a result of FUA, or to better accommodate flows and/or other flight conditions such as weather. Published routes cannot afford for individual flight requirements as they are designed for significant/regular flows; typically flights from/to small airports with infrequent traffic will seldom find their optimum route pre-designed. In addition, published routes offer little freedom once they are published. This issue can be solved by authorising flights to fly direct from a certain position to another point downstream their trajectory; this is generally a benefit to airspace users, but at the price of a significant workload for ATC.

1.1.2 Change brought by the module

Free routing correspond to the ability for flights to file a flight plan with at least a significant part of the intended route which is not defined according to published route segments but specified by the airspace users. It is a user-preferred route, not necessarily a direct route, but the flight is supposed to be executed along the direct route between any specified way-point.

The use of free routing may be subject to conditions, in particular inside a defined volume of airspace, at defined hours, for defined flows. Its use may be limited to traffic under a certain density in order for controllers to be able to perform conflict detection and resolution with limited automation and while still being fully in the loop.

It is also in these conditions of density that the greater freedom for individual flights is less to be traded-off against the achievement of capacity objectives at the network level.

This module would mark the greatest advance in terms of routings by providing maximum individual freedom. However, it is also recognised in the Global Concept that there are conditions where individual freedom has to give way to a more collective handling of traffic flows so as to maximise the overall performance.

2 Intended Performance Operational Improvement/Metric to determine success

Capacity	The availability of a greater set of routing possibilities allows reducing potential congestion on trunk routes and at busy crossing points. This in turn allows reducing controller workload by flight. Free routings naturally spreads traffic in the airspace and the potential interactions between flights, but also reduces the "systematisation" of flows and therefore may have a negative capacity effect in dense airspace if it is not accompanied by suitable assistance. Metric: sector capacity increases, reduced delays
Efficiency	Trajectories closer to the individual optimum by reducing constraints imposed by permanent design. In particular the module will reduce flight length and related fuel burn and emissions. The potential savings are a significant proportion of the ATM related inefficiencies. Where capacity is not an issue, fewer sectors may be required as the spreading of traffic should reduce the risk of conflicts. Easier design of high-level Temporary Segregated Airspace (TSAs). Metric: reduced flight length; savings in ANSP costs.
Environment	Fuel burn and emissions will be reduced; however, the area where emissions and contrails will be formed may be larger Metric: volumes of saved fuel and CO_2
Flexibility	Choice of routing by the airspace user would be maximised. Metric: proportion of traffic and of flight length using the free routing

CBA	The business case has proven to be positive due to the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts).
Human Performance	The required training is available and the change step is achievable from a human factors perspective; the roles and responsibilities of controller/pilot are not affected. Free routing requires training, especially for controllers, and it can be implemented progressively, e.g. starting in low traffic conditions

3 Necessary Procedures (Air & Ground)

The airspace requirements (RNAV, RNP and the value of the performance required) may require new ATS procedures and ground system functionalities. Some of the ATS procedures required for this module are linked with the processes of notification, coordination and transfer of control. Care needs to be taken so that the development of the required ATM procedures provides for a consistent application across regions.

4 Necessary Technology (Air & Ground)

Adequate navigation infrastructure in the airspace of application. Another important capability is the capability for the flight planning and the flight data processing system to support the air traffic controller with the means to understand/visualise the flight paths and their interactions, as well as to communicate with adjacent controllers.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

ICAO material is available. Specifications are already available in RTCA and EUROCAE documents.

6 Implementation and Demonstration Activities

6.1 Current Use

- **Oceanic areas**: TBC
- **Europe**: several States have declared their airspace as "free routes": Ireland, Portugal, Sweden or planning to do so (Albania, Benelux-Germany in Maastricht UAC, Cyprus, Denmark, Finland, Estonia, Latvia, Malta, Norway on a 24-hour basis; Bulgaria, Greece, Hungary, Italy, Romania, Serbia at night).

A CBA conducted in 2001 for a Free Route Airspace (FRA) implementation initially planned in Europe in 2006 concluded as follows:

FRA is planned to be introduced in 8 European States: Belgium, Denmark, Finland, Germany, Luxembourg, the Netherlands, Norway and Sweden. This CBA has assumed that it will be introduced from the end of 2006 and in the airspace above Flight Level 335.

The total costs of implementing FRA are estimated at € 53M, incurred mostly in 2005 and 2006. The benefit (reduced flight distances and times due to more direct flights) in the first year of operation, 2007, is € 27M, and the benefit is expected to increase each year with traffic growth. FRA is likely to become 'financially beneficial' (ie the financial benefits will be greater than the costs) because the costs are mostly incurred once while the benefits cumulate year on year. The CBA shows that, under the baseline assumptions, the cumulative benefits will overtake the costs in 2009. Over the 10 year project lifetime, from 2005 to 2014, the project has a Net Present Value (NPV) of € 76M and an Internal Rate of Return (IRR) of 40%.

The costs of FRA do not fall evenly to all stakeholders. Aircraft operators flying GAT (mostly civilian airlines) receive almost all the financial benefits. The main costs fall to civil and military Air Traffic Service Providers (ATSP) and Air Defence units that must implement changes to their ground systems. Their costs differ according to how much work they must do to implement the necessary changes for FRA. The range of ATSP costs is from less than € 1M (Denmark) to € 10M (Germany).

An estimate of the approximate costs and benefits to each State has been made. The analysis shows that, for most States, the total of ATC and Air Defence costs of FRA are much less than the benefit delivered to civil traffic in those States. For Germany, for example, FRA has an estimated NPV of € 53M when comparing all of the DFS' ATC costs and Germany's AD costs against the benefit that DFS will deliver to civil traffic. For Norway, however, FRA has a small net cost because Norway has relatively high system upgrade costs to support FRA. Belgium and the Netherlands are a special case. In these States, the Maastricht UAC will deliver a benefit to civil traffic in FRA, but their military ATC and Air Defence organisations will still incur costs to implement FRA. In particular, the Belgian and Netherlands Air Forces will pay over € 9M to implement FRA and not see any significant financial benefits..

- **US**: TBC
- **Australia**: TBC

6.2 Planned or Ongoing Trials

- **Terra X:** TBC

Module N° B1-105: Better Operational Decisions through Integrated Weather Information (Strategic >40 Minutes)

<table>
<tr><td rowspan="1">Summary</td><td colspan="2">The primary goal of this module is to enable the reliable identification of applicable air traffic management (ATM) solutions when weather phenomena are impacting, or forecast to impact, aerodromes or airspace. In order to achieve this goal, full ATM-Weather Integration is necessary. ATM-Weather Integration means that weather information is included in the logic of a decision process or aid such that the impact of the weather constraint is automatically calculated and taken into account when the decision is made or recommended.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 Capacity, KPA-04 Efficiency, KPA-09 Predictability, KPA-10 Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">En-route, Terminal Area, Aerodrome, Supporting Infrastructure domains
All flight phases</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Applicable to traffic flow planning, and to all aircraft operations in all domains and flight phases, regardless of level of aircraft equipage. Benefits accrue and/or costs are avoided as processes and Decision Support Tools (DSTs) employing ATM-Weather Integration concepts and techniques are adopted.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">AOM - Airspace Operations and Management
DCB - Demand and Capacity Balancing
AO - Aerodrome Operations</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-19: Meteorological Systems
GPI-6: Air Traffic Flow Management
GPI-16: Decision Support Systems and Alerting Systems</td></tr>
<tr><td>Reference Documents</td><td colspan="2">None at this time</td></tr>
<tr><td>Main Dependencies</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>2018</td></tr>
<tr><td>Avionics Availability</td><td>TBD</td></tr>
<tr><td>Infrastructure Availability</td><td>2018</td></tr>
<tr><td>Ground Automation Availability</td><td>2018</td></tr>
<tr><td>Procedures Available</td><td>2018</td></tr>
<tr><td>Operations Approvals</td><td>2018</td></tr>
</table>

1 Narrative

1.1 General

Weather is a major cause of flight delay in many airspace systems. Research analyses have suggested that a significant portion of that delay could be mitigated if weather forecasts were "perfect" and appropriate air traffic management (ATM) solutions were able to be consistently devised and employed. Unfortunately, weather forecasts, while improving steadily, are not perfect. Rigid airspace structures often preclude the consistent employment of the best ATM solutions.

Today, the task of taking weather observations and forecasts and turning them into the impact values needed to devise operationally effective ATM solutions is left almost completely up to the individual human ATM decision maker. Therefore the accurate assessment of the impact of a forecast weather constraint and quality of resultant ATM initiatives are dependent on both the cognitive capability and experience level of the decision maker. The primary goal of Enhanced Weather Decision-Making Capability is to enable the reliable identification of operationally effective ATM solutions when weather phenomena are affecting, or are forecast to affect, aerodromes or airspace. In order to achieve this goal, full ATM-Weather Integration is necessary.

ATM-Weather Integration means that weather information is included in the logic of a decision process or aid such that the impact of the weather constraint is automatically calculated and taken into account when the decision is made or recommended. By minimizing the need for humans to manually gauge weather constraints and determine the most appropriate mitigation of those constraints, ATM-Weather Integration enables the best ATM solutions to be consistently identified and executed.

There are four elements of ATM-Weather Integration (see Attachment 1) as enabled by this module. With respect to airspace, the output of the first element, *Weather Information*, is ingested by automation associated with the second, *Weather Translation*. Through filters such as safety regulations and standard operating procedures, the weather information (observations and forecasts) is turned ("translated") into a non-meteorological parameter called an airspace constraint, a measure of the expected capacity of the affected airspace. This parameter is, in turn, fed to the third component called *ATM Impact Conversion.* By comparing projected demand and weather-constrained capacity, this component transforms ("converts") the airspace constraint into an airspace impact. The fourth component, *ATM Decision Support*, takes the quantified impact values from *ATM Impact Conversion* and develops one or more strategic and tactical ATM solutions to the forecast or actual weather constraint.

The concepts, capabilities and processes achieved in this module are applicable to multiple decision time frames, from pre-flight planning to daily flow planning to tactical flow planning. Tactical weather avoidance is considered, but utilization of aircraft-based capabilities in this regard is emphasized in module B3-105.

1.1.1 Baseline

In today's baseline case, ATM decision makers manually determine the amount of change in capacity associated with an actual or forecast weather phenomenon, manually compare the resultant capacity with the actual or projected demand for the airspace or aerodrome, and then manually devise ATM solutions when the demand exceeds the weather-constrained capacity value.

1.1.2 Improvement brought by the module

The transition to systems and processes embodied by ATM-Weather Integration leads to the consistent identification and use of operationally effective ATM solutions to weather-related demand/capacity imbalances.

1.1.3 Other remarks

This module is a key component in the evolution of procedures and automation capabilities, both aircraft-based and ground-based, intended to mitigate the effects of weather on flight planning, flight operations and flow management.

2 Element 1: Weather Information

Weather Information is the superset of all approved meteorological observations, analyses and forecasts available to operator and air navigation service provider (ANSP) decision makers. Included in this superset are data designated as the authoritative weather information based upon which ATM decision makers will build their solutions.

2.1 Intended Performance or Operational Improvement / Metric for Success

Capacity and Efficiency

Improvements in weather information lead to better data concerning the extent, time period and severity of weather impacts on airspace. This in turn enables more precise estimates of expected capacity of that airspace.

Associated Metric - Capacity

One measure of capacity improvement due to improved weather information would be the number of user-preferred profiles that can be accommodated.

Associated Metric - Efficiency

An improvement in efficiency associated with improved weather information would be the number of deviations from user-preferred profiles.

Safety

Weather information improvements should lead to increased situation awareness by pilots, AOCs and ANSPs, enabling avoidance of hazardous weather conditions.

Associated Metric – Safety

A safety improvement associated with better weather information would be the number of weather-related aircraft incidents and accidents.

2.2 Necessary Procedures (Air & Ground)

Procedures exist today for ANSPs and users to collaborate on weather-related decisions. Extensions to those procedures must be developed to reflect the increased use of decision support automation capabilities by both. International standards for information exchange between systems to support global operations must also be developed, including the development of global standards for the delivery of weather information.

2.3 Necessary Technology (Air & Ground)

Technology development in support of this element will include the creation and implementation of a consistent, integrated 4-D database of global weather observations and forecasts, including linkage (data exchange and communications standards) between global weather information systems. ATM ground systems will have to be modified to make use of the weather information to better serve the ATM community.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This element requires the development of global standards for weather information exchange, with emphasis on the exchange of 4-D (X, Y, Z and T [time]) gridded weather information, and regulatory agreement on what constitutes required weather information in the age of digital exchange, versus text and graphics.

2.5 Business Case specific to the Element

The business case for this element is still to be determined as part of the development of this overall module, which is in the research phase. However, current experience with the utilization of enhanced weather information to improve ATM decision making by stakeholders has resulted in benefits due to more efficient flight planning and less disruption to user-preferred trajectories.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

The development of the United States' 4D Weather Data Cube is underway. Decisions concerning internal infrastructure, data exchange standards and communications are nearing completion, and initial demonstrations of the system have taken place.

2.6.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this element. There is a need to develop such a plan as part of the collaboration on this module.

3 Element 2: Weather Translation

Weather Translation refers to automated processes which ingest raw weather information and translate them into characterized weather constraints and aerodrome threshold events. The output of the Weather Translation process is a non-meteorological value which represents a potential change in the permeability of airspace or capacity of the aerodrome.

It is unlikely that future automation systems will incorporate Weather Translation methodology without also including ATM Impact Conversion components. As such, this element is likely to be more of an enabler of the next element and the entire process as opposed to an interim end state.

3.1 Intended Performance or Operational Improvement / Metric for Success

Predictability

Weather Translation combined with ATM Impact Conversion will lead to more consistent evaluations of weather constraints, which in turn will allow users to plan trajectories that are more likely to be acceptable from the standpoint of the ANSP. Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected. Consequently, users will be able to carry less contingency fuel than is felt necessary today, resulting in lower fuel burn.

Associated Metric - Predictability

Among the measures of success for both Weather Translation and Impact Conversion are decreases in the variability and numbers of responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation.

3.2 Necessary Procedures (Air & Ground)

The only procedural changes likely to be associated with this element are cultural in nature, as automation is introduced which performs tasks currently accomplished manually.

3.3 Necessary Technology (Air & Ground)

Technology development in support of this element will include the introduction of automated weather translation methodologies based on the operational needs for such information.

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This element will require the development of standardised Weather Translation parameters.

3.5 Business Case specific to the Element

The business case for this element is still to be determined as part of the development of this overall module, which is in the research phase. However, current limited experience (see 1.3.6) with the utilization of translated weather information in the face of convective weather has shown that the concept can help inform ATM decision making.

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

A considerable amount of research and analysis is currently underway for this element. One example is the weather avoidance field (WAF) methodology currently in operational use in the Route Availability Planning Tool (RAPT) in the New York and Chicago areas.

3.6.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this element. There is a need to develop such a plan as part of the collaboration on this module.

4 Element 3: ATM Impact Conversion

The ATM Impact Conversion element determines the anticipated weather-constrained capacity of the airspace or aerodrome and compares this to the projected demand. If an imbalance exists between the two, this information is provided to the system user and/or the ATM Decision Support element to inform development of mitigation strategies for dealing with the imbalance.

4.1 Intended Performance or Operational Improvement / Metric for Success

Predictability

ATM Impact Conversion, informed by Weather Translation, will lead to more consistent evaluations of weather constraints, which in turn will allow users to plan trajectories that are more likely to be acceptable from the standpoint of the ANSP. Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected. Consequently, users will be able to carry less contingency fuel than is felt necessary today, resulting in lower fuel burn.

Associated Metric - Predictability

Among the measures of success for both Weather Translation and Impact Conversion are decreases in the variability and numbers of responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation.

4.2 Necessary Procedures (Air & Ground)

The only procedural changes likely to be associated with this element are cultural in nature, as automation is introduced which performs tasks currently accomplished manually.

4.3 Necessary Technology (Air & Ground)

Technology development in support of this element will include the introduction of automated methodologies that utilize weather translation information to assess the impact on ATM operations, for flows and individual flights.

4.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This element will require the development of standardised ATM Impact Conversion parameters.

4.5 Business Case specific to the Element

The business case for this element is still to be determined as part of the development of this overall module, which is in the research phase. However, current limited experience (see 1.4.6) with the utilization of weather information which has been converted to ATM Impact has shown that the concept results in better and more consistent information going to ATM decision maker and systems.

4.6 Implementation and Demonstration Activities

4.6.1 Current Use

A considerable amount of research and analysis is currently underway for this element. One system (Integrated Departure Route Planner [IDRP]) that identifies the impact of convective activity on departure routes is in early testing. A weather forecast product called the Aviation Impact Guidance for Convective Weather that calculates impact through the joint probability of the presence of convective activity and air traffic is in operational testing.

4.6.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this element. There is a need to develop such a plan as part of the collaboration on this module.

5 Element 4: Weather Integrated Decision Support

The final element is Weather Integrated Decision Support, which is comprised of automated systems and processes that create ranked mitigation strategies for consideration and execution by ATM decision makers. The solutions are based on requirements and rules established by the ATM community.

5.1 Intended Performance or Operational Improvement / Metric for Success

Capacity

Advanced decision support tools, fully integrated with weather information, support stakeholders in assessing the weather situation and in planning optimal mitigation strategies which make maximum use of available airspace.

Associated Metric - Capacity

With respect to capacity, the number of user-preferred profiles that can be accommodated would be an appropriate metric for Weather Integrated Decision Support.

Efficiency

Advanced decision support tools, fully integrated with weather information, support stakeholders in planning for the most efficient routes possible, given the anticipated weather situation.

Associated Metric - Efficiency

Among the measures of success for Weather Integrated Decision Support in the area of efficiency would be the number of deviations from user-preferred profiles.

Predictability

Advanced decision support tools, fully integrated with weather information, produce consistent, optimal solution sets, and allow users to plan trajectories that are more likely to be acceptable from the standpoint of the ANSP. Fewer reroutes and less variability in other associated traffic management initiatives (TMIs) can be expected. In turn, this will allow users to carry less contingency fuel than is felt necessary today, resulting in lower fuel burn.

Associated Metric - Predictability

Among the measures of success for Weather Integrated Decision Support are decreases in the variability and numbers of ATM responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation.

Safety

Advanced decision support tools, fully integrated with weather information, produce solution sets which minimize pilot exposure to hazardous weather. This, combined with increased weather situational awareness by pilots and ANSPs, enables avoidance of hazardous conditions.

Associated Metric - Safety

Among the measures of success for both Weather Translation and Impact Conversion are decreases in the variability and numbers of responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation.

A safety improvement associated with Weather Integrated Decision Support would be the number of weather-related aircraft incidents and accidents.

5.2 Necessary Procedures (Air & Ground)

No changes in procedures, either in the air or on the ground, are required to support the development of this element.

5.3 Necessary Technology (Air & Ground)

Technology development in support of this element will include the introduction of decision support tools, for both ANSPs and users, which automatically ingest ATM Weather Impact information, and support decision making via generation of candidate mitigation strategies..

5.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Aside from identifying and using the most capable tools, there would appear to be no regulatory or standardisation needs or approval plan associated with this element.

5.5 Business Case specific to the Element

The business case for this element is still to be determined as part of the development of this overall module, which is in the research phase. Current experience with utilization of ATM decision support tools, with rudimentary weather inputs, to improve ATM decision making by stakeholders has proven to be positive in terms of producing consistent responses from both the ANSP and user community.

5.6 Implementation and Demonstration Activities

5.6.1 Current Use

Research and analysis is in the early stages for this element. One system, the San Francisco (SFO) Ground Delay Program Parameters Selection Model (GPSM), meets all Weather Integrated Decision Support system definition criteria. It has been field tested and is now in the initial stages of being used operationally.

5.6.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this element. There is a need to develop such a plan as part of the collaboration on this module.

6 Main Dependencies

This module is dependent on the concurrent development of weather capabilities (e.g. Weather Translation and ATM Impact Conversion methodologies) and ATM automation capabilities that will utilize the translated and converted weather information to inform decision making. It is a predecessor of B3-105.

This module has an impact on, or is a key component of, a number of related Block 0 and Block 1 Modules. Several of these key modules, along with an explanation of the connection between the two, are listed below:

- Module B0-10: Improved En-Route Profiles

Desired en-route profiles can be significantly impacted by ATM initiatives associated with weather constraints such as thunderstorms, turbulence and icing. Module B1-105: Enhanced Weather Decision Making Capability provides a better understanding of the impact on airspace of forecast weather constraints. This will allow users to more frequently plan profiles that are appropriate for the actual or expected weather conditions and airspace managers to more consistently allow those profiles to be flown.

- Module B0-15: Runway Arrival Sequencing
- Module B0-35: Air Traffic Flow Management/Network Operations Procedures (ATFM/NOP) and Collaborative Decision Making (CDM)
- Module B1-15 Arrival Management/Departure Management (AMAN/DMAN) Metroplex and Linked DMAN/Surface Management (SMAN)
- Module B1-35: Enhanced NOP, Integrated Airspace/Flow Management

Trajectory-based, time-based and sequencing operations require processes and procedures for dealing with weather constraints in the aerodrome and en-route airspace. Improvements derived from Module B1-105, such as a better understanding of weather constraints and their ATM impact, allows more accurate, less volatile trajectory information to be calculated and used in the above four modules.

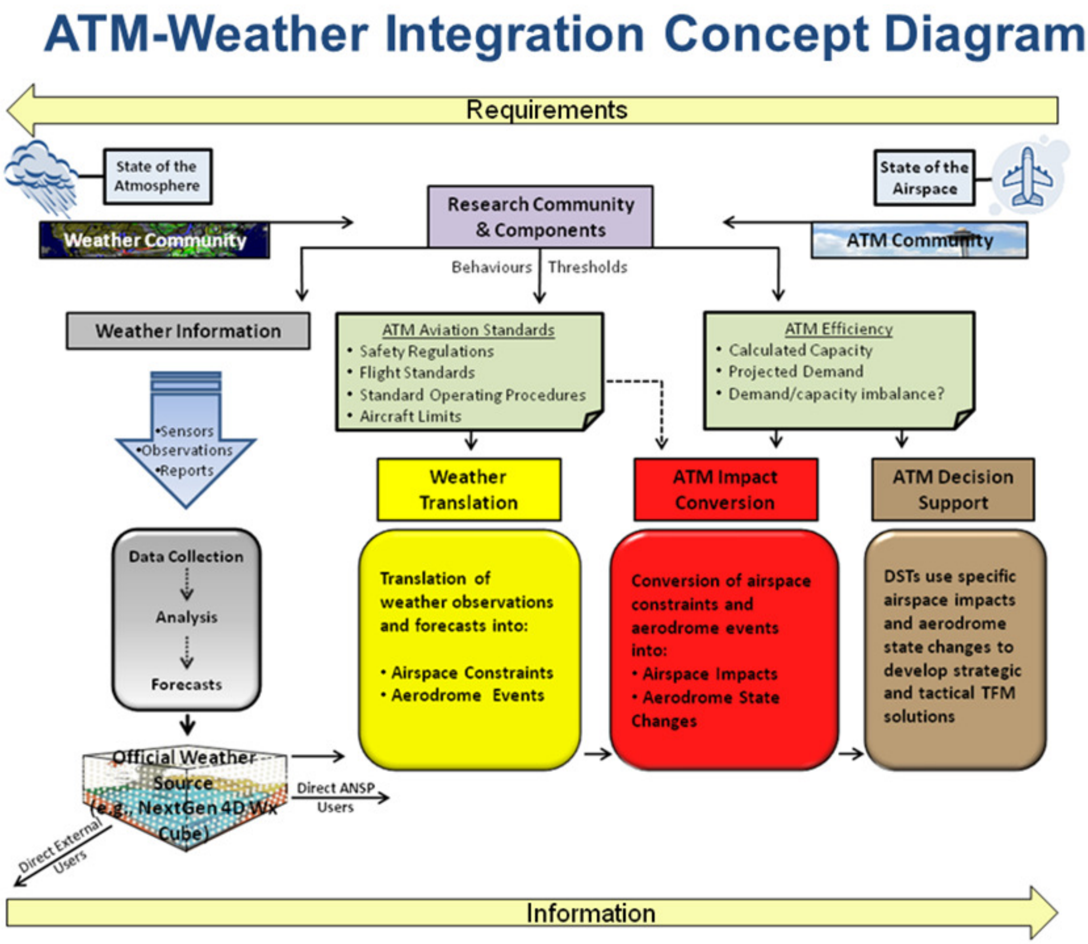

Figure 1. ATM-Weather Integration Concept Diagram.

Module N° B1-85: Increased Capacity and Flexibility through Interval Management

Summary	IM provides an improved means for managing traffic flows and aircraft spacing, including: • the use of ground tools that assist the controller in evaluating the traffic picture and determining appropriate clearances to merge and space aircraft efficiently and safely • the use of airborne tools that allow the flight crew to conform with the IM Clearance.
Main Performance Impact	KPA-03 Cost-Effectiveness, KPA-04 Efficiency and KPA-05 Environment.
Domain / Flight Phases	Cruise, Arrival, Approach, Departure.
Applicability Considerations	All high density en-route and terminal areas.
Global Concept Component(s)	DCB – Demand and Capacity Balancing; TS –Traffic Synchronisation; CM – Conflict Management
Global Plan Initiatives (GPI)	GPI-7 Dynamic and Flexible ATS Route Management; GPI-12 Functional Integration of ground systems with airborne systems; GPI-17 Data Link Applications.
Reference Documents	EUROCONTROL Documents – Flight Crew Guidance on Enhanced Traffic Situational Awareness during Flight Operations; Flight Crew Guidance on Enhanced Situational Awareness on the Airport Surface; Flight Crew Guidance on Enhanced Visual Separation on Approach; RTCA Document DO-328, Safety, Performance and Interoperability Requirements Document for Airborne Spacing – Flight Deck Interval Management (ASPA-FIM)
Main Dependencies	B0-40, B0-100

Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	2018
	Avionics Availability	2018
	Infrastructure Availability	2013
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

Interval Management is more complex and hence requires a longer description. IM is defined as the overall system that enables the improved means for managing traffic flows and aircraft spacing, including the use of ground tools that assist the controller in evaluating the traffic picture and determining appropriate clearances to merge and space aircraft efficiently and safely and the use of airborne tools that allow the flight crew to conform with the IM Clearance. IM operations in the first phase will cover the arrival phase of flight (from the end of cruise to final approach) of airspace under surveillance, where Direct Controller Pilot Communications (such as voice or CPDLC) exist. As the applications evolve they will be applied to other phases of flight.

IM includes both the ground capabilities needed for the controller to support an IM Clearance and the airborne capabilities needed for the flight crew to follow the IM Clearance.

1.1.1 Baseline

As these applications are under development there is no existing baseline.

1.1.2 Improvement brought by the module

Interval Management is a suite of functional capabilities that can be combined to produce operational applications to achieve or maintain an interval or spacing from a target aircraft. ATC will be provided with a new set of (voice or datalink) instructions directing, for example, that the flight crew establish and maintain a given time from a reference aircraft. These new instructions will reduce the use of ATC vectoring and speed control, which is expected to reduce the overall number of transmissions. These reductions are expected to reduce ATC workload per aircraft.

The flight crew will perform these new tasks using new avionics functions e.g. airborne surveillance, display of traffic information, and spacing functions with advisories. A few examples of IM in various phases of flight include: Cruise - delivering metering or miles-in-trail prior to top-of-descent; Arrival – interval management during optimum profile descents to merge (if applicable); Approach – achieve and maintain appropriate interval to stabilized approach point; and Departure – maintain interval no-closer-than to previous departure. These examples provide more efficient flight trajectories, better scheduling performance, reduced fuel burn and decreased environmental impacts.

Benefits of the interval management include;

- Early speed advisories removing requirement for later path-lengthening
- Consistent, low variance spacing between paired aircraft (e.g., at the entry to an arrival procedure and on final approach)
- Continued Optimized Profile Descents (OPDs) in medium density environments
    - expected to allow OPDs when demand <=70%
- Reduced ATC instructions and workload
    - Without unacceptable increase in flight crew workload

1.1.3 Other remarks

NIL

2 Intended Performance Operational Improvement/Metric to determine success

For KPA-03 Cost Effectiveness, the improvement/metric will be reduced fuel burn. For KPA-04, Efficiency, the improvement will be operating with reduced holding times and flight times. For KPA-05 Environment, the improvement/metric will be reduced emissions.

3 Necessary Procedures (Air & Ground)

Procedures for Interval Management have yet to be developed.

4 Necessary Technology (Air & Ground)

Necessary technology includes and ADS-B IN capability, CPDLC in accordance with message set developed by SC-214 and a cockpit based CDTI. Similarly ground automation will be required.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

TBD

6 Business Case specific to the module

TBD

7 Implementation and Demonstration Activities

7.1 Current Use

7.2 Planned or Ongoing Trials

8 Main dependencies

This module depends on the following modules:

- B0-40
- B0-100

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Module N° B1-86: Improved Access to Optimum Flight Levels through Climb/Descent Procedures using ADS-B

Summary	The In Trail Procedure (ITP) is designed to enable an aircraft to climb or descend through the altitude of other aircraft when the requirements for procedural separation would not be met. The aim is to prevent flights to be trapped at an unsatisfactory altitude for a prolonged period of time.	
Main Performance Impact	KPA-02 Capacity, KPA-03 Cost Effectiveness, and KPA-05 Environment.	
Domain / Flight Phases	En-Route	
Applicability Considerations	This can be applied to all air routes,	
Global Concept Component(s)	CM, AUO, AOM	
Global Plan Initiatives (GPI)	GPI-9, GPI-7	
Reference Documents	ICAO circular – “Safety Assessment for the development of Separation Minima and Procedures for In-Trail Procedure (ITP) using Automatic Dependant Surveillance – Broadcast (ADS-B) Version 1.5.3” RTCA DO-312: “Safety, Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application”. EUROCAE ED-159: “Safety, Performance and Interoperability Requirements Document for ATSA-ITP Application”	
Main Dependencies	B0-100	
Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

The use of ITP facilitates en-route climb or descent to enable better use of optimal flight levels in environments where a lack of ATC surveillance and/or the large separation minima currently implemented was a limiting factor. The In Trail Procedure (ITP) is designed to enable an aircraft to climb or descend through the altitude of other aircraft when the requirements for procedural separation would not be met. The system benefit of ITP is significant fuel savings and the uplift of greater payloads through the reduction in contingency fuel carriage requirements. This will be the first airborne surveillance application to generate operational benefits through the reduction in separation standards.

The ability of an aircraft to climb through the altitude of another aircraft when normal separation procedures would not allow this prevents an aircraft being trapped at an unsatisfactory altitude and thus incurring non-optimal fuel burn for prolonged periods. This immediately results in reduced fuel-burn and emissions. Once the procedure has been field proven, it will also allow for a reduction in the contingency fuel carriage requirement, which in turn will result in reduced fuel-burn and emissions. ITP also provides safety benefits by providing a tool to manage contingency scenarios such as emergency descent; climbing out of turbulence and avoiding weather.

1.1.1 Baseline

ITP using ADS-B is undergoing validation at this time and should be in operational use by August 2011 and hence can be considered to be a baseline.

1.1.2 Improvement brought by the module

ITP reduces fuel-burn and emissions by allowing aircraft to overcome altitude constraints due to aircraft flying at higher or lower altitudes and fly at the most efficient altitude. ITP also provides safety benefits by providing a tool to manage contingency scenarios such as emergency descent; climbing out of turbulence and avoiding weather.

1.1.3 Other remarks

ITP using ADS-B will require both aircraft to have ADS-B OUT capability, while the manoeuvring aircraft will require ADS-B IN.

2 Intended Performance Operational Improvement/Metric to determine success

For KPA-03 Cost Effectiveness, the improvement/metric will be reduced fuel burn. For KPA-05 Environment, the improvement/metric will be reduced emissions. For KPA-02 Capacity, the improvement/metric will be an improvement in capacity on a given air route.

3 Necessary Procedures (Air & Ground)

Procedures for ITP using ADS-B have been developed and will soon be available in an ICAO circular – “Safety Assessment for the development of Separation Minima and Procedures for In-Trail Procedure (ITP) using Automatic Dependant Surveillance – Broadcast (ADS-B) Version 1.5.3”

4 Necessary Technology (Air & Ground)

The aircraft performing the in-train procedure will require an ADS-B IN capability compliant with DO-312/ED-159. The other aircraft involved in the procedure will require an ADS-B OUT capability compliant with DP-312-/ED-159.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

For ITP using ADS-B, the following documents apply:

a. AC 20-172

b. TSO C195

c. FAA Memo; Interim Policy and Guidance Automatic Dependent Surveillance Broadcast (ADS-B) Aircraft Surveillance Systems Supporting Oceanic In-Trail Procedures (ITP). Dated: May 10, 2010.

d. DO-312/ED-159

6 Business Case specific to the module

The benefit is largely driven by savings in contingency fuel.

The EUROPEAN CRISTAL trial had shown that ITP is capable of saving ~ 1% Fuel burn reduction

- Saving € 108 million (€ 124k per aircraft) annually and
- Reducing carbon dioxide emissions with 344 000 tonnes annually

Greater benefits will be achievable on the PACOTS. For ITP in the PACOTS, the business case for one major carrier operating in the South Pacific was as follows:

- Per annum savings per aircraft : $202K
- PV Cumulative Benefit (through 2035) per aircraft : $20.9M
- Benefit to Cost Ratio : 10.7
- Time to Payback : 3 years
- Internal Rate of Return : 68%

7 Implementation and Demonstration Activities

7.1 Current Use

The EUROPEAN (ISAVIA, NATS, EUROCONTROL, AIRBUS, SAS) CRISTAL ITP trial validated the concepts for ITP.

ITP is a part of trials to be undertaken under the ASPIRE programme. ASPIRE is a joint programme between AirServices Australia, the Airways Corporation of New Zealand, CAA of Singapore and the Japan Civil Aviation Bureau.

7.2 Planned or Ongoing Trials

Once the above trials have been completed, it is expected that ITP will become operational.

8 Main dependencies

B0-100

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Module N° B1-05: Improved Flexibility and Efficiency in Descent Profiles (OPDs)

Summary	This module provides the baseline for using Required Navigation Performance (RNP) with Vertical Containment. Vertical RNP is the requirement on vertical system accuracy at the 99.7% probability level. It indicates the normal operating error characteristics of a navigation system. The system is designed to enhance vertical flight path precision during descent, arrival, and while in the non-precision environment and enables aircraft to fly an approach procedure not reliant on ground based equipment for vertical guidance.
Main Performance Impact	KPA-04 Efficiency
Domain / Flight Phases	Descent, Arrival, Flight in Terminal Area
Applicability Considerations	Currently applies to Boeing aircraft
Global Concept Component(s)	Airspace Organization and Management (AOM) Demand and Capacity Balancing (DCB) Airspace User Operations (AUO) Aerodrome operations (AO) Traffic synchronization (TS) Conflict management (CM)
Global Plan Initiatives (GPI)	GPI-2 Reduced vertical separation minima GPI-5 RNAV and RNP (Performance-Based Navigation) GPI-9 Situational Awareness
Reference Documents	• ICAO Document 9750, Global Air Navigation Plan • RTCA DO-236B, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation • Boeing Document D6-39067-3, RNP Capability of FMC Equipped 737, Generation 3 • Boeing Document D243W018-13 Rev D, 777 RNP Navigation Capabilities, Generation 1
Main Dependencies	

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2018
	Avionics Availability	√
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	√
	Operations Approvals	2018

1 Narrative

1.1 General

RNP with Vertical Containment is an altimetry-based capability which enables an equipped aircraft to precisely descend on a vertical path, as computed by the Flight Management Computer (FMC), within a tolerance set in feet, while providing the flight crew with navigation performance information though avionics monitoring and alerting. The system defaults to an initial tolerance set by the individual operator, but a crew may select a new tolerance (e.g., 75 feet in the terminal area.) It is similar to lateral containment of RNP, but in the vertical plane.

1.1.1 Baseline

The baseline for this block is Improved Flight Descent Profile enabled by Block B0-5. This block is a component of Trajectory-Based Operations (TBO).

1.1.2 Improvement brought by the module

Vertical RNP contributes to Terminal airspace design and efficiency due to an aircraft's ability to maintain a vertical path during descent thus enabling vertical corridors for ingressing and egressing traffic. Other benefits include reduced aircraft level-offs, enhanced vertical precision in the terminal airspace, de-confliction of arrival and departure procedures and adjacent airport traffic flows, and the ability of an aircraft to fly an approach procedure not reliant upon ground based equipment for vertical navigation. This ultimately leads to higher utilization of airports and runways lacking vertical approach guidance.

1.1.3 Other remarks

None

1.2 Element 1: Title

There are no sub-elements associated with Vertical RNP.

2 Intended Performance Operational Improvement/Metric to determine success

- **Capacity** – Vertical RNP allows for precision flight in a non precision environment. This capability allows for the potential to expand the applications of standard terminal arrival and departure procedures for improved capacity and throughput, and improve the implementation of precision approaches.
- **Efficiency** – Enabling an aircraft to maintain a vertical path during descent allows for vertical corridors for ingressing and egressing traffic thus increasing the efficiency of the airspace. Additionally, Vertical RNP promotes the efficient use of airspace through the ability for aircraft to fly a more precisely constrained descent profile allowing the potential for further reduced separation and increased capacity.
- **Predictability** – Vertical RNP allows for enhanced predictability of flight paths which leads to better planning of flights and flows.
- **Safety** – Precise altitude tracking along a vertical descent path leads to improvements in overall system safety.

3 Necessary Procedures (Air & Ground)

Flight crews require training in the proper use of the Vertical RNP functions of the FMC. Standard procedures guide the flight crews on which altitude tolerances may be selected for a particular phase of flight.

4 Necessary Technology (Air & Ground)

The technology for Vertical RNP is contained within the Flight Management Computer.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Vertical RNP availability is better than 99.9%/hour for a single FMC installation. From an equipment certification standpoint, the loss of function is probable. Redundant equipment installation supports improbable loss of function, where required.

6 Business Case specific to the module

The business cases for this module are:

- Safety Enhancement: Flying more precise vertical profiles
- Efficiency: Vertical RNP contributes to Terminal airspace efficiency by enabling an aircraft to maintain a vertical path during descent. This allows for vertical corridors for ingressing and egressing traffic which makes the airspace more efficient. Vertical RNP will also lay the foundation for expanded use of Optimized and Continuous Descent Profiles
- Economic: Vertical RNP allows for reduced aircraft level-offs, resulting in fuel and time savings.

7 Implementation and Demonstration Activities

7.1 Current Use

RNP with Vertical Containment is currently being used on Boeing aircraft during the descent phase of flight.

7.2 Planned or Ongoing Trials

No demonstration trials are currently planned for this module. There is a need to develop a trial plan as part of the collaboration on this module.

8 Main dependencies

This module is dependent on the accomplishment of block B0-5: Improved Flight Descent Profile. There is also a dependency on the development of future concepts and automation capabilities that will allow for increased utilization of RNP with Vertical Containment during the climb and cruise phases of flight.

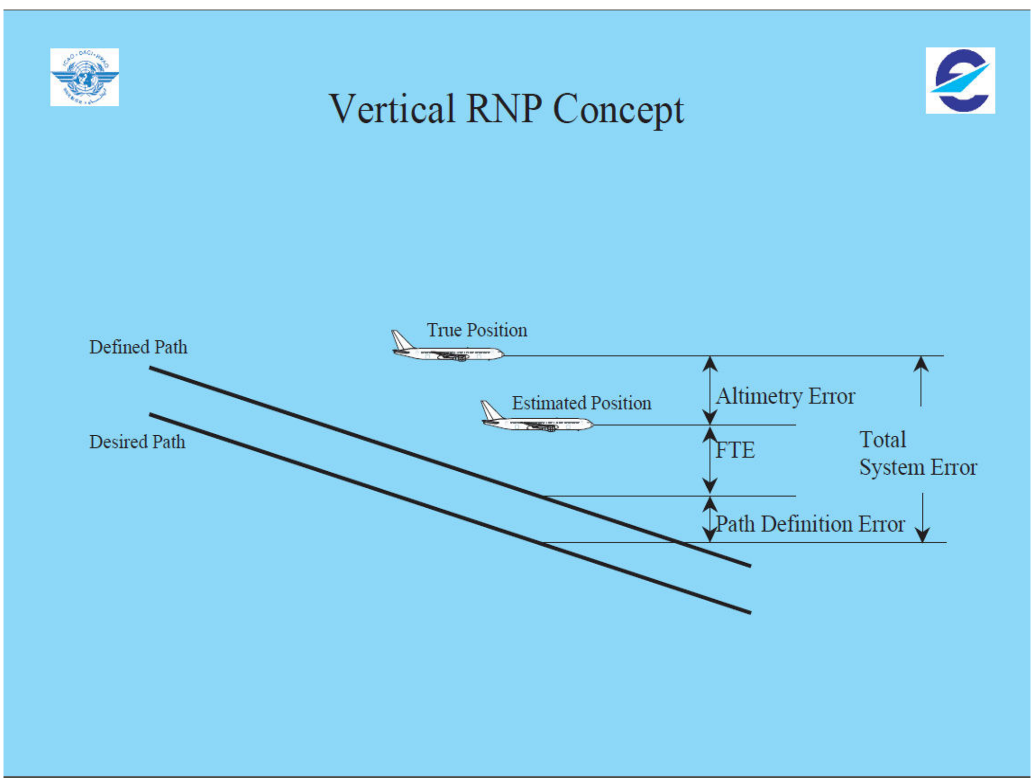

Figure 2 – Vertical RNP Concept

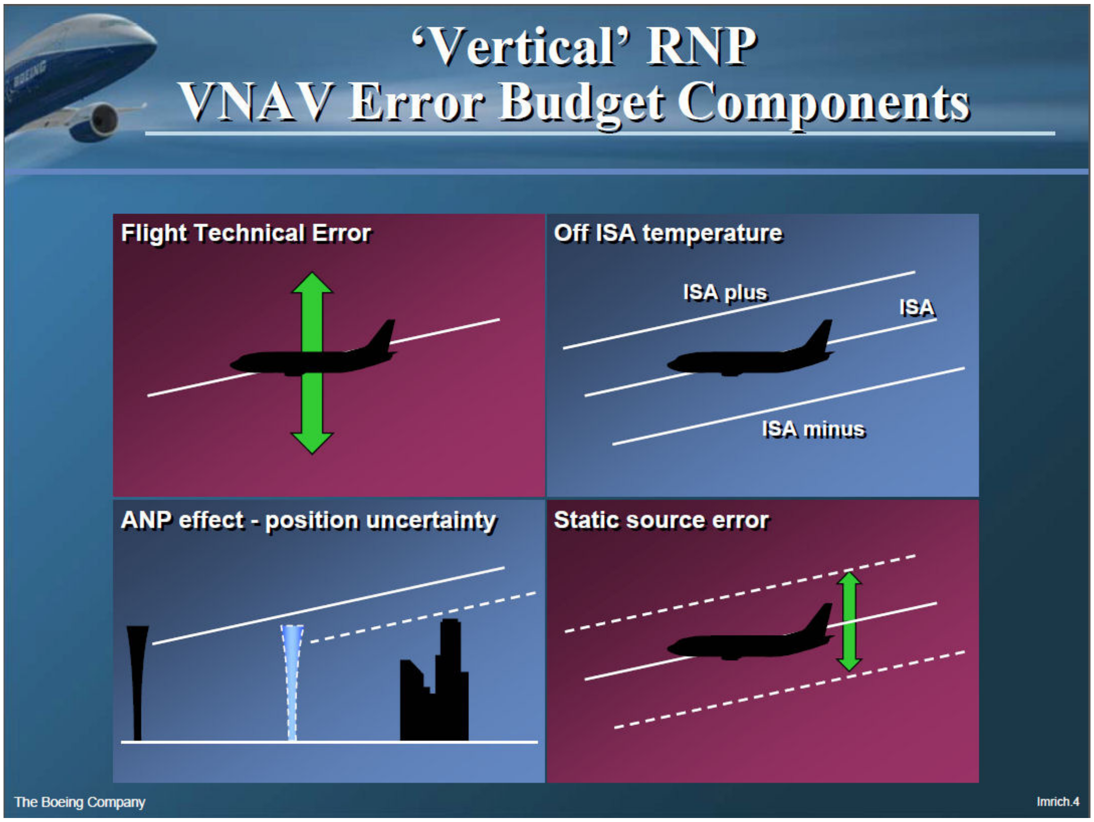

Figure 3 – 'Vertical' RNP – VNAV Error Budget Components

Module N° B1-40: Improved Traffic Synchronisation and Initial Trajectory-based Operations

Summary	This module implements additional air-ground data link applications to download trajectory information and improve the synchronisation of traffic flows at merging points, in particular in view of optimising an approach sequence. The negotiation of a controlled time of arrival allows the FMS functionality, using the aircraft Required Time of Arrival function or speed control to meet the target efficiently and enhances the predictability of the system and reduces controller workload. This module also implements a number of Airport applications such as Data Link Operational Terminal Information Service, Departure Clearance and Data link TAXI. These applications increase safety and reduce pilot and controller workload.
Main Performance Impact	KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment; KPA-09 Predictability, KPA-10 Safety
Domain / Flight Phases	All flight phases
Applicability Considerations	Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those equipped. Benefit increases with size of equipped aircraft population in the area where the services are provided Not applicable to light aircraft.
Global Concept Component(s)	IM – Information Management TS – Traffic Synchronisation CM – Conflict Management
Global Plan Initiatives (GPI)	GPI-9 Situational awareness GPI-17 Implementation of data link applications GPI-18 Electronic information services
Reference Documents	• Manual of Air Traffic Services Data Link Applications (Doc 9694) • New OPLINK Ops Guidance under development • EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280 • 4DTRAD: Initial 4D – 4D Trajectory Data Link (4DTRAD) Concept of Operations – EUROCONTROL, December 2008 • Point Merge: Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent. Operational Services and Environment Definition – EUROCONTROL, July 2010 • EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.
Main Dependencies	B0-40

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

This module is a step towards the goal to introduce 4D trajectory based operations that uses the capabilities of aircraft Flight Management Systems to optimise aircraft flight trajectories in four dimensions. Trajectory Based Operations will manage uncertainty by improving predictability for all ATM Stakeholders across all boundaries or ATM sector structures. In this context it will facilitate Traffic Synchronisation and strategic Conflict Management supported by Separation Provision that minimises tactical “radar type” intervention (e.g. open loop vectoring). It also introduces a number of Airport applications that increase safety and reduce controller-pilot workload.

1.1.1 Baseline

Traffic synchronisation is based on the flight data processing information fed by flight plan data with current positions updated by radar information and on mental extrapolation by controllers. This is not accurate and represents a workload for assessing the situation and monitoring its evolution. Actions are difficult to anticipate in upstream sectors which may not be aware of the problem to be solved.

The transmission of information at and around airports, including for complex routings is done through voice radio, implying a high workload for pilots and controllers, frequent misunderstandings and repetitions.

1.1.2 Change brought by the module

This module implements additional air-ground data link applications to: download trajectory information and improve the synchronisation of traffic flows at merging points, in particular in view of optimising an approach sequence, with negotiation of a required time of arrival using the FMS functionality. Existing ground-ground coordination capabilities will be improved to allow complex route clearances to be exchanged across multiple airspace boundaries.

The module will also implement data transmission for airport/TMA related information and clearances.

1.2 Element 1: Initial 4D Operations (4DTRAD)

Supporting this is 4DTRAD, a recognised approach to initial Trajectory Based Operations which offers an advanced view of the future ATM environment including seamless integration of operational goals through an increased situational awareness and by the sharing of air ground data in a strategic and tactical collaborative decision making environment.

4DTRAD requires the availability of sophisticated air ground data exchange that includes use of new ADS-C and data link functionality beyond current capabilities and performance requirements. Furthermore, ground-ground data exchange to exchange complex clearances needs to be secure, widely available.

As a step transition to Trajectory Based Operations, the introduction of a common time reference with the use of aircraft FMS required time of arrival (RTA) and speed control with less demanding performance and technology requirements to that of 4DTRAD promises early predictability and efficiency benefits to airspace users and service providers.

Using the aircraft RTA for planning arrival flows from En-route (or Oceanic) into Terminal airspace is feasible using current aircraft capability with lower performance requirements than for example 4DTRAD. This would only focus on building traffic flows and sequences leaving more precise metering and separation provision to be achieved through current operations or with new RNAV performance based navigation procedures.

Synchronising the RTA and Controlled Time of Arrival (CTA) with appropriate PBN levels offers the opportunity to further develop stable and predictable traffic flows into a Terminal area, letting the pilot optimise the flight profile (e.g. top of descent and descent profile).

Furthermore, predictable pre-planned traffic flows facilitate consistent application of Continuous Decent Operations and Tailored Arrival procedures whilst Terminal holding can be avoided through pre-planned path stretching undertaken by the aircraft using the RTA or speed control as well as integrating both long and short haul flights into arrival sequences.

The deployment of RNP/RNAV procedures and use of techniques such as “Point Merge” and others provide the opportunity to manage aircraft without recourse to radar vectoring intervention, leading to a closed loop FMS operation and an informed ground system supporting efficient aircraft profiles and predictable ATM operations.

To realise such benefits, communication between en-route and terminal control units is needed to coordinate the CTA constraint which may be achieved through existing mechanisms such as on-line data exchange with delivery to the aircraft via R/T or coordination with the airline operations centres to deliver to long haul aircraft by company data link.

A wider approach to the block will consider the combination with arrival management techniques using currently available ground based tools providing a more demanding performance facilitating refined metering of traffic into Terminal airspace and existing CPDLC capability to deliver the CTA.

A first step which relies on existing systems and capabilities or requiring only minor modifications will make use of current FMS capability to define and output an RTA or speed control. Existing data link capabilities such as CPDLC, AOC, or even voice could be used to agree this RTA or speed control with the ground CTA. Most ground systems are incorporating trajectory prediction functionality and existing AMAN calculate the equivalent of a CTA. Ground-ground communications infrastructure will enable the exchange of flight plan and can be updated to exchange CTA.

Beyond this first step more significant changes are anticipated to enable 4DTRAD and trajectory based operations with advanced, and standardised FMS functionality able to provide more accurate and complete trajectory information which could be down linked with new ADS-C or CPDLC protocols. Depending on the definition of this trajectory information for download new data link technology may be required in the long term. The ground-ground communication infrastructure, in the context of SWIM will enable this trajectory information to be made available to the various en-route, terminal and airport systems which can use the common trajectory reference. System modifications to make full use of this trajectory information must also be planned.

Initial 4D operations can be broken down in to two steps; the first is the synchronisation between air and ground of the flight plan or Reference Business Trajectory. The second step is imposing a time constraint and allowing the aircraft to fly its profile in the most optimal way to meet that constraint.

Trajectory Synchronisation and Monitoring

The ATM system relies on all actors having the same view; it is therefore essential that the trajectory in the Flight Management System (FMS) is synchronised with that held on the ground in the Flight Data Processing Systems (FDPS) and the wider Network systems.

The crew and the ATC agree on the trajectory to be flown and during the entire execution, they continuously check if it is, and will be, followed by the aircraft. In case of non-conformance warning are raised and a new interaction between the crew and the responsible ATC occurs.

The early air/ground agreement on the trajectory to be flown and its execution allows the FMS to optimize the trajectory providing efficiency benefits to the User in terms of aircraft flight profile optimisation and ensuring maximum environmental benefits, both through reduced fuel burn and optimum routings en-route, in the Terminal Area and in the vicinity of the airport avoiding noise sensitive areas.

Improved consistency between air & ground trajectory ensures that controllers have highly reliable information on aircraft behaviour. This more accurate trajectory prediction enables better performance from the decision support tools providing a better anticipation of congestion by allowing early detection of traffic bunching providing better adaptation to the real traffic situation and reduced inefficient radar based tactical intervention.

The increased levels of predictability mean that potential conflicts within a medium-term time horizon will be identified and resolved early while the increased accuracy of ground computed trajectory, especially for short term prediction, reduces the risk of unexpected events.

Required Time of Arrival

The avionics function, Required Time of Arrival (RTA), can be exploited by both en-route and TMA controllers for demand/capacity balancing, metering of flows and sequencing for arrival management.

By preparing the metering of aircraft at an earlier stage of their flight the impact of the constraint is minimised. This allows ATC to make optimum use of capacity at the right time, minimising risks through complexity reduction to ensure that human capabilities are not exceeded. This also supports optimised aircraft profile management by the pilot.

Reduction of inefficient ATC tactical interventions through early planning of traffic en-route and in to the arrival management phase avoids severe and costly sequencing measures. This process enhances aircraft profile optimisation, flight predictability and allows improvements in the stability and reliability of the sequence built by ATC.

It should lead to reduced need for aircraft to hold, inefficiently burning fuel with the associated chemical and noise pollution. Aircraft will be able to plan better and adhere more accurate to arrival schedules leading to better planning for the airlines due to increased flight predictability.

1.3 Element 2: Data Link Operational Terminal Information Service (D-OTIS)

Before flight departure, the flight crew may request meteorological and operational flight information and NOTAMs of the departure and destination aerodrome using a single data link service - Data link-Operational Terminal Information Service (D-OTIS).

At any time during the flight, the pilot may receive automatic updates of the meteo data, operational information and NOTAMS of the destination or alternate aerodromes. D-OTIS may be tailored for the specific flight crew needs and so the pilot can readily form a picture from meteo and operational perspectives.

1.4 Element 3: Departure Clearance (DCL)

The implementation of DCL eliminates potential misunderstandings due to VHF voice, hence enabling the ATC to provide a safer and more efficient service to their users. DCL also enables to reduce controllers’ workload. DCL supports the airport system automation and information sharing with other ground systems.

For busy airports, the use of DCL data link results in a significant decrease in ATC tower frequency congestion. CPDLC systems that are integrated with FMS allow direct input of more complex clearances into the FMS.

1.5 Element 4: Data link TAXI (DTAXI)

This provides automated assistance and additional means of communication to controllers and pilots when performing routine communication exchanges during ground movement operations, Start-up, Pushback, Routine taxi messages and Special airport operations.

2 Intended Performance Operational Improvement/Metric to determine success

2.1 Element 1:

Capacity	positively affected because of the reduction of workload associated to the establishment of the sequence close to the convergence point and related tactical interventions Metric: sector capacity increases
Efficiency	increased by using the aircraft RTA capability for traffic synchronisation planning through en-route and into Terminal Airspace “closed loop” operations on RNAV procedures ensuring common air and ground system awareness of traffic evolution flight efficiency through proactive planning of top of descent, descent profile and en-route delay actions, and enhances terminal airspace route efficiency efficiency at airports: Metric:
Environment	more economic and environmentally friendly absorption of some delays
Predictability	increased predictability of the ATM system for all stakeholders through greater strategic management of traffic flow between and within FIRs en-route and Terminal Airspace using the aircraft RTA capability or speed control to manage a ground CTA; predictable and repeatable sequencing and metering “closed loop” operations on RNAV procedures ensuring common air and ground system awareness of traffic evolution
Safety	Safety at airports Metric: incident occurrences

CBA	Establishment of the business case is underway. The Benefits of the proposed Airport services were already demonstrated in the EUROCONTROL CASCADE Programme.
Human Performance	

3 Necessary Procedures (Air & Ground)

New ICAO Data Link procedures.

4 Necessary Technology (Air & Ground)

Initial operations based on existing aircraft FMS capability, air-ground data link and ground-ground data interchange. The necessary technology is defined the EUROCAE WG78/RTCA SC 214 standards and comprises converged CPDLC and ADS-C implementations.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Related to airspace and procedures design based on existing guidance and ICAO material.

Publication of the EUROCAE WG78/RTCA SC 214 standards.

Air and ground certification and approvals basis.

6 Implementation and Demonstration Activities

6.1 Current Use

- **X**: TBC Capability used ad hoc for tailored arrivals with RTA as well as arrival planning for Oceanic arrivals plus wide scale trials of point merge techniques now focused on deployment in European Terminal airspace and Approach areas with available OSED SPR material.
- **Australia**: TBC

6.2 Planned or Ongoing Trials

- **Europe**: CASCADE D-TAXI and D-OTIS Trials
- **Europe**: For Initial 4D and Airport Services, SESAR Release 1 and 2 (2011 & 2012).

Module N° B1-90 Initial Integration of Remotely Piloted Aircraft (RPA) Systems into Non-segregated Airspace

Summary	This module describes the baseline procedures for operating RPAS in non-segregated airspace. It also includes a brief description of the improvements anticipated during the prescribed timeframe. These improvements include streamlining access to non-segregated airspace, working toward establishing certification methods, defining RPAS airworthiness certification, operator certification, and remote pilot licensing, and working on defining and developing detect and avoid, surveillance, and communications issues.
Main Performance Impact	KPA-01 Access & Equity, KPA-10 Safety
Domain / Flight Phases	En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing)
Applicability Considerations	Applies to all RPAS operating in controlled airspace and at aerodromes. Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those able to meet minimum certification and equipment requirements.
Global Concept Component(s)	AOM - Airspace Organization and Management CM - Conflict Management AUO - Airspace User Operations
Global Plan Initiatives (GPI)	GPI-6, Air traffic flow management GPI-9, Situational awareness GPI-12, Functional integration of ground systems with airborne systems GPI-17, Data link applications GPI-21, Navigation systems GPI-23, Aeronautical radio spectrum
Reference Documents	ICAO Circ 328 – *Unmanned Aircraft Systems (UAS)* Annex 2 — *Rules of the Air* proposal for amendment U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766. , NATO STANAG 4586 EUROCAE Document (under development)
Main Dependencies	NIL

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2018
	Avionics Availability	2018
	Infrastructure Availability	2018
	Ground Automation Availability	2018
	Procedures Available	2018
	Operations Approvals	2018

1 Narrative

1.1 General

This module will discuss the baseline from which the improvements discussed will be based. The aim is to move from accommodation of RPAS, to integration into traffic within controlled airspace and at controlled aerodromes, and finally to full transparent operation within the airspace. Block 1 is the first step in this process. The Block 1 improvements are:

- Streamline process to access non-segregated controlled airspace
- Define airworthiness certification for RPAS
- Define operator certification
- Define remote pilot licensing requirements
- Define detect and avoid technology performance requirements

<u>The United States, specifically the FAA, is in the review process for defining “small RPAS” procedures</u>: Once small RPAS procedures are approved, small RPAS operations in the U.S., outside of military operating areas may be permitted, first in unpopulated, then sparsely populated areas. Small RPAS policy will be based on the successive expansions of use and the rules and procedures that are established. These small RPAS procedures will continue to be developed to allow small RPAS to operate in more types of airspace. VLOS will be used to provide detect and avoid mitigation for these RPAS. This is a U.S.-focused approach that currently may not apply for other States.

Some states are looking at localized ground-based detect and avoid (GBDAA) technology to support the detect and avoid requirements.

Below is a list of definitions that are used in the development of this block.

- ***Command and control (C2) link.*** The data link between the remotely-piloted aircraft and the remote pilot station for the purposes of managing the flight.
- ***Controlled airspace.*** An airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification.
- ***Segregated airspace.*** Airspace of specified dimensions allocated for exclusive use to a specific user(s).
- ***Detect and avoid.*** The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.
- ***Remote pilot.*** A person charged by the operator with duties essential to the operation of a remotely-piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.
- ***Remote pilot station.*** The component of the remotely-piloted aircraft system containing the equipment used to pilot the remotely-piloted aircraft.
- ***Remotely-piloted aircraft (RPA).*** An unmanned aircraft which is piloted from a remote pilot station.
- ***Remotely-piloted aircraft system (RPAS).*** A remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links, and any other components as specified in the approved type design.
- ***RPA observer.*** A trained and competent person designated by the operator who, by visual observation of the remotely-piloted aircraft, assists the remote pilot in the safe conduct of the flight.
- ***Visual line-of-sight (VLOS) operation.*** An operation in which the remote pilotor RPA observer maintains direct visual contact with the remotely-piloted aircraft.

1.1.2 Baseline

The baseline is applicable to RPAS IFR operations in non-segregated controlled airspace, including over the high seas, and at controlled aerodromes.

Block 1	Class B and C Airspace	Class A Airspace (Other than High Seas)	High Seas (Class A Airspace)	Class D, E, F, and G
Authorization	Strict compliance with the provisions of the authorization is required			Operations not permitted, unless by waiver or authorization
C2 Link Failure Procedures	Must be clearly defined. Will be pre-coordinated with the appropriate ATC facility and included in the authorization. Will include as determined by state authorities: C2 link failure route of flight, transponder use including a standard squawk code, emergency orbit points, communications procedures, and pre-planned flight termination points in the event recovery of the RPA is not feasible.			
Communications	Continuous two-way communications as required for the airspace. RPA will squawk 7600 in case of communications failure.		Continuous two-way communications will be maintained directly or via a service provider (e.g. ARINC or SITA) depending on location and operation.	
Separation Standards	TBD (New separation standards may be required and may or may not be available in this time frame)			
ATC Instructions	RPAS will comply with ATC instructions as required			
RPA Observers	TBD			
Medical	Remote pilots shall have an appropriate medical certificate			
Presence of Other Aircraft	RPAS shall not increase safety risk to the air navigation system			
Visual Separation	RPAS are not able to provide their own visual separation from other aircraft			
Responsibility of Remote Pilot	Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization			
Populated Areas	Restrictions to be determined by the State			
ATC Services	Consistent with Annex 11			
Flight Plan	RPAS operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed.			
Meteorological Conditions	Restrictions to be determined by the State			
Transponder	RPA shall have and use an operating mode C/S transponder			
Safety	Identify the hazards and mitigate the safety risks; adhere to the authorization			
NOTAMs	NOTAM requirements, if any, to be determined by the State			

1.1.3 Improvements brought by the module

Streamline process to access non-segregated controlled airspace. State authorities will need to consider if current national processes are adequate for enabling the level of airspace access necessary to accomplish all missions proposed or envisioned for RPAS flights. While international RPAS standards and certification requirements are being developed, national authorization processes will continue to provide access to airspace. Methods for improving and streamlining these processes will be worked on during this time frame. Approval to use existing technologies, such as ground-based detect and avoid systems, may support access to airspace through enhanced collision avoidance capability. This will allow authorities to streamline the process to grant authorization for airspace access.

Defining airworthiness certification for RPAS: Standards committees (such as RTCA SC-203, ASTM, F 38, EUROCAE WG 73, and others) will continue their work in the Block 1 timeframe, developing minimum aviation system performance standards (MASPS). Certification takes into account system configuration, usage, environment, and the hardware and software of the entire system (e.g. aircraft, remote pilot stations, C2 links). It also considers design characteristics, production processes, reliability, and in-service maintenance procedures that adequately mitigate risk of injury/damage to people, property or other aircraft. EASA's Rulemaking Directorate has issued policy statement E. Y013-01 for Airworthiness Certification of RPAS that outlines procedures for type certification of civil RPAS once standards have been established. Standards will need to be developed to certify all of the components of the RPAS. The certificate of Airworthiness will be issued for the entire RPA system. The C2 links will have to meet identified performance criteria. Certification standards and procedures will need to be worked out during this time frame.

Define operator certification:

Define remote pilot licensing requirements:

Define detect and avoid technology performance requirements. These performance-based requirements will be developed and certified to support the RPAS operational improvements as discussed above. The technology will be developed in conjunction with other risk mitigation efforts to gain incremental access to the airspace. Initial capabilities may include ground-based detect and avoid systems consisting of any combination of policy, procedures, and technology derived from ground-based sensors intended to facilitate safe airspace access over land or water. Surveillance (radar, ADS-B) initiatives will help gather, test, and verify data, along with the appropriate modeling and simulation activities, to establish requirements and build an overall safety case for detect and avoid. The detect and avoid technology will be used by the remote pilot to meet collision and hazard avoidance responsibility and provide situational awareness.

1.1.4 Other Remarks

This module describes the baseline and consists of only one element, accommodation of RPAS operating in controlled airspace. All of the improvements are related to this activity of accommodating the RPAS in the controlled airspace.

2 Intended Performance Operational Improvement/Metric to determine success

Access and Equity	Access to airspace by a new category of users Metric: volume of RPA traffic
Capacity	Could be negatively impacted due to larger separations being applied for safety reasons between RPAs and traditional traffic Metric: sector capacity increases
Global Interoperability	The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States.
Safety	Increased situational awareness; controlled use of aircraft Metric: incident occurrences

CBA	The business case is directly related to the economic value of the aviation applications supported by RPAS.
Human Performance	The controller-pilot relationship is changing and will need to be investigated. Specific training for controllers, remote pilots and pilots will be required, in particular with respect to the new detect and avoid situations.

3 Necessary Procedures (Air & Ground)

It is anticipated that as the improvements take shape in this block, air traffic services and procedures will have to change to accommodate these new airspace users. RPAS procedures such as C2 link failure will need to be standardized. These procedures may include a specific transponder code or ADS-B emergency mode to indicate a C2 link failure.

4 Necessary Technology (Air & Ground)

Ground-based Detect and Avoid (GBDAA) is the technology in this time frame envisioned to afford the greatest return on investment to allow better access to non-segregated airspace. This technology will improve the "detect and avoid" situational awareness for the RPAS pilot within the specific coverage areas defined by the systems and has the potential to be the near/midterm solution to the detect and avoid problem plaguing the RPAS community. This approach is currently utilized on a limited basis and may become a global approach in this time frame.

Communications. Communications includes traditional voice/data communications as well as all data related to command and control of the RPA. Current air-to-ground communications networks presume the pilot is on board the aircraft. The implications of the remote pilot being external to the aircraft will require a review and revision to preferred communications networks as well as bandwidth to support the amount of data required to operate and manage the RPA (STANAG 4586).

5 Regulatory/standardization needs and Approval Plan (Air & Ground)

Certificate of airworthiness

Operator certificate

Remote pilot licence

Frequency spectrum

Communications (including C2 link failure)

Detect and avoid

6 Business Case specific to the element

TBD

Numbers ($$, Euro) on industry outlook

7 Implementation and Demonstration Activities

7.1 Current Use

7.1.2 United States

The baseline is currently being used in the U.S. The Army has an authorization for ground-based sense and avoid (GBSAA) operations of their Medium/Large RPA, the Sky Warrior (Predator variant) at El Mirage, CA. The Marines/Navy are in the process of getting authorization for GBSAA operations at Cherry Point, SC. The USAF is looking at a corridor for Predator/Reaper aircraft climbing out of Cannon AFB, NM. This GBSAA concept will include a 12 NM corridor between the military Class D airspace and nearby restricted airspace. By 2013, the USAF will have developed a Dynamic Protection Zone (DPZ) concept that will shrink these large exclusion zones down to non-cooperative aircraft self-separation criteria of less than 10 NM much like is used for cooperative aircraft flying under IFR today.

7.1.3 Europe

- EUROCONTROL is in the process of integrating an RPAS in Class C and D airspace under IFR and VFR. Detect and avoid is mitigated through GBDAA and scanning through the on-board camera system. This will enable further integration.
- The MIDCAS consortium is developing a detect and avoid test bed that should be available for testing beginning in 2012
- In regard to VLOS, the Netherlands will certify an RPAS this year (civil certified)
- Euro Hawk is flying in controlled airspace as “operational air traffic”
- EUROCAE has finalized their work on a guidance document for VLOS
- A strategy document outlining EC policy on UAS is in preparation through an EC UAS panel, addressing industry and market issues, UAS insertion and spectrum, safety, societal dimensions and R&D
- Legal framework for the development of AMC (???) is in place. EASA will only deal with UAS with a mass greater than 150 kg.

7.2 Planned or On-going Trials

- In the US and Europe, several civil applications, initially VLOS and more integration of civil IFR/VFR operations in this time frame are expected based on full certification and special authorization
- Requirements for frequency spectrum for RPAS will be established in this time frame
- SESAR addresses UAS within WP 9, 11 and 15
- The European Defence Agency has launched the MIDCAS project. It is addressing detect and avoid from both military and civil perspectives. The budget is 50 million Euros and it is expected to produce a working prototype for detect and avoid application by the end of 2013.
- Mercator, an ultra-light UAS that is solar/battery powered for long duration flights at around FL450 is being tested in Belgian airspace to demonstrate a UAS flight in a busy ATM environment.

BLOCK 2

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Module N° B2-70: Advanced Wake Vortex Separation (Time-based)

Summary	Wake Vortex Separation – Time-based This ICAO ATM System Block Upgrade addresses the capacity enabling revisions to the Air Navigation Service Provider (ANSP) applied aircraft-to-aircraft wake separation standards and associated changes to the procedures the ANSP uses to apply the wake separation standards.	
Timescale	Block 2: 2023 - 2028	
Main Performance Impact	Capacity – Establishment of a time based separation criteria between pairs of aircraft extends the existing variable distance re-categorization of existing wake turbulence into a conditions specific time-based interval. This will optimize the inter-operation wait time to the minimum required for wake disassociation and runway occupancy. Runway throughput is increased as a result.	
Domain / Flight Phases	Aerodrome	
Applicability Considerations	Most Complex -	
Global Concept Component(s)	CM - Conflict Management	
Global Plan Initiative (GPI)	GPI-13 Aerodrome Design GPI 14 Runway Operations	
Reference Documents	ICAO Doc 9854 Global ATM Operational Concept, and ICAO Doc 9750 Global Air Navigation Plan This module also incorporates R199Doc 9882	
Main Dependencies		
Global Readiness Checklist		**Status (indicate ready with a tick or input date)**
	Standards Readiness	2023
	Avionics Availability	x
	Infrastructure Availability	x
	Ground Automation Availability	2023
	Procedures Available	2023
	Operations Approvals	2023

1 Narrative

1.1 General

Refinement of the Air Navigation Service Provider (ANSP) aircraft-to-aircraft wake mitigation processes, procedures and standards to time-based assignment will allow increased runway capacity with the same or increased level of safety. Block 2 upgrade will be accomplished without any required changes to aircraft equipage or changes to aircraft performance requirements although full benefit from the upgrade will require, as in block 1, aircraft broadcasting their aircraft based real-time weather observations during their airport approach and departure operations to continually update the model of local conditions.. The upgrade is dependent on the block 1 establishment of wake vortex characterization based on the wake generation and wake upset tolerance of individual aircraft types.

1.1.1 Baseline

ANSP applied wake mitigation procedures and associated standards were developed over time, with the last comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved 6 category wake vortex separation standards. Block 1 represented technology being applied to make available further runway capacity savings by enhancing the efficiency of wake vortex separation standards and the ease by which they can be applied by the ANSP. In particular the expansion of the 6 category wake separation standards to a Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings), is expected to yield an average increased airport capacity of 4% above that which was obtained by the Block 0 upgrade to the ICAO 6 category wake separation standards. In addition Block 1 expanded the use of specialized ANSP wake mitigation separation procedures to more airports by using airport wind information (predicted and monitored) to adjust the needed wake mitigation separations between aircraft on approach.

1.1.2 Change brought by the module

This Module (B2–70) represents a shift to time-based application of the Block 1 expanded distance based wake separation standards and ANSP wake mitigation procedures upgrade. Block 1 represented technology being applied to make available further runway capacity savings by enhancing the efficiency of wake vortex separation standards by expanding the 6 category wake separation standards to a Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings). Automation supported the ANSP by providing the minimum distance to be applied by the ANSP between pairs of aircraft. That expanded matrix represented a less conservative, but albeit still conservative, conversion of essentially time based wake characteristics into a standard set of distances. Block 1's goal was to reduce the number of operations in which an excessive wake spacing buffer reduced runway throughput. Block 2 uses the underlying criteria represented in the expanding re-categorization, the current winds, assigned speeds, and real time environmental conditions to dynamically assess the proper spacing between the aircraft to achieve wake separation. It couples that information with expect runway occupancy to establish a time spacing that provides a safe separation. These time-based separations are provided with support tools to the ANSP on their displays, and to the flight deck in the instances of cooperative separation which assumes already available flight deck tools for interval management.

2 Intended Performance Operational Improvement/Metric to determine success

To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:

Access and Equity	
Capacity	Y
Cost Effectiveness	
Efficiency	Y
Environment	Y
Flexibility	
Global Interoperability	Y
Participation by the ATM community	
Predictability	Y
Safety	
Security	

CBA	

3 Dependencies

Block 2 implementation is dependent on the successful adoption and implementation of the predecessor block B1-70.

4 Necessary Procedures (Air & Ground)

4.1 Implement Leader/Follower - Pair Wise Time-based Separation Standards

The change to the ICAO wake separation standards implemented in the Block 2 timeframe will change from a distance based separation that was expanded through the previous blocks form 3 to 60 or more to a tailored time based minima. This new ANSP procedure will need automation support in providing the required time-based aircraft-to-aircraft wake separations to its air traffic controllers.

Implementing Element 2 will not require any changes to air crew flight procedures. Necessary Technology (Air & Ground)

5 Regulatory/Standardisation needs and Approval Plan (Air & Ground)

5.1 Implement Leader/Follower - Pair Wise Time-based Separation Standards

The product of this activity is a new procedure with supporting automaton requirements to establish time-based separation standards for high density and high throughput terminal areas. This will require an expansion of ICAO wake separation standards and supporting documentation. Once approved, ICAO's revised wake separation standards will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards. Implementation and Demonstration Activities

6 Implementation and Demonstration Activities

6.1 Current Use

6.2 Planned Trials

Module N° B2-75: Optimised Surface Routing and Safety Benefits (ASMGCS Level 3-4, ATSA-SURF IA and SVS)

Summary	This block is intended to improve efficiency and reduce the environmental impact of surface operations, including during periods of low visibility. These improvements are achieved through collaboration and data sharing between ANSPs, Aerodrome Operators, and Airspace Users, in the management of pushback times, the creation and execution of surface trajectories (including times), and integration with arrival and departure flow management operations. Queuing for departure runways is reduced to the minimum necessary to optimize use of the runway, and taxi times are reduced. Operations are made more robust so that low visibility conditions (weather obscuration, night) have minor effect on execution of surface movement.	
Main Performance Impact	KPA-04 Efficiency, KPA-10 Safety	
Domain / Flight Phases	Aerodrome	
Applicability Considerations	Most applicable to large aerodromes with high demand, as the upgrades address issues surrounding queuing and management of complex operations	
Global Concept Component(s)	AO - Aerodrome Operations CM - Conflict Management DCB - Demand Capacity Balancing IS - Traffic Synchronisation AUO - Airspace User Operations	
Global Plan Initiatives (GPI)	GPI-14 Runway Operations GPI-16 Decision Support Systems and Alerting Systems GPI-17 Data Link Applications	
Reference Documents	ICAO Doc 9830 Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual. FAA Advisory Circulars AC120-28D Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout, AC120-57A Surface Movement Guidance and Control System. FAA NextGen Implementation Plan	
Main Dependencies	B1-75 primary B0-15, B1-15, B2-15, B3-15 B1-40 B0-80 - secondary	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

Globally, aerodrome operations have typically been handled in an ad hoc manner, in that decision-making regarding the pushback of aircraft from aprons into the movement area have been made almost entirely by the Airspace User. When consideration of the ATM system in pushback is included, it has been limited to manual coordination of Air Traffic Flow Management, not the aerodrome operation itself. As a result, taxiway congestion and departure queues may form which extend taxi times, increase direct operating costs (excess fuel burn), impact environment (emissions), and can even impede the efficient implementation of Air Traffic Flow Management plans.

This block is focused on improving the baseline case (completion of B1-75, Enhanced Surface Situational Awareness), by the introduction of new capabilities that enhance the coordination among ANSP, Airspace Users, and the Aerodrome Operator, and permit automated management of surface operations:

- Initial Surface Traffic Management (A-SMGCS Level 3)
- Enhanced Surface Traffic Management (A-SMGCS Level 4)

These capabilities will include changes to ANSP, Airspace User and Airport Operations, and Flight Deck Operations.

1.1.1 Baseline

The baseline case, which is based upon the completion of Block 1 (B1-75 Enhanced Surface Situational Awareness), assumes that a cooperative aircraft surveillance capability is in operational use at aerodromes, and that ANSP and flight crews have access to surveillance and safety logic. This provides a common situational awareness between the ANSP and Flight Crew, upon which the Block 2 capabilities are built.

1.1.2 Improvement brought by the module

The following capabilities are added by this Block:

- Initial Surface Traffic Management (A-SMGCS Level 3) includes the ability for a basic aerodrome taxi schedule to be created. This is based on scheduled flights, with updates and additions provided by initial data sharing of flight status from Airspace Users and/or Airport Operators (e.g. ramp tower, airspace user aerodrome operations, airspace user dispatch office, etc.). A basic capability to manage departure queues is also provided. Flight Deck operations include the ability to receive taxi clearances via data link communications.
- Enhanced Surface Traffic Management (A-SMGCS Level 4) includes the ability to create a more accurate aerodrome taxi schedule, including development of taxi trajectories (i.e. including times at points along the taxi path). The taxi schedule is integrated with ANSP arrival management and departure management capabilities, to improve execution of overall Air Traffic Flow Management strategies. Flight Deck operations are enhanced by taxi route guidance and synthetic vision displays.

Note that parts Enhanced Surface Traffic Management may only be performed during periods of exceptional demand; operations may fall back to Initial Surface Traffic Management operations during less busy periods.

1.1.3 Other remarks

Because the improvements in this block are intended to address congested operations, it is likely that a business case for specific aerodrome implementations will need to be studied to determine whether to deploy these capabilities at large aerodromes / airspace user hubs.

2 Element 1: Initial Surface Traffic Management (A-SMGCS Level 3)

This element of the block includes the following capabilities:

- Taxi Routing Logic for ANSP – automation provides suggested taxi routes based on current aircraft position and heuristics. These rules take into consideration the departure route, the departure runway usually associated with the departure route, and most efficient paths to the runway
- Data Link Delivery of Taxi Clearance – the taxi clearance is provided electronically to aircraft
- Taxi Conformance Monitoring for ANSP – automation monitors the movement of aircraft on the surface and provides an alert if aircraft deviate from their assigned taxi route
- Basic Taxi Schedule - automation builds a projected schedule for the surface based on scheduled flights. This schedule is modified as airspace users update their projections for when flights will be actually ready for pushback.
- Aggregate Departure Queue Management – if congestion is predicted on the taxi schedule (e.g. excessive queues are predicted to form), then airspace users will be assigned a target number of flights that will be permitted to begin taxi operations over a future parameter time period; airspace users may choose their own priorities for assigning specific flights to these taxi opportunities. This capability will have basic ability to incorporate any Air Traffic Flow Management Constraints to specific flights.
- Data Sharing – information about taxi times, queues, and delays is shared with other ANSP flight domains, and with external users (airspace users and airport operators).

2.1 Intended Performance Operational Improvement / Metric to determine success

These activities are intended to directly improve efficiency by maximizing runway utilization while minimizing taxi times, within the context of any higher level Air Traffic Flow Management strategy and available airport resources (e.g. gates, apron areas, stands, taxiways, etc.) This will result in reduced fuel burn, with associated lowering of environmental impacts.

Further, data sharing will improve the information available to Air Traffic Flow Management, leading to better coordination and decision making among ANSP and airspace users.

A secondary impact of this element will be improved safety, as conformance to taxi clearance is monitored. Aircraft will receive taxi clearances electronically, to further reduce potential confusion about taxi routes.

2. Efficiency
    a. Reduced Taxi Out Times
        i. Reduced fuel burn and other direct operating cost
        ii. Associated reduced impact to environment
3. Flexibility
    a. Improved Information to Air Traffic Flow Management
        i. Improved ability to predict congestion (actual demand vs capacity)
        ii. Improved application of Air Traffic Flow Management Actions
    b. Improved flexibility on the aerodrome surface
        i. Improved ability to resequence departing aircraft to meet changing conditions
4. Safety
    a. Reduced Taxi Non-Conformance
    b. Reduced Taxi Clearance Communications Errors

2.2 Necessary Procedures (Air & Ground)

Significant ANSP procedure changes for managing aerodrome surface operations will be required, including the creation of collaboration procedures and norms with airspace users and/or aerodrome operators for aggregate surface scheduling. In particular, managing surface operations by ANSP control of pushback times is potentially a significant change in aerodrome management policies at many locations. Specific procedures for each element and sub-element are required to effectively achieve the benefits of this Block, and ensure safety, including procedures for ANSP use of Data Link Taxi Clearances and procedures for coordination with Air Traffic Flow Management.

Airspace users and/or aerodrome operators need to make significant changes to their procedures for managing surface operations, especially for the collaborative building of aggregate surface taxi schedules and the accommodation of ANSP control of pushback times.

Flight deck procedures for use and integration of Data Link Taxi Clearances are required.

2.3 Necessary Technology (Air & Ground)

This element requires the following ANSP technology:

1. Initial A-SMGCS / Surface Traffic Management Automation
2. Data sharing with Air Traffic Flow Management
3. Data Link Communications.

This element requires the following Airspace User/Aerodrome Operator technology:

1. Initial A-SMGCS / Collaboration Capability with ANSP Surface Traffic Management capability

This element requires the following Aircraft technology:

2. Data Link Communications

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Standards for (a) Initial A-SMGCS / Surface Traffic Management Automation, (b) communication standards with Air Traffic Flow Management and Airspace User and/or Aerodrome Operators (aggregate collaboration on schedule), and (c) Data Link Communications are required.

2.5 Business Case specific to the element

The business case for this element is based on minimizing taxi times, thus reducing the amount of fuel burned during the taxi operation. Air Traffic Flow Management delays are taken at the gate, stands, apron, and taxiway holding areas rather than in queues at the departure end of the runway. Runway utilization will be maintained so as to not impact throughput. Details TBD.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

ANSPs and commercial companies have developed initial capabilities in this area. These capabilities allow for data exchange of surface surveillance data between ANSPs, airspace users, and airport operators. Enhancements to operations are largely centered on improvements that shared surface situational awareness provides.

2.6.2 Planned or Ongoing Trials

Various ANSPs, research and government organizations and industry are working on prototype capabilities of Surface Traffic Management. These activities include Surface Traffic Management / Airport Collaborative Decision Making capabilities and concepts under evaluation at airports around the world (e.g. Memphis, Dallas-Fort Worth, Orlando, Brussels, Paris/Charles de Gaulle, Amsterdam, London/Heathrow, Munich, Zurich, Frankfurt). Laboratory simulation experiments on more advanced capabilities such as Taxi Conformance Monitoring (MITRE) have been performed. European development is being accomplished via SESAR Work Program 6, Eurocontrol, and others. Deployment in the United States of initial capabilities is slated for the 2018 timeframe.

3 Element 2: Enhanced Surface Traffic Management (A-SMGCS Level 4)

This element of the block enhances capabilities from Element 1:

- Taxi Trajectories – automation builds a predicted trajectory for each aircraft including times along the taxi path. When this capability matures, taxi trajectories will be used to assist with deconflicting runway crossings. Conformance monitoring is enhanced to monitor against trajectory times in addition to paths, with prediction and resolution of taxi trajectory conflicts.
- Taxi Trajectory Guidance for Pilots – digital taxi clearances are parsed by the aircraft avionics to allow depiction of the taxi route on surface moving maps. Avionics may be further enhanced to provide visual and/or aural guidance cues for turns in the taxi route, as well as taxi speed guidance to meet surface trajectory times. This can be displayed on the instrument panel or on a Heads-Up Display.
- Synthetic Vision Systems – area navigation capability on the aircraft and detailed databases of aerodromes will allow for a computer-synthesized depiction of the forward visual view to be displayed in the cockpit. Integration with Enhanced Vision System will add integrity to this depiction. This capability reduces the impact that low visibility conditions have on the safety and efficiency of the surface operation. The depiction can be displayed on the instrument panel or on a Heads-Up Display.
- Flight-Specific Departure Schedule Management – ANSP and airspace users will collaboratively develop a flight-specific surface schedule. Automation assists in identifying appropriate departure times that consider any Air Traffic Flow Management actions. Other operational factors such as wake vortex separation requirements will be considered by automation in sequencing aircraft for departures. Pushback and taxi operations will be managed to this schedule.
- Integration with Arrival and Departure Management – taxi schedules are built to account for arriving aircraft, and so that aircraft departures meet the objectives for system-wide Air Traffic Flow Management activities. Flight will be permitted to pushback with the intent to meet targeted departure times.

3.1 Intended Performance Operational Improvement / Metric to determine success

These activities are intended to further improve taxi efficiency by managing by trajectory both in the tower and in the cockpit. This allows aircraft to stay in motion for longer periods during the taxi operation, reducing the taxi times and associated fuel burn even further. Coordination of schedules among arrivals, surface, and departures further enhances the efficiency of operations.

Additionally, this element improves the safety of surface operations, by adding taxi route guidance and trajectory conformance capabilities to the aircraft. This will further reduce navigation errors on the surface, and will provide a means for further deconfliction path intersections such as runway crossings.

1. Efficiency
    a. Reduced Taxi Out Times
        i. Reduced fuel burn and other direct operating cost
        ii. Associated reduced impact to environment
    b. Reduced Start/Stop of during Taxi
        i. Reduced fuel burn and other direct operating cost
        ii. Associated reduced impact to environment
2. Flexibility
    a. Coordination with Air Traffic Flow Management
        i. Improved ability to predict congestion (actual demand vs capacity)
        ii. Improved application of Air Traffic Flow Management by trajectory
    b. Improved flexibility on the aerodrome surface
        i. Improved ability to resequence departing aircraft to meet changing conditions
3. Safety
    a. Reduced Taxi Non-Conformance

3.2 Necessary Procedures (Air & Ground)

Significant ANSP procedure changes for managing aerodrome surface operations will be required, including the creation of collaboration procedures and norms with airspace users and/or aerodrome operators for flight-specific surface scheduling. In particular, managing surface operations by ANSP control of pushback times is potentially a significant change in aerodrome management policies at many locations. Specific procedures for each element and sub-element are required to effectively achieve the benefits of this Block, and ensure safety, including procedures for coordination with Air Traffic Flow Management.

Airspace users and/or aerodrome operators need to make additional changes to their procedures for managing surface operations, especially for the collaborative building of flight-specific surface taxi schedules and the accommodation of ANSP control of pushback times.

Flight deck procedures for use and integration of Taxi Trajectory Guidance and Synthetic Vision Systems into taxi operations are required.

3.3 Necessary Technology (Air & Ground)

This element requires the following ANSP technology:

1. Enhanced A-SMGCS / Surface Traffic Management Automation
2. Advanced integration with Air Traffic Flow Management

This element requires the following Airspace User/Aerodrome Operator technology:

1. Enhanced A-SMGCS / Collaboration Capability for Surface Traffic Management

This element requires the following Aircraft technology:

1. Taxi Trajectory Guidance capability
2. Synthetic Vision System

3.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Standards for (a) Enhanced A-SMGCS / Surface Traffic Management Automation, (b) communication standards with Air Traffic Flow Management (integration of arrival, surface, and departure schedules) and Airspace User and/or Aerodrome Operators (flight-specific collaboration on schedule), (c) Flight Deck Taxi Trajectory Guidance, and (d) Flight Deck Synthetic Vision Systems (RTCA SC-213/Eurocae WG-79) are required.

3.5 Business Case specific to the element

This element further reduces taxi times and the amount of fuel burned during the taxi operation. Air Traffic Flow Management delays are taken at the gate, stands, apron, and taxiway holding areas rather than in queues at the departure end of the runway. Details TBD.

3.6 Implementation and Demonstration Activities

3.6.1 Current Use

The operations of this Element are still under research, and have not yet been implemented in current use.

3.6.2 Planned or Ongoing Trials

Collaborative Departure Scheduling is under research in the United States by the FAA, but has not yet undergone operational trials. Laboratory simulation experiments on more advanced capabilities such as Taxi Route Guidance (NASA) have been performed. Other areas such as management of aerodrome surface operations by trajectory are still under concept formulation.

Operational deployment in the United States of capabilities is slated for beyond 2018.

4 Main Dependencies

Successor of B1-75: Enhanced Surface Situational Awareness

This block requires some capabilities in: B0-15, B1-15, B2-15, B3-15 (AMAN/DMAN/SMAN); B1-40 (Data Link); B0-80 (A-CDM/Airport Planning).

This block also has technical or operational relationship to: B2-80 (Remote Tower)

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Module N° B2-15: Linked AMAN/DMAN

<table>
<tr><td>Summary</td><td colspan="2">This module includes a brief description of integrated arrival and departure management. The module also summarizes the benefits of such integration and the elements that facilitate it.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-04 Efficiency; KPA-09 Predictability</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">Terminal, En-route, Aerodrome, and Supporting Infrastructure</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Benefits are greatest in high density TMA around the globe. The benefits do not depend on aircraft equipage.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">TS - Traffic Synchronization
AO - Aerodrome Operation
CM - Conflict Management
AUO - Airspace User Operations
AOM - Airspace Organization and Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-5 RNAV and RNP (PBN)
GPI-10 Terminal area Design and Management
GPI -11 RNP and RNAV Standard Instrument Departures (SIDs) and Standard Terminal Arrivals (STARs)
GPI-12 Functional Integration of Ground Systems with Airborne Systems
GPI-14 Runway Operation</td></tr>
<tr><td>Reference Documents</td><td colspan="2">ICAO Doc 9584 Global ATM Operational Concept,
ICAO Doc 9750 Global Air Navigational Plan.
European ATM Master Plan,
SESAR Definition Phase Deliverable 2 – The Performance Target,
SESAR Definition Phase Deliverable 3 – The ATM Target Concept,
SESEAR Definition Phase 5 – SESAR Master Plan
TBFM Business Case Analysis Report
NextGen Midterm Concept of Operations v.2.0
RTCA Trajectory Concept of Use
and various Industry standards</td></tr>
<tr><td>Main Dependencies</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>√</td></tr>
<tr><td>Avionics Availability</td><td>NA</td></tr>
<tr><td>Infrastructure Availability</td><td>2023</td></tr>
<tr><td>Ground Automation Availability</td><td>2023</td></tr>
<tr><td>Procedures Available</td><td>2023</td></tr>
<tr><td>Operations Approvals</td><td>2023</td></tr>
</table>

1 Narrative

1.1 General

NextGen and SESAR share a common strategic objective to introduce operational and technical capabilities that builds toward the future ICAO Global Air Traffic Management Operational Concept. Both efforts seek to implement automation systems and more efficient operational schemes to better utilize congested airspace.

In Block 2 (2023), departure and arrival sequence will be synchronised. This is a logical step following the synchronisation of surface departure management. The coupled departure and arrival management will lead to an optimised departure/arrival sequence and dynamic configuration of runways and airspace..

The synchronization of arrival and departure management allows ANSPs to configure arrival and departure procedures to maximize utilization of aerodrome and terminal airspace, e.g. the ANSP can, based on runway configuration and demand, via manipulation of meter fixes and/or runway configuration, to adjust departure and arrival flows such that airspace capacity is used efficiently. This synchronisation will foster greater runway throughput and airspace capacity. In addition, the integration enables dynamic sequencing for both arrival and departure. ANSP can adjust departure and CTAs to mitigate the effects of wake vortex and other restrictions. This joint sequencing, will aid with ANSP's demand and capacity balancing prerogatives and enable more efficient terminal and aerodrome airspace design

Synchronisation of arrival and departure sequences relies upon operational consistency and information homogeneity. Flight information, such as speed, position, restrictions, and other relevant information, must be uniform and share across all ATC authorities. Information homogeneity and common procedures are essential in achieving the operational consistency between ATC authorities that is the stepping stone for departure and arrival synchronisation.

1.1.1 Baseline

Block 1 brought about the synchronisation of surface and departure management. Specifically, surface surveillance and departure sequencing will be linked to further streamline departure operations. Precise surface movement reduces runway occupancy time and improve conformance to assigned departure time. RNAV/RNP procedures usage in high density terminal domain is more prevalent. Greater usage of RNAV/RNP procedures optimises throughput and provides fuel-efficient routes for airspace users. Metering will also be extended into en-route airspace, ensure greater monitoring on conformance to Control Time o f Arrivals. Extended metering will also assist in funnelling flights from en-route to terminal airspace.

1.1.2 Improvement brought by the module

In Block 2, arrival and departure sequencing will be synchronised. The primary benefits of such synchronisation are optimised allocation of airspace/aerodrome resources and greater runway throughput

Synchronization of departure and arrival management will serves a tool to maximize airspace capacity and runway throughput. Capacity augmentation is achieved via optimization of terminal and aerodrome resource allocation. The coupling of the two enables dynamic sequencing and flexible airspace design. More efficient airspace design will aid in the mitigation of negative impacts of restrictions such as Miles-In-Trail (MIT) spacing, resulting in higher throughput for gridlocked terminal domain airspace. More efficient airspace design leads to more streamlined traffic flows, reducing delays and conflicts.

Coordination of departure operation between ATC authorities, such as coordination of departure and arrival flow with relevant ATC authorities, will promote more agile and efficient terminal operations.

The synchronised information flow as the result of harmonisation between departure and arrival also foster greater common situation awareness for all stakeholders. Information transferred between all ATC authorities involved will be reconciled to provide a common operational picture. This reduces the complexity of ATM operations and system interfaces.

1.2 Element 1: Arrival and Departure Synchronization

Arrival and departure synchronization establishes a predictable and efficient stream of flights in the terminal and aerodrome airspace. The synchronization will optimize both terminal procedures and runway configuration to accommodate the maximum volume of aircrafts. Dynamic sequencing of arrival and departure flow will aid in the optimization of terminal procedures by avoiding or lessening the impact of relevant restrictions. The coupled arrival and departure sequence can be adjusted to accommodate the demand and terminal domain resource constraints. . Integration of arrival and departure sequencing further remove inconsistency in ATM decisions.

2. Intended Performance Operational Improvement/Metric to determine success

<table>
<tr><th>Key Performance Area</th><th>Performance Operational Improvement</th></tr>
<tr><td>Efficiency</td><td>1. Increased departure throughput
2. Increased tower productivity
3. Increased Center TMU productivity</td></tr>
<tr><td>Capacity</td><td rowspan="2">1. Decreased Miles-In-Trail (MIT) spacing</td></tr>
<tr><td>Safety</td></tr>
<tr><td>Predictability</td><td>1. Increased control departure time compliance</td></tr>
<tr><td>Global Interoperability</td><td>1. Increased common situational awareness</td></tr>
<tr><th colspan="2">Performance Measurements</th></tr>
<tr><td rowspan="4">Metrics</td><td>1. aircraft/hour</td></tr>
<tr><td>2. minutes per flight managed</td></tr>
<tr><td>3. Nautical Miles</td></tr>
<tr><td>4. pilot deviation/hours of operation.</td></tr>
</table>

3. Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing integrated arrival and departure capability consistent with the vision of a performance-oriented ATM System. The TBFM and AMAN/DMAN efforts will develop the systems and operational procedures necessary. In particular, procedures for the expansion of metering to departure will be necessary. RNAV/RNP for arrival will also be crucial as well.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM 1System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

4. Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. TBFM, Integrated Arrival and Departure Management represent a major stride toward that vision. The key aspects include support for the synchronization of arrival sequencing and departure sequencing, and departure information dissemination. Other aspects include boosting predictability of arrival flow, further honing sector capacity and demand estimates, and management by trajectory.

Both TBFM and Arrival/Departure Management (AMAN/DMAN) will leverage existing technologies that are readily available. Both efforts will take incremental steps toward the long term capability described in their respective strategic documents.

5. Regulatory/standardisation needs and Approval Plan (Air & Ground)

5.1.1 This TBFM and AMAN/DMAN implementation will impact ICAO Annex 1, the PANS-ATM document (ICAO Doc 4444) and the Global ATM Operational Concepts (ICAO Doc 9584).

6. Business Case specific to the module

6.1.1 Time Base Flow Manager Business Case Analysis Report

6.1.2 Should reduce environmental effects (emission, noise, and fuel burn).

7. Implementation and Demonstration Activities

7.1 Current Use

Traffic Management Advisor is currently used in the US as the primary time based metering automation. NextGen efforts will field augmentation to the Traffic Management Advisor incrementally. EuroControl will begin deployment of Arrival and Departure Manager (AMAN/DMAN).

7.2 Planned or Ongoing Trials

SESAR: AMAN/DMAN/SMAN deployment

NextGen: TBD

8. Main dependencies

B1-15

Module N° B2-25 Improved Coordination through multi-centre Ground-Ground Integration: (FF-ICE/1 and Flight Object, SWIM)

Summary	FF-ICE supporting Trajectory based Operations through exchange and distribution of information for multicentre operations using Flight Object implementation and Interoperability (IOP) standards. Extension of use of FF-ICE after departure supporting Trajectory based Operations. New system interoperability standards will support the sharing in ATM services that could involve more than two ATSUs.	
Timescale	2023	
Main Performance Impact	KPA-02 Capacity, KPA-04 Efficiency, KPA-06 Flexibility; KPA-07 Global Interoperability, KPA-10 Safety,	
Domain / Flight Phases	All flight phases and all type of ground stakeholders	
Applicability Considerations	Applicable to all ground stakeholders (ATS, Airports, Airspace Users) in an homogeneous areas, potentially global.	
Global Concept Component(s)	AUO –Airspace User Operations AO – Airport Operations DCB – Demand capacity Balancing CM - Conflict management IM - Information Management	
Global Plan Initiatives (GPI)	GPI-6 ATFM GPI-7 Dynamic and flexible route management GPI-16 Decision Support Systems	
Reference Documents	• FF-ICE Concept Document • FF-ICE FIXM SARPs to be developed • Eurocae ED133 Flight Object Interoperability Standard for distributed FDPS.	
Main Dependencies	Successor of B1-25, B1-31	
Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	2018
	Avionics Availability	No requirement
	Infrastructure Availability	2020
	Ground Automation Availability	2020
	Procedures Available	2020
	Operations Approvals	2020

1 Narrative

1.1 General

1.1.1 Baseline

The baseline for this module is coordination transfers and negotiation in B1-25

First step of FF-ICE/1 for ground application, during the planning phase before departure

1.1.2 Change brought by the module

Sharing of all the Flight and Flow information during Planning and Execution Flight Phase

1.2 Element:

FF-ICE/1 – will be extended for a complete use of FF-ICE after departure supporting Trajectory based Operations. The technical specification for FF-ICE will be implemented in the ground systems of the ground stakeholders using Flight Object implementation and IOP standard.

The module makes available a protocol to support exchange and distribution of information for multicentre operations.

SWIM will facilitate information sharing.

1.3 Other remarks

This module is a second step towards the more sophisticated 4D trajectory exchanges between both ground/ground and air/ground according to the ICAO Global ATM Operational Concept.

2. Intended Performance Operational Improvement/Metric to determine success

2.1 Element :

Access and Equity	
Capacity	reduced controller workload and increased data integrity
Cost Effectiveness	
Efficiency	Through more direct route and use of RTA to upstream centres..
Environment	
Flexibility	
Global Interoperability	Easier facility of system connexion and wide exchange of the information among the actors..
Participation by the ATM community	FF-ICE will facilitate the participation of all interested parties
Predictability	
Safety	
Security	

CBA	
Human performance	

3 Necessary Procedures (Air & Ground)

Need for new procedures for new set of application toward Trajectory Based operation

4 Necessary Technology (Air & Ground)

ATM ground systems needs to support IOP and SWIM concept.

There are no specific airborne requirements.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

Eurocae ED133 is available for Flight data Processing. It address only ATSUs-FDP interoperability needs

Further standards are needed to support CDM application and Flight information sharing and access to all ground stakeholders

6 Implementation and Demonstration Activities

6.1 Current Use

6.2 Planned or Ongoing Trials

In SESAR Project 10.2.5, Flight Object Interoperability (IOP) System Requirement & Validation using Eurocae ED133 first demonstration and validation activities are planned during 2012-2014 period and first development in industrial systems are available from 2015.

It is anticipated that the initial implementation date in Europe between two ATSUs from two system providers and two ANSP will occur between 2018 and 2020.

SESAR R&D on SWIM are in WP14 SWIM technical architecture and WP8 Information management.

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Module N° B2-31: Enabling Airborne Participation in Collaborative ATM through SWIM

Summary	This module allows the aircraft to be fully connected as an information node in SWIM, enabling full participation in collaborative ATM processes with access to voluminous dynamic data including meteorology. This will start with non-safety critical exchanges supported by commercial data links. The applications of this module are integrated into the processes and the information infrastructure which had evolved over the previous blocks.	
Main Performance Impact	KPA-01 Access & Equity, KPA-04 Efficiency, KPA-05 Environment, KPA-08 Participation by the ATM Community, KPA-09 Predictability, KPA-10 Safety	
Domain / Flight Phases	All phases of flight	
Applicability Considerations	long-term evolution potentially applicable to all environments	
Global Concept Component(s)	IM – Information Management	
Global Plan Initiatives (GPI)	GPI-17 Implementation of data link applications GPI-18 Electronic information services	
Reference Documents	FF-ICE Manual (under development) ICAO Global Concept	
Main Dependencies	Successor of: B1-30, B1-31, B1-105, B1-50	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2023
	Avionics Availability	2023
	Infrastructure Availability	2023
	Ground Automation Availability	2023
	Procedures Available	2023
	Operations Approvals	2023

1. Narrative

1.1 General

The Global concept envisages that the aircraft is an integral part of the collaborative, information-rich ATM environment. This ultimately makes it a regular node of the SWIM processes and infrastructure, able to participate in the 4D trajectory management and collaborative processes.

1.1.1 Baseline

Modules B1-30 and B1-31 have created the ground SWIM infrastructure and the information reference model, and implemented processes and applications for ground users. Through Aeromacs, a high capacity data link exists for aircraft at the gate (end of pre-flight phase). Aviation, motivated first by non-ATM needs, has access to commercial satellite communication.

1.1.2 Change brought by the module

This module allows the aircraft to be fully connected as an information node in SWIM, enabling full participation in collaborative ATM processes with access to voluminous dynamic data including meteorology, initially for non-safety critical exchanges supported by commercial data links. The applications of this module are integrated into the processes and the information infrastructure which had evolved over the previous blocks.

The module can then evolve smoothly to the use of other technologies as they become available for the air-ground link when the aircraft is airborne. The safety-critical aspects of ATM communications are covered by module B2-55 which may provide enough throughput for all ATM-related data exchanges.

2. Intended Performance Operational Improvement/Metric to determine success

Access and Equity	Access by the aircraft to the ATM information environment
Efficiency	Better exploitation of meteorological and other operational (e.g. airport situation) information to optimise the trajectory
Environment	Better exploitation of meteorological information to optimise the trajectory
Participation by the ATM community	The aircraft becomes an integral part of continuous collaboration and of the overall information pool.
Predictability	Anticipation of situations affecting the flight through the access to relevant information
Safety	Anticipation of potentially hazardous or safety bearing situations affecting the flight through the access to relevant information

CBA	The business case will be established in the relevant validation programmes.
Human Performance	

3. Necessary Procedures (Air & Ground)

Procedures are to be defined. They will define the conditions of access to information and the use to supported applications depending on the characteristics of these and of the communication channels available, in particular safety, security and latency.

4. Necessary Technology (Air & Ground)

The enabling technologies are under development. A number of them are provided by the other modules with which this one has dependencies.

5. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Specifications are to be defined.

6. Implementation and Demonstration Activities

6.1 Current Use

- **None**

6.2 Planned or Ongoing Trials

- **Terra X:**TBC.

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Module N° B2-35: Increased User Involvement in the Dynamic Utilisation of the Network

Summary	This module introduces CDM applications by which ATM will be able to offer/delegate to the users the optimisation of solutions to flow problems, in order to let the user community take care of competition and their own priorities in situation when the network or its nodes (airports, sector) does no longer provide actual capacity commensurate with the satisfaction of the plans. The previous module has introduced an initial version UDPP, focused on the issues at an airport. This module brings it forward, building on SWIM but for more complex situations.
Main Performance Impact	KPA-02 Capacity, KPA-09 Predictability
Domain / Flight Phases	Pre-flight phases
Applicability Considerations	Region or sub-region
Global Concept Component(s)	DCB Demand-Capacity Balancing TS Traffic Synchronisation AOM Airspace Organisation and Management AUO Airspace Users Operations
Global Plan Initiatives (GPI)	GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management
Reference Documents	
Main Dependencies	Successor of B1-35 Requires B1-30 and probably B2-25

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2023
	Avionics Availability	2023
	Infrastructure Availability	2018
	Ground Automation Availability	2023
	Procedures Available	2023
	Operations Approvals	2023

1. Narrative

1.1 General

1.1.1 Baseline

The previous module, B1-35, has introduced an initial version UDPP, focused on the issues at an airport.

1.1.2 Change brought by the module

This module further develops the CDM applications by which ATM will be able to offer/delegate to the users the optimisation of solutions to flow problems, in order to let the user community take care of competition and their own priorities in situation when the network or its nodes (airports, sector) does no longer provide actual capacity commensurate with the satisfaction of the schedules. This module also builds on SWIM for more complex situations.

2. Intended Performance Operational Improvement/Metric to determine success

Capacity	Improved use of the available capacity in situations where it is constrained. Metric: applied horizontal separation minima
Predictability	The module offers airlines the possibility to have their priorities taken into account and optimise their operations in degraded situations. Metric: deviations from user-preferred profiles

CBA	To be established when the research on the module has progressed more significantly
Human Performance	No significant issue identified

3. Necessary Procedures (Air & Ground)

Procedures to specify the conditions (in particular rules of participation, rights and duties, equity principles, etc) and notice for UDPP to be applicable. The process will need to be done in a way that does not conflict with or degrades the optimisation of the network done by ATFM.

4. Necessary Technology (Air & Ground)

Will be supported by SWIM environment technology.

5. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Equity requirements will likely imply that the mechanisms underlying the process are transparent and verifiable. The procedures mentioned above will need be regulated.

6. Implementation and Demonstration Activities

6.1 Current Use

None

6.2 Planned or Ongoing Trials

- **Europe**: SESAR work programme has just started to formulate the concept of UDPP, and will need to elaborate this module further before describing the trials for it**.**

Module N° B2-100: New Collision Avoidance System

Summary	This module describes the need for a new Airborne Collision Avoidance System (ACAS) to satisfy the emerging procedures that promotes greater accuracy. In addition, the module describes the necessary improvements for the new ACAS.
Main Performance Impact	KPA-10 Safety;
Domain / Flight Phases	En-route flight phases, including areas where radar systems cannot be installed such as desert or oceanic airspace.
Applicability Considerations	
Global Concept Component(s)	CM - Conflict Management
Global Plan Initiatives (GPI)	GPI- 2 Reduced vertical separation minima, GPI- 9 Situational awareness, GPI-16 Decision support system and alerting systems
Reference Documents	RTCA DO-298 *Safety Analysis of Proposed Change to TCAS RA Reversal Logic.* M. J. Kochenderfer and J. P. Chryssanthacopoulos, "*Robust airborne collision avoidance through dynamic programming*," Massachusetts Institute of Technology, Lincoln Laboratory, Project Report ATC-371, 2010.
Main Dependencies	
Global Readiness Checklist	

	Status (ready or date)
Standards Readiness	2023
Avionics Availability	2023
Infrastructure Availability	√
Ground Automation Availability	√
Procedures Available	√
Operations Approvals	√

1 Narrative

1.1 General

The existing airborne collision avoidance system – ACAS II has been very effective in mitigating the risk of mid-air collisions. Safety studies indicate that ACAS II reduces risk of mid-air collisions by 75 – 95% in encounters with aircraft that are equipped with either a transponder (only) or ACAS II respectively. In order to achieve this high level of safety, however, the alerting criteria used by ACAS II often overlap with the horizontal and vertical separation associated with many safe and legal airspace procedures. ACAS II monitoring data from the U.S. indicate that as many as 90% of observed Resolution Advisories (RAs) are due to the interaction between ACAS II alerting criteria and normal ATC separation procedures (e.g., 500 feet IFR/VFR separation, visual parallel approach procedures, level-off with a high vertical rate 1,000 feet above/below IFR traffic, or VFR traffic pattern procedures). In order to achieve intended efficiencies in the future airspace, a reduction in collision avoidance alerting thresholds may be necessary in order to further reduce separation while minimizing “nuisance alerts”. Initial examination of NextGen procedures such as Closely Spaced Parallel Operations (CSPO) or use of 3 nautical mile en-route ATC separation indicate that existing ACAS performance is likely not sufficient to support these future airspace procedures. As a result, a new approach to airborne collision avoidance is necessary.

1.1.1 Baseline

Implementation of an improved airborne collision avoidance system must minimize “nuisance alerts” while maintaining existing levels of safety. Additionally, this new system must be able to more quickly adapt to changes in airspace procedures and the environment.

1.1.2 Improvement brought by the module

Implementation of a new airborne collision avoidance system will enable more efficient operations and future airspace procedures while complying with safety regulations. The new airborne collision avoidance systems will accurately discriminating between necessary alerts and “nuisance alerts” across the expected horizontal and vertical separation projected in future airspace procedures. Improved differentiation leads to reduction in ATC personnel workload, as ATC personnel spent exert less time to respond to “nuisance alerts”.

These procedures facilitate the optimized utilization of constrained airspace, while maintain safety standards. The revision of horizontal and vertical separation enables grid-locked areas to accommodate more aircrafts in all flight domains. Augmented ACAS will facilitate Closely Spaced Parallel Operations, increasing terminal and aerodrome throughput. The new ACAS will also increase capacity of the en-route domain via the implementation of 3 nautical mile separation standards.

1.1.3 Other remarks

The U.S. Federal Aviation Administration (FAA) has funded research and development of a new approach to airborne collision avoidance for the past 3 years. This new approach takes advantage of recent advances in dynamic programming and other computer science techniques to generate alerts using an off-line optimization of resolution advisories. This approach uses extensive actual aircraft data to generate a highly accurate dynamic model of aircraft behaviour and sensor performance. Based on a predetermined cost function and using advance computational techniques, this approach generates an optimized table of optimal actions based on information regarding intruder state information. This approach significantly reduces logic development time and effort by focusing developmental activities on developing the optimization process and not on iterative changes to pseudo-code.

2 Element 1: Improve differentiation between legitimate and “nuisance” alerts

To facilitate future airspace procedures, such as Closely Spaced Parallel Operations (CSPO) and 3 nautical mile separation, the current Resolution Advisory (RA) rate accuracy is inadequate for such procedures. New airborne collision avoidance system will leverage recent advancements in computer science to achieve the desired RA rate accuracy. In addition, alerting criteria and procedures will be revisited for the new airborne collision avoidance system.

2.1 Intended Performance Operational Improvement/Metric to determine success

Key performance metrics include Probability of a Near Mid-Air Collision (p(NMAC), RA alert rate and operational acceptability. Computation of these metrics is conducted assuming both the future system as well as in conjunction with existing ACAS and operational environment.

P(NMAC) – Since ACAS is a safety-critical system, the key performance metric is the probability of a near mid-air collision. This probability is computed using Monte Carlo simulation and has historically been used in the development and evaluation of ACAS II. This probability may be expressed by itself, or may use risk ratio to express the change in risk associated with implementation of system changes when compared to the existing system.

Resolution Advisory (RA) rate – The future collision avoidance system must minimize nuisance alerts to enable reduced separation; RA rate is another key performance metric. The RA rate is assessed using Monte Carlo simulation. These simulations are conducted using encounter models and airspace procedures representative of the current and/or future environment. The observed RA rate may be compared either against the existing system or against an objective standard.

State can use the following metrics to gauge the performance of this module.

4. Safety
    a. Improve Resolution Advisory (RA) rate accuracy to support future airspace procedures, such as new separation standards.
        i. Resolution Advisory rate
        ii. Nuisance alerts rate

    b. Reduction in the probability of near mid-air collision
        i. Probability of Near Mid-Air Collision – P(NMAC)

5. Environmental
    a. Reduced use of the 1030/1090 MHz spectrum

2.2 Necessary Procedures (Air & Ground)

Necessary operational procedures for future ACAS are contained in PANS-OPS (ICAO Doc. 8168) and PANS-ATM (Doc 4444). Future ACAS capabilities should support the implementation of these procedures.

2.3 Necessary Technology (Air & Ground)

Improved algorithm and computational technique is needed to increase the accuracy of the RA rates and better differentiate “nuisance” and legitimate alerts. The necessary technical issues and requirements can be found in ICAO Annex 6, Part I, and ACAS Manual (ICAO Doc 9863).

2.4 Business Case specific to the element

This module is currently in research and development. Initial evaluation, simulation and safety studies show that the new ACAS, compared to existing ACAS II, will significantly reduces the probability of a Near Mid-Air Collision (NMAC) while also significantly reducing the number of alerts and RA reversals. In addition to enhanced alerting and safety, development of associated new surveillance logic also has the potential to dramatically reduce use of the 1030/1090 MHz spectrum. Initial research on improved ACAS surveillance logic indicates that a 50% reduction in spectrum can be achieved and further reductions are likely. Initial evaluations of this approach have been conducted using the same Monte Carlo safety simulation employed in recent TCAS v7.1 safety studies.

Based on these very promising initial results, the FAA is working towards developing a prototype for initial flight testing in the next 3 – 5 years. This system can accommodate surveillance information in addition to Mode S surveillance and is designed to be compatible with legacy ACAS.

2.5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

ICAO Annex 6, Part I, Part II, and Annex 10, Vol. 4 specified the international standards for ACAS equipage and procedures.

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

TCAS is currently required for all aircrafts in the NAS. Level of equipage is dependent on the Max. Take Off Weight (MTOW) of the aircraft.

2.6.2 Planned or Ongoing Trials

TBD

3 Main dependencies

The implementation of this block depends on the on-going effort to develop a successor to the current TCAS technology. This successor should be capable of accommodating more robust separation assurance and other new airspace procedures.

Module N° B2-5: Optimised Arrivals in Dense Airspace

Summary	This module provides the baseline for using Optimised Arrivals in dense airspace. Optimised arrivals may include Optimised Profile Descents (OPDs) and Continuous Descent Arrivals (CDAs). A key emphasis is on the use of arrival procedures that allow the aircraft to apply little or no throttle in areas where traffic levels would otherwise prohibit this operation. This block will consider airspace complexity, air traffic workload, and procedure design for enabling Optimised Arrivals in dense airspace. It will also consider the development of operational and performance requirements for use of Optimised Arrivals in dense airspace, as well as standards for global exchange of the information.	
Main Performance Impact	KPA-04 Efficiency; KPA-05 Environment.	
Domain / Flight Phases	En-route, Terminal Area (Landings), Descent	
Applicability Considerations	Global, High Density Airspace (based on US FAA Procedures)	
Global Concept Component(s)	Airspace Organization and Management (AOM) Demand and Capacity Balancing (DCB) Airspace User Operations (AUO) Traffic synchronization (TS) Conflict management (CM) ATM service delivery management (ATM SDM)	
Global Plan Initiatives (GPI)	GPI-1 Flexible use of airspace GPI-5 RNAV and RNP (Performance-based navigation) GPI-6 Air Traffic Flow Management GPI-7 Dynamic and flexible ATS route management GPI-8 Collaborative airspace design and management GPI-10 Terminal area design and management GPI-11 RNP and RNAV SIDs and STARs	
Reference Documents	ICAO Doc 9331, Continuous Descent Operations (CDO) Manual	
Main Dependencies	B0-5, B1-35	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	2023
	Infrastructure Availability	2023
	Ground Automation Availability	2023
	Procedures Available	2023
	Operations Approvals	2023

1 Narrative

1.1 General

Optimised Arrivals in Dense Airspace integrates capabilities that will provide improved use continuously descending arrivals in highest congested airspace. Key aspects of Optimised Profiles in Dense Airspace are:

- Arrival procedures which allow the aircraft to fly a “best economy descent” from en-route airspace to final approach.
- Limited or no throttle is applied throughout the descent, with momentary level-offs being used to slow an aircraft as required by airspace restrictions.
- Flow management automation that allows air traffic control to manage aircraft flying Optimised arrivals with crossing, departing, and other arriving traffic.
- Cockpit automation that allows aircraft to freely choose top-of-descent and descent profile based on aircraft state and weather conditions.
- En-route and terminal controllers rely on automation to identify conflicts and eventually propose resolutions.
- Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of navigational aids, enabling the flexibility of point-to-point aircraft operations.
- Required Navigation Performance (RNP) operations introduce the requirement for onboard performance monitoring and altering. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor its achieved navigation performance for a specific operation, and inform the air crew if the operational requirement is being met.
- The basis for the operation is an accurate three-dimensional trajectory that is shared among aviation system users. This provides accurate latitude, longitude, and altitude information to airspace users.
- Consistent and up-to-date information describing flights and air traffic flows are available system-wide, supporting both user and service provider operations.

1.1.1 Baseline

The baseline for this block is Improved Flight Descent Profile and Complexity Management enabled by blocks B0-5 and B3-10. Optimised Arrivals are a component of Trajectory-Based Operations (TBO) initiatives. Decision support capabilities are available that are integrated to assist aircraft crew and air traffic separation providers in making better decisions and optimizing the arrival profile. Consistent 3D trajectory information is available to users to inform ATM decision making.

1.1.2 Improvement brought by the module

This block provides extensions to the baseline, with emphasis on economic descents in airspace with dense traffic levels. Benefits of these Trajectory Based Operations include fuel savings and noise and emission reduction by keeping aircraft at a higher altitude and at lower thrust levels than traditional step-down approaches. Simplifying routes using Optimised Arrivals may also reduce radio transmissions between aircraft crew and controllers.

Benefits of these operations in dense airspace include achieving target traffic and throughput levels while also enabling fuel savings and noise reduction. A traditional assumption is that the use of Optimised Arrivals will reduce throughput in dense airspace, or may not be achievable at all due to complexities created in sequencing Optimised arrivals with non-Optimised arrivals, departures, and crossing traffic.

The aircraft’s ability to accurately fly an Optimised Arrival, coupled with the state and intent information sent form the aircraft to ATC automation, will increase accuracy of trajectory modelling and problem prediction.

1.1.3 Other remarks

This module continues the evolution in RNAV and RNP procedure design in dense airspace, and the evolution of automation used to aid in decision support for both air crews and Air Traffic Control.

1.2 Element 1: Accurate Trajectory Modelling

This element is focused on obtaining the most accurate trajectory model for use by all automation systems. This includes accurate position information, clearance information, and the use of automated resolutions that reduce controller workload.

1.3 Element 2: Advanced Aircraft Capabilities

This element will focus on cockpit capabilities that enable optimal trajectory selection and the ability to fly point-to-point RNAV and RNP procedures. This element will also examine cockpit automation that enables the aircraft to self-separate and avoid potential conflicts. This element will focus on globally-harmonized standards development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

1.4 Element 3: Traffic Flow Management and Time-Based Metering

This element will harmonize the Traffic Flow Management automation which continuously predicts the demand and capacity of all system resources, and will identify when the congestion risk for any resource (airport or airspace) is predicted to exceed an acceptable risk. Traffic Management will take action in the form of just in time reroutes and metering times to congested resources. The problem resolution element will create a solution that meets all system constraints.

1.5 Connections to Other Blocks/Elements

In addition, the development of this block should be coupled with the development of the following major blocks (at a minimum) to ensure enhanced operations in dense airspace:

B0-5. Improved Flight Descent Profile

B1-35. Enhanced NOP, Integrated airspace/flow management

2 Intended Performance Operational Improvement/Metric to determine success

- Capacity: Better use of terminal airspace. High levels of traffic can be accommodates while still allowing the use of best economy descents that save fuel, emissions, and noise. Capacity will be enhanced by improved ability to plan for flows in and out of the airport.
- Efficiency: Users will fly more fuel and noise efficient arrivals and descent profiles. Time in flight may also be reduced to automation that enhances decision making and selection of a preferred trajectory.
- Safety: Economical descents used without sacrificing safety due to enhanced airspace management and automation to aid in aircraft separation.
- Flexibility: Users will be able to select arrival trajectory that best accommodates aircraft according to traffic conditions, weather conditions, and aircraft state.

3 Necessary Procedures (Air & Ground)

For strategic actions, the necessary procedures basically exist for Air Navigation Service Providers (ANSPs) and users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation. The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and will necessitate procedure development, including the roles of ANSPs. International standards for information exchange between systems to support these operations need to be developed. This includes development of global standards for the exchange of trajectory information between ground and air.

4 Necessary Technology (Air & Ground)

The continued development of automation for both the cockpit and ANSPs is needed to aid in trajectory modelling and required separation decision making. In addition, development of technology that provides mitigation strategies for conflicts or potential conflicts will also aid in enabling Optimised profiles in dense airspace. Aircraft-based capabilities, such as ADS-B/CDTI exist, but applications are still being developed to support the objectives of this module.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This module requires:

- Development of global standards for trajectory information exchange.
- Standardisation of procedure design guidance
- Standardisation of ATC/Pilot phraseology, such as the use of a "Descend Via" clearance when utilizing an Optimised Arrival

6 Business Case specific to the module

The major qualitative business case elements of this module are as follows:

- Capacity: Additional flights can be accommodated in terminal airspace because of reduced controller workload and better trajectory modelling/planning.
- Efficiency: Users will fly more fuel and noise efficient arrival descent profiles.
- Safety: Economic descents flown without sacrificing safety.
- Flexibility: Users will have greater flexibility in selecting the flight trajectory that best meets their needs.

7 Implementation and Demonstration Activities

7.1 Current Use

Optimised Arrivals are currently being used at the following U.S. airports in dense airspaces:

- Los Angeles International Airport (LAX)
- Phoenix Sky Harbor International Airport (PHX)
- Atlanta Hartsfield International Airport (ATL)
- Las Vegas International Airport (LAS)

7.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this module. There is a need to develop a trial plan as part of the collaboration on this module.

8 Main dependencies

This module is dependent on the accomplishment of block B0-5: Improved Flight Descent Profile and B3-10: Complexity Management. There is also a dependency on the development of future concepts and automation capabilities that will allow for flexible trajectory selection and mitigation strategies for detected conflicts. These technologies should be validated in field operations. The GPIs mentioned at the beginning of this block are assumed to provide the framework necessary for developing these capabilities.

Module N° B2-90: Remotely-Piloted Aircraft (RPA) Integration into Traffic

Summary	Block 2 builds on Block 1 by: continuing to improve the RPAS access to non-segregated airspace; continuing to improve the RPAS certification process; continuing to define and refine the RPAS operational procedures, standardizing the C2 link failure procedures and agreeing on a unique squawk code for C2 link failure; and working on detect and avoid technologies, to include ADS-B and algorithm development to integrate RPAS into the airspace. This effort also requires work to be done with ATM procedures and increasing the reliability, availability and security of C2 links, to include SATCOM links for beyond line-of-sight.	
Main Performance Impact	N/A – as this is a new development which must be accommodated within the Global ATM System.	
Domain / Flight Phases	Continental, High Seas, Terminal Area (arrival and departure), Aerodrome (taxi, take-off, and landing)	
Applicability Considerations	Global	
Global Concept Component(s)	Airspace Operations and Management (AOM), Conflict Management (CM), Airspace User Operations (AUO)	
Global Plan Initiatives (GPI)	GPI-6, Air traffic flow management. GPI-9, situational awareness. GPI-21, Navigation systems. GPI-23, Aeronautical radio spectrum	
Reference Documents	ICAO Cir 328, Unmanned Aircraft Systems (UAS); U.S. Department of Transportation Federal Aviation Administration Air Traffic Organization Policy N JO 7210.766.	
Main Dependencies	B1-90	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

1 Narrative

1.1 General

Based on Block 1, basic RPA procedures, Block 2 includes the procedures and technology that are possible in the block 2 timeframe. As discussed below.

Block 2	Class B and C	Class A Airspace (Other than High Seas)	High Seas (Class A Airspace)	Class D, E, F, and G
Authorization	Strict compliance with the provisions of the authorization is required			Operations not permitted, unless by waiver or authorization
C2 Link Failure Procedures	Will follow standardized procedures. A special purpose transponder code will be established.		Will follow standardized procedures.	
Communications	Continuous two-way communications as required for the airspace. UAS will squawk 7600 in case of loss of communications.		Continuous two-way communications will be maintained directly or via a service provider (e.g. ARINC or SETA) depending on location and operation.	
Separation Standards	New separation standards may be required		Separation criteria will be analysed and special separation criteria might be developed.	
ATC Instructions	RPAS will comply with ATC instructions as required			
RPA Observers	As required for the operation			
Medical	Remote pilots shall have an appropriate medical certificate			
Presence of Other Aircraft	RPAS shall not increase safety risk to the air navigation system			
Visual Separation	Visual separation may be permitted.		TBD	
Responsibility of Remote Pilot	Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization			
Populated Areas	Restrictions to be determined by the State.			
ATC Services	Consistent with Annex 11,			
Flight Plan	RPAS operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed.			
Meteorological Conditions	Restrictions to be determined by the State			
Transponder	Shall have and use an operating mode C/S transponder			
Safety	Identify the hazards and mitigate the safety risks; adhere to the authorization			
NOTAMs	NOTAM requirements, if any, to be determined by the State			
Certification	TBD			

1.1.1 Improvements brought by the module

The projected changes during this time frame include:

- **<u>Access to most airspace for select airframes without specific airspace constraints:</u>** As aircraft certification (based on an established safety case for a particular RPA system – airframe, link, and RPS) is developed and procedures are defined, airspace constraints will gradually be lifted and specific RPAs will be permitted to fly in more situations. In the Block 2 timeframe, this will start with a very small number of RPAs, but will be permitted to grow as the RPA proves it can meet standards, and certification and procedures are developed. This access will be based on the improvements to the RPA, the developed technology, (GBDAA, ADS-B, and Specific C2 link failure squawk) and improved ATM procedures.

- **RPAS certification procedures** Using Minimal Aircraft System Performance Specification (MASPS) developed by standards committees or adopted by ICAO, material solutions will be developed for integration into RPAS. As these solutions are integrated into selected RPAS, the RPAS will go through the process of being certified airworthy. Airworthiness and certification are based on a well-established airworthiness design standards. Therefore the following RPA related issues will have to be addressed:
  - Procedures Standards and Recommended Practices for all RPA classes
  - Procedures and standards for Ground Control Stations (RPS),
  - Provisions for C2 links
  - Possible rule changes to set forth a type standard for various RPA
  - Modification of type design (or restricted category) standards to account for unique RPA features (e.g., removal of windscreens, crashworthiness standards, control handoff from one RPS to another, etc.)
- **RPA procedures defined**: Procedures will be developed to permit selected RPA (proven airworthy) to fly in non-segregated airspace with manned aircraft. Training for pilots and ATC personal must be developed to accommodate these RPAS.
  - **New special purpose transponder code for lost link**: A new transponder code will be developed so that the ATC automation can differentiate RPA lost C2 links from loss of two-way radio communications in any aircraft. Because transponder codes cannot be received over the high seas, RPA will broadcast position to nearby aircraft via ADS-B. If ADS-C is mandated for high seas RPA, lost link position may be tracked by ATC if that electronic link remains intact.
  - **Standardized lost link procedures**
  - **Revised separation criteria and/or handling procedures (i.e. moving airspace)**
- **ADS-B on most RPA classes**: IT is envisioned that ADS-B will be included on most new RPA's being built during this time period and a retrofit program should be established.
- **Detect and Avoid technologies** will be improved and certified to support RPAs and operational improvements. Ground Based Detect and Avoid (GBDAA) will be certified and approved for more pieces of airspace. Other approaches to consider include an onboard (airborne) detect and avoid solution (ABDAA). ABDAA efforts are currently focused on developing the capability to perform both self-separation and collision avoidance onboard the aircraft that ensure an appropriate level of safety even in the event of lost command and control links. The initial capability will provide an ability to collect and analyze valuable data for developing a robust airborne DAA system.

Protected spectrum and security (ICAO Cir 328 An/190 Unmanned Aircraft Systems (UAS) refers) this necessitates the use of designated frequency bands, i.e. those reserved for aeronautical safety and regularity of flight under Aeronautical Mobile (route) Service (AM(R)S), Aeronautical Mobile Satellite (route) Service (AMS(R)S), Aeronautical Radio Navigation Service (ARNS) and Aeronautical Radio Navigation Satellite Service (ARNSS) allocations as defined in the ITU Radio Regulations. It is essential that any communications between the GCS and RPA for C2 meet the performance requirement applicable for that airspace and/or operation, as determined by the appropriate authority. SATCOM links may require a backup.

1.1.2 Other remarks

1.2 Elements

There is only one element for this module, RPA integration into traffic, (evolution of basis procedures). All of the improvement listed above relate to the integration of RPAS's into traffic.

2 Intended Performance Operational Improvement/Metric to determine success

- **Access to most airspace for select airframes without specific airspace constraints:** One of the metrics would be the number of RPA's that have access to more airspace routinely.
- **RPA certification procedures:** The standards committees (RTCA SC203, ASTM F38, EUROCAE WG 73, and others) have provided certification standards and procedures. The metric will be how many existing RPA's are certified, and, how many RPA's are in the process of being certified
- **RPA procedures defined:** More RPA will be "authorized" (based on the improvements to the RPA's, updated procedures, and improved technologies) to operate in non-segregated airspace under these defined procedures providing metrics and data on integration efforts.
- **New special purpose transponder code for lost link:** (GAIT final draft paper on Integrating Unmanned aircraft into non-Segregated Airspace, refers) – Discussions of a special purpose Code to Indicate Lost Link
- The Global Airspace Integration Team (GAIT) has concluded that a special purpose Secondary Surveillance Radar (SSR) code to provide rapid and unambiguous indication to ATC of a RPA lost link may well improve future aviation safety. GAIT future recommends that specific experimentation and simulation be undertaken to validate this finding. It is anticipated that during this block, this specific experimentation should be undertaken.
- **ADS-B on most RPA classes:** The metric will be ADS-B equipage percentage of the fleet.
- **Detect and Avoid technologies:** Process for validating and certifying Airborne Detect and Avoid Algorithms (ABDAA) algorithms will be established during this time frame. Metrics will address the validity of these algorithms.
- **Protected spectrum and security** Metrics will be developed to monitor the security of the links required when operating specific RPA's. This links include command and control (C2) links as well as data links.

3 Necessary Procedures (Air & Ground)

Improved air traffic management (ATM) procedures will need to be in place to allow the access of RPA's into the non-segregated airspace. Specifically:

- ATM provisions need to be amended to accommodate the RPA taking into account the unique operational characteristics of each RPA type as well as their automation and non-traditional IFR/VFR capabilities,
- Air navigation service providers will need to review emergency and contingency procedures to take account of unique RPA failure modes such as a lost link, to include standardized lost link procedures, and the new special purpose transponder code for lost link. Also consider procedures that may be necessary if the RPA is using an alternate control link that results in excessive delay in responding to RPA pilot inputs,
- Terminal area will need to improve their procedures to allow for the increased volume of RPA activity,
- Ground operations will need to be modified to accommodate the increased activity of RPA's as well.

Improved RPA certification procedures will need to be developed, as well as standardizing the lost link procedures. As ABDAA algorithms are developed, associated RPA operations procedures will need to be developed.

4 Necessary Technology (Air & Ground)

- GBDAA where applicable
- ADS-B on most RPA as well as all manned aircraft
- ATC automation will need to be able to respond to this new lost link code
- Preliminary development and testing of (ABDAA)
- Automatic position reporting to ATC capability for lost link over high seas

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

- Lost link procedures and standards
- Specific special purpose transponder code for lost link
- Updated ATM procedures to allow for the integration of RPA's into en-route and terminal airspace
- Update airworthiness standards and procedures

6 Implementation and Demonstration Activities

6.1 Current Use

TBD

6.2 Planned or Ongoing Trials

6.2.1 Europe

- So far all strategies are aimed at full integration within the timeframe of Block 2. SESAR will address this. ADS-B and Satcom are on the agenda
- Integrated RPA/manned Airports operations

Separation and airspace safety panel (SASP) will make determination on separation standards that will be applicable

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BLOCK 3

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Module N° B3-15: Integrated AMAN/DMAN/SMAN

Summary	This module includes a brief description of integrated arrival, en-route, surface, and departure management.
Main Performance Impact	KPA-04 Efficiency; KPA-09 Predictability
Domain / Flight Phases	Terminal, En-route, Aerodrome, and Supporting Infrastructure
Applicability Considerations	Benefits are greatest in high density TMA around globe. The benefits do not depend on aircraft equipage.
Global Concept Component(s)	TS - Traffic Synchronization AO - Aerodrome Operation CM - Conflict Management AUO - Airspace User Operations AOM - Airspace Organization and Management
Global Plan Initiatives (GPI)	GPI-5 RNAV and RNP (PBN) GPI-10 Terminal area Design and Management GPI -11 RNP and RNAV Standard Instrument Departures (SIDs) and Standard Terminal Arrivals (STARs) GPI-12 Functional Integration of Ground Systems with Airborne Systems GPI-14 Runway Operation
Reference Documents	ICAO Doc 9584 Global ATM Operational Concept, ICAO Doc 9750 Global Air Navigational Plan. European ATM Master Plan, SESAR Definition Phase Deliverable 2 – The Performance Target, SESAR Definition Phase Deliverable 3 – The ATM Target Concept, SESEAR Definition Phase 5 – SESAR Master Plan TBFM Business Case Analysis Report NextGen Midterm Concept of Operations v.2.0 RTCA Trajectory Concept of Use and various Industry standards
Main Dependencies	B2-15

Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	√
	Avionics Availability	NA
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

NextGen and SESAR share a common strategic objective to introduce operational and technical capabilities that builds toward the future ICAO Global Air Traffic Management Operational Concept. Both efforts seek to implement automation systems and more efficient operational schemes to better utilize congested airspace

This integration represents successful traffic synchronisation of all phases of flight. An optimised time profile for flights can be derived, and use as a mean to manage demand and capacity and optimally space aircrafts. Moreover, the optimised time profile will fully leverage aircraft capability in assessing the control time at various metering fixes.

Synchronization of all flight phases represents the full integration of all control loops. This synchronization, together with the other ATM components, will contribute to improvement in efficiency of ATM from gate to gate. Time based flow management is a crucial component of 4-D trajectory management. 4-D trajectory management advocates the use of trajectories as the basis for planning and executing all flight operations by ATC authorities. 4-D trajectory management enables airspace users and ATC authorities to negotiate conflict-free trajectories that best suits various stakeholder concerns. Moreover, all stakeholders will share a coherent and consistent view of the trajectories from gate to gate. Strategic flow adjustments to the trajectory based on Demand and Capacity Balancing, along with tactical changes, can be managed timely and effectively. The synchronization and the use of 4-D trajectories will promote superior predictability and reduce uncertainty between the planned and executed trajectory.

Traffic synchronization also implies that information is synchronized across flight phases. Coordination is needed between ATC authorities for information synchronization. This coordination requires information homogeneity – the information that is shared must be of the desired quality and is consistent in content and format. Information such as position, speed, Required Time of Arrival (CTAs), Scheduled Time of Arrival (STAs), aircraft weight, and relevant ATM decisions must satisfy the quality requirements of each ATC authorities. In addition to uniformed quality and format, a common information exchange scheme will be implemented to ensure the unhindered information flows between adjacent ATC authorities.

1.1.1 Baseline

Block 2 brought about the synchronisation of arrival and departure management. Arrival and departure sequencing will be linked to further augment airspace capacity and efficient terminal and aerodrome airspace design. This is realized by adjusting the departure and arrival sequence to ensure that they are both free from conflicts. In addition, this harmonization will also serve to reduce idle time at the gates and ground delays.

Arrival and departure synchronization lead to the lessening of restrictions such as Miles-In-Trail (MIT). Less MIT restrictions implies more flights can be accommodated in a congested airspace. In addition, this synchronization will bring about positive impact to runway throughput.

Electronic coordination of departure operation between ATC authorities, such as coordination of departure flow with relevant ATC authorities, will promote more agile and efficient operations. Automated distribution of relevant information has the added benefit of reduced workloads at the respective ATC authorities.

1.1.2 Improvement brought by the module

In block 3, all physical phases of flight will be synchronised. The integration of surface, arrival, and departure management, along with extended metering into en-route will lead to optimized utilization of airspace capacity. Traffic synchronization is a crucial part of the 4D trajectory management.

The synchronization will enable the use of optimized time profile, thus provide greater predictability and mitigate uncertainty. Greater predictability enables better planning and enhances operational efficiency. In addition to predictability, synchronization and 4D trajectory management facilitate greater flexibility. Airspace users and ATC authorities can negotiate trajectories to avert conflicts and other hindering factors. These trajectories will be conflict free, and will both meet the business objectives (e.g. fuel efficient routes) of the airspace users and conform to ATM decisions.

In addition to predictability, the implementation of time based flow management will advance information homogeneity, leading to greater common situational awareness and rapid collaborative ATM decision making across multitude of ATC facilities. Information homogeneity across all flight phases presents both the airspace users and ATM with consistent, accurate, timely, and relevant information. Furthermore, information homogeneity reduces the complexity of ATM operations. As the need for reconciliation of discrepancy in various aspects of ATM operations is lessen.

1.2 Element 1: En-route, Arrival, and Departure Synchronization

The synchronization of en-route, arrival, departure, and surface represents the establishment and maintenance of a safe, efficient, and orderly flow of air traffic. Conflict management, demand and capacity, and synchronization will be fully integrated. Traffic synchronization will encompasses all physical phases of a flight. It will also be a tool for flexibility and a mechanism for capacity management. Traffic synchronization will utilize automation to optimize all domains – surface, departure, arrival, and en-route. The complete integration of all flight phases is a crucial component in the effort toward 4D trajectory management.

2 Intended Performance Operational Improvement/Metric to determine success

Key Performance Area	Performance Operational Improvement
Efficiency	*4.* Increased airspace throughput *5.* Increased tower productivity *6.* Increased Center TMU productivity
Capacity	*7.* Greater airspace throughput
Predictability	*7.* Increase ATM decision compliance *8.* More accurate demand and capacity estimate
Flexibility	*3.* Increased utilization of user-preferred trajectories
Performance Measurements	
Metrics	*5.* Aircraft per hour
	6. minutes spent per flight managed
	7. Nautical Miles
	8. pilot deviation/hours of operation.

3 Necessary Procedures (Air & Ground)

The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides guidance on implementing integrated arrival and departure capability consistent with the vision of a performance-oriented ATM System. The TBFM and AMAN/DMAN efforts will develop the systems and operational procedures necessary. In particular, procedures for the expansion of metering to departure will be necessary. RNAV/RNP for arrival will also be crucial as well.

The vision articulated in the *Global ATM Operational Concept* led to the development of ATM System requirements specified in the *Manual on ATM System Requirements* (ICAO Document 9882).

4 Necessary Technology (Air & Ground)

The *Global ATM Operational Concept* (ICAO Document 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System. TBFM, Integrated Arrival and Departure Management represent a major stride toward that vision. The key aspects include support for the synchronization of arrival sequencing and departure sequencing, and departure information dissemination. Other aspects include boosting predictability of arrival flow, further honing sector capacity and demand estimates, and management by trajectory.

Both TBFM and Arrival/Departure Management (AMAN/DMAN) will leverage existing technologies that are readily available. Both efforts will take incremental steps toward the long term capability described in their respective strategic documents.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

5.1.1 This TBFM and AMAN/DMAN implementation will impact ICAO Annex 1, ICAO Global Air Navigational Plan (ICAO Doc 9750), the PANS-ATM document (ICAO Doc 4444) and the Global ATM Operational Concepts (ICAO Doc 9584).

6 Business Case specific to the module

6.1.1 Time Base Flow Manager Business Case Analysis Report

6.1.2 Reduce environmental effects (emission, noise, and fuel burn).

7 Implementation and Demonstration Activities

7.1 Current Use

Traffic Management Advisor is currently used in the US as the primary time based metering automation. NextGen efforts will field augmentation to the Traffic Management Advisor incrementally. EuroControl will begin deployment of Arrival and Departure Manager (AMAN/DMAN).

7.2 Planned or Ongoing Trials

SESAR: TBD

NextGen: TBD

8 Main dependencies

TBD

Module N° B3-25 Improved Operational Performance through the Introduction of Full FF-ICE

Summary	All data for all relevant Flights systematically shared between the air and ground systems using SWIM in support of collaborative ATM and Trajectory Based Operations.	
Timescale	Beyond 2028	
Main Performance Impact	KPA-02 Capacity, KPA-04 Efficiency, KPA-06 Flexibility, KPA-07 Interoperability, KPA-08 Participation by the ATM Community, KPA-10 Safety	
Domain / Flight Phases	All phases of flight from initial planning to post-flight	
Applicability Considerations	Air and ground	
Global Concept Component(s)	IM information management	
Global Plan Initiatives (GPI)	GPI-6 ATFM GPI-7 Dynamic and flexible route management GPI-16 Decision Support Systems	
Reference Documents	FF-ICE concept document and TBO documents	
Main Dependencies	After B2-31, B1-30	
Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	2022
	Avionics Availability	2025
	Infrastructure Availability	2025
	Ground Automation Availability	2025
	Procedures Available	2025
	Operations Approvals	2025

1 Narrative

1.1 General

Draft Brochure: FLIGHT & FLOW INFORMATION FOR A COLLABORATIVE ENVIRONMENT (FF-ICE) A Concept to Support Future ATM systems

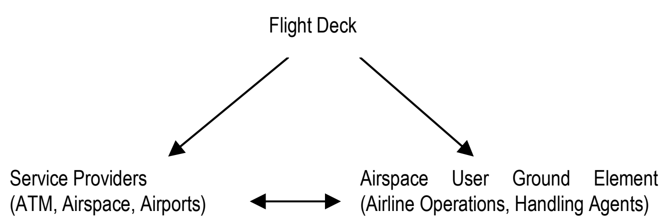
The Role of FF-ICE

As a product of the ICAO Global ATM Concept, FF-ICE defines information requirements for flight planning, flow management and trajectory management and aims to be a cornerstone of the performance-based air navigation system. Flight information and associated trajectories are principal mechanisms by which ATM service delivery will meet operational requirements.

FF-ICE will have global applicability and will support all members of the ATM community to achieve strategic, pre-tactical and tactical performance management.
FF-ICE emphasises the need for information sharing to enable significant benefits.

The exchange of flight/flow information will assist the construction of the best possible integrated picture of the past, present and future ATM situation. This exchange of information enables improved decision making by the ATM actors involved in the entire duration of a flight, i.e. gate-to-gate, facilitating management of the full 4-D trajectory.
FF-ICE ensures that definitions of data elements are globally standardised and provides the mechanisms for their exchange. Thus, with appropriate information management a Collaborative Decision Making environment is created enabling the sharing of appropriate data across a wider set of participants resulting in greater coordination of the ATM community, situational awareness and the achievement of global performance targets.

The future collaborative and dynamic flight information process will involve the full spectrum of ATM Community members as envisaged in the ATM Global Operational Concept. The cornerstone of future air traffic management is the interaction between these various parties and FF-ICE allows dynamic exchange of information.



The Global ATM concept, implemented through regional programmes such as SESAR (Single European Sky ATM Research) in Europe, NextGen (Next Generation Air Transportation System) in North America and CARATS (Collaborative Action for Renovation of Air Traffic Systems) in Japan, foresees Air Traffic Control becoming traffic management by trajectory. The roles of the parties illustrated above will evolve to support the requirements of this concept which will:

- Entail systematic sharing of aircraft trajectory data between actors in the ATM process
- Ensure that all actors have a common view of a flight and have access to the most accurate data available
- Allow operations respecting the airspace users' individual business cases

The Need for Change

The Global ATM Concept envisages an integrated, harmonised and globally interoperable system for all users in all phases of flight. The aim is to increase user flexibility and maximise operating efficiencies while increasing system capacity and improving safety levels in the future ATM system. The current system, including the flight planning process, has many limitations. FF-ICE helps to address these limitations and establishes the environment to enable improvements such as:

- Reduced reliance on voice radio communications for air/ground links
- Increased collaborative planning amongst ATM actors
- Providing facilities for real time information exchange
- Maximising benefits of advanced equipment and encouraging deployment of improved air and/or ground systems

1.1.1 Baseline

FF-ICE step 1 is implemented

1.1.2 Change brought by the module

New way to exchange trajectory data for better knowledge

1.2 Element:

The main challenge is to implement FF-ICE in airborne systems and use SWIM for airborne access to ATM information.

2 Intended Performance Operational Improvement/Metric to determine success

2.1 Element :

Access and Equity	
Capacity	Y
Cost Effectiveness	Y
Efficiency	Y
Environment	Y
Flexibility	Y
Global Interoperability	Y
Participation by the ATM community	Y
Predictability	
Safety	Y
Security	

CBA	
Human performance	

3 Necessary Procedures (Air & Ground)

Publish and subscribe mechanism will allow real-time sharing of the FI for concerned and authorized actors.

The use of this data will be mainly used by system for decision making tools and further automation.

The sharing of information between aircraft and ground systems will enhanced the predictability.

4 Necessary Technology (Air & Ground)

There is a need for full secure and high throughput ground-ground and air-ground communications networks supporting SWIM access for exchange of Flight and Flow information from planning phase to post-Flight phase .

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

6 Implementation and Demonstration Activities

6.1 Current Use

6.2 Planned or Ongoing Trials

Full-FF-ICE could be considered as the ultimate goal of the TBO and it is part of NextGen and SESAR R&D plan.

List of SESAR Projects: WP14 and WP8.

Module N° B3-10: Traffic Complexity Management

Summary	While Trajectory-based Operations are the long-term evolution of the management of an individual trajectory, a number of events and phenomena affect traffic flows due to physical limitations, economic reasons or particular events and conditions. The long-term evolution of their management is addressed in this module in relation with traffic densities higher than the present ones, and/or with a view to improve the solutions applied so far and provide optimised services while working closer to the system limits. This is referred to as "managing complexity". The module integrates various ATM components to generate its extra performance benefits and will introduce further refinements in DCB, TS and AOM processes (and possibly SDM, AUO and AO) to exploit the more accurate and rich information environment. This is an area of active research, where innovative solutions are probably as important as the understanding of the uncertainties inherent to ATM and of the air transport mechanisms and behaviours to which ATM performance is sensitive to.	
Main Performance Impact	KPA-02 Capacity, KPA-04 Efficiency, KPA-06 Flexibility, KPA-09 Predictability	
Domain / Flight Phases	Pre-flight and in-flight	
Applicability Considerations	Regional or sub-regional. Benefits are only significant over a certain geographical size and assume that it is possible to know and control/optimise relevant parameters. Benefits mainly useful in the higher density airspace	
Global Concept Component(s)	AOM – Airspace Organisation and Management TS – Traffic Synchronisation DCB – Demand & Capacity Balancing	
Global Plan Initiatives (GPI)	GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management	
Reference Documents		
Main Dependencies	B1-10, B2-35	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2028
	Avionics Availability	2028
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

While Trajectory-based Operations are the long-term evolution of the management of an individual trajectory, a number of events and phenomena affect traffic flows due to physical limitations, economic reasons or particular events and conditions. The long-term evolution of their management is addressed in this module in relation with traffic densities higher than the present ones, and/or with a view to improve the solutions applied so far and provide optimised services while working closer to the system limits. This is referred to as “managing complexity”.

The module integrates various ATM components to generate its extra performance benefits and will introduce further refinements in DCB, TS and AOM processes (and possibly SDM, AUO and AO) to exploit the more accurate and rich information environment expected from TBO, SWIM and other longer term evolutions.

This is an area of active research, where innovative solutions are probably as important as the understanding of the uncertainties inherent to ATM and of the air transport mechanisms and behaviours to which ATM performance is sensitive to.

1.1.1 Baseline

Prior to this module, most of the ingredients of the Global ATM Concept will have been progressively put in place, but not yet completely pending the dissemination of a certain number of capabilities and enablers, and also not fully integrated. There remains room to achieve performance gains by addressing the issues that the lack of optimised integration will raise.

1.1.2 Change brought by the module

The module provides for the optimisation of the traffic flows and air navigation resources usage. It addresses the complexity within ATM due to the combination of higher traffic densities, more accurate information on trajectories and their surrounding environment, closely interacting processes and systems, and the quest for greater levels of performance.

2 Intended Performance Operational Improvement/Metric to determine success

Capacity	Increase and optimised usage of system capacity Metric: reduction of delays; increase of airspace capacity
Efficiency	Optimisation of the overall network efficiency Metric: fuel burn/flight time reduction at network level
Flexibility	Accommodation of change requests Metric: tbd
Predictability	Minimise the impact of uncertainties and unplanned events on the smooth running of the ATM system Metric: reduced variability arrival times

CBA	To be established as part of the research related to the module.
Human Performance	The high degree of integration of the traffic information and the optimisation of the processes will likely require high levels of automation and the development of specific interfaces for the human operators.

3 Necessary Procedures (Air & Ground)

To be defined.

4 Necessary Technology (Air & Ground)

The module will exploit technology available, in particular SWIM and TBO which will provide the accurate information on the flights and their environment. It will also likely rely on automation tools.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

To be defined.

6 Implementation and Demonstration Activities

6.1 Planned or Ongoing Trials

- **Europe:** the SESAR programme has established a research network on "complexity" together with research projects addressing some of the relevant issues.
- **US:** research is being conducted at NASA and Universities.

No live trials in the foreseeable future.

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Module N° B3-105: Better Operational Decisions through Integrated Weather Information (Tactical <40 Minutes)

Summary	This module is focused on developing advanced concepts and necessary technologies to enhance global ATM decision making in the face of adverse weather. This module builds upon the initial weather integration concept and capabilities developed under B1-105. A key emphasis is on tactical weather avoidance in the 0-40 minute timeframe, including making greater use of aircraft based capabilities to detect meteorological parameters (e.g. turbulence, winds, and humidity), and to display weather information to enhance situational awareness. This module considers the development of operational and performance requirements for meteorological information to support these advanced concepts, and the establishment of standards for global exchange of the information.	
Main Performance Impact	KPA-02 Capacity, KPA-04 Efficiency, KPA-06 Flexibility. KPA-09 Predictability, KPA-10 safety,	
Domain / Flight Phases	En-route, Terminal, Aerodrome	
Applicability Considerations	Applicable to air traffic flow planning, en-route operations, terminal operations (arrival/departure), and surface. Benefits accrue to both flows and individual aircraft. Aircraft equipage is assumed for ADS-B In/CDTI, aircraft-based weather observations and weather information display capabilities, such as EFBs.	
Global Concept Component(s)	Airport Operations and Management (AOM), Demand and Capacity Balancing (DCB), Aerodrome Operations (AO), Traffic Synchronization (TM) and Conflict Management (CM).	
Global Plan Initiatives (GPI)	GPI-19: Meteorological Systems; GPI-1: Flexible Use of Airspace; GPI-6: Air Traffic Flow Management; GPI-9: Situational Awareness; GPI-10: Terminal Area Design and Management; GPI-15: Match IMC and VMC Operating Capacity	
Reference Documents	World Meteorological Organization standards for weather information content and format. Others TBD	
Main Dependencies	B1-105	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2028
	Avionics Availability	2028
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

This module is focused on developing advanced concepts and necessary technologies to enhance global ATM decision making in the face of adverse weather. The major components include a consistent, integrated set of meteorological information available to all users and ANSPs, advanced decision support tools that utilize the information to assess the potential operational impacts of the weather situation and decision support tools that develop candidate mitigation strategies for dealing with the impacts. This module builds upon the initial weather integration concept and capabilities developed under B1-105 “Enhanced Weather Decision Making Capability (Strategic)”. A key emphasis is on tactical weather avoidance in the 0-40 minute timeframe, including making greater use of aircraft based capabilities to detect meteorological parameters (e.g. turbulence, winds, and humidity), and to display weather information to enhance situational awareness. Utilization of ADS-B In/CDTI for weather information display and avoidance is featured. Also, air-to-air concepts enabled by ADS-B will be developed where, for example, aircraft-based observations of turbulence are provided to neighbouring aircraft to enhance safety. ANSPs will also have access to this meteorological information and these decision support tools to enhance their ability to assist pilots in weather avoidance, when requested. This module will develop operational and performance requirements for meteorological information to support these advanced concepts, as well as standards for global exchange of the information, including from aircraft-to-ground, and air-to-air exchanges. It will also develop enhanced capabilities to improve weather-related decision making in the strategic timeframe. Extended capabilities will be developed to produce translations of weather information into characterizations of potential weather constrained airspace. ANSP and user decision support tools not only will directly ingest and use these characterizations, but the tools allow automation-to-automation negotiation of trajectories that take into account the constraint information. These capabilities benefit pre-flight planning, flow planning, and in-flight operations in the en-route, terminal and aerodrome domains. These negotiation capabilities will be globally interoperable to allow for seamless planning of trajectories for international flights. Standards to support these negotiation capabilities must be developed.

1.1.1 Baseline

The baseline for this module is the initial, enhanced weather decision making capabilities enabled by module B1-105. Decision support capabilities are available, and integrated with weather information, to assist ANSPs and users to make better decisions in the strategic timeframe (40 minutes and out). A consistent, integrated weather information base is available to all ANSPs and users, to inform ATM decision making.

1.1.2 Improvement brought by the module

This module provides extensions to this baseline, with emphasis on the tactical (0-40 minute) timeframe, and greater use of aircraft-based capabilities for weather awareness and avoidance. A major focus is on the provision of enhanced automation capabilities (building on B1-105) for developing characterizations of potential weather impacted airspace, and for using those characterizations to determine impact on ATM operations. This information will be provided for all planning horizons and flight domains. ANSP and user decision support tools not only will directly ingest and use these characterizations and resultant impact analyses, but the tools will allow automation-to-automation negotiation of trajectories and mitigation strategies that take into account the weather constraint information. These capabilities benefit pre-flight planning, flow planning, and in-flight operations in the en-route, terminal and aerodrome domains. The negotiation capabilities must be globally interoperable to allow for seamless planning of trajectories for international flights.

1.1.3 Other remarks

This module continues the evolution in procedures and automation capabilities, both ground-based and aircraft-based, for mitigating the effects of weather on flight planning, flight execution, and traffic flow planning.

1.2 Element 1: Enhanced Weather Information

This element is focused on the development of enhanced weather information for integration into ATM decision making. This includes an emphasis on increasing the availability of characterizations of potentially weather constrained airspace which may be directly integrated into ANSP and user decision making. This element also focuses on the development or revision of global standards for weather information content and format, given the migration to 4-D representations of weather information, versus current text and graphics.

1.3 Element 2: Weather-Integrated ATM Decision Support Tools

This element continues the evolution to the utilization of ATM decision support tools, used by ANSPs and users, which directly integrate the above weather information into their processing. Based on experiences gained from development and deployment of initial capabilities as part of module B1-105, extensions are developed to generate more efficient and operationally acceptable weather mitigation solutions. This element also develops direct automation-to-automation negotiation capabilities to streamline the development of mutually acceptable ATM decisions.

1.4 Element 3: Cockpit Weather Capabilities

This element will focus on aircraft-based capabilities that will assist pilots with weather avoidance, and thus enhance safety. Capabilities such as ADS-B In, air-to-air information exchange, and integration of weather into cockpit-based automation tools are considered. This element must focus on globally-harmonized standards development for weather information exchange to support these capabilities.

1.5 Connections to Other Modules/Elements

The development of this module should be coupled with the development of the following major modules (at a minimum) to ensure enhanced ATM operations in adverse weather:

- B3-5 - Full 4D TBO
- B3-10 - Complexity Management
- B3-15 - Integration AMAN/DMAN/SMAN
- B3-25 - Full FF-ICE
- B3-40 - "Full" 4D TBO

2 Intended Performance Operational Improvement/Metric to determine success

This module supports the following KPAs:

- Capacity – A more efficient use of en route airspace that is being impacted by weather, along with less conservative decisions about permitting aircraft to utilize the airspace, results in more aircraft being able to traverse the affected area. Similarly, terminal arrival/departure capacity will be enhanced by improved ability to plan for flows in and out of the airport.
- Efficiency – Users will be better able to plan and receive their preferred trajectory, based on increased knowledge of the anticipated weather situation.
- Predictability – With better planning of flights and flows in adverse weather, users' preferred trajectories will be less impacted by re-routing actions, ground stops, and ground delays.
- Safety – Pilots will have improved access to weather information in the cockpit, thereby enhancing situational awareness. ANSPs will have the same weather information, and will thus be able to provide better assistance to pilots, if requested.
- Flexibility - Users will have enhanced, advanced knowledge of the anticipated weather situation, and will thus have greater flexibility in selecting the flight trajectory that best meets their needs, while avoiding the weather.

3 Necessary Procedures (Air & Ground)

For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on weather-related decisions. Extensions to those procedures will be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation. The use of ADS-B/CDTI and other cockpit capabilities to support weather avoidance will necessitate procedure development, including the roles of ANSPs. International standards for information exchange between systems to support these operations must be developed. This includes development of global standards for the delivery of weather information to aircraft.

4 Necessary Technology (Air & Ground)

For this longer-term module, the needed technology is still in development. With respect to ground-based technology, research is on-going into decision support tools that ingest weather information directly, and support the automated development of candidate mitigation strategies. Work is also needed to ensure a globally harmonized, common weather information base that is available to all ANSPs and users for decision making. Although aircraft-based capabilities such as ADS-B/CDTI and EFBs exist, applications are still being developed to support the objectives of this module.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This module requires the following:

- Development of global standards for weather information exchange, with emphasis on exchange of 4-D (X, Y, Z, and T [time]) gridded weather information.
- Regulatory agreement on what constitutes required weather information in the age of digital exchange, versus text and graphics.
- Certification decisions on aircraft-based weather display and dissemination. Dissemination includes air-to-ground for aircraft based observations (e.g. turbulence and humidity), as well as possible air-to-air exchange of those observations (e.g. turbulence information to nearby aircraft) via ADS-B.

6 Business Case specific to the module

The major qualitative business case aspects of this module are as follows:

- Capacity – Additional flights can be accommodated in en route airspace and in airport terminals because of more precise knowledge of weather location and timing.
- Efficiency – Users will be better able to plan and be granted their preferred trajectory, based on increased knowledge of the anticipated weather situation.
- Predictability – Users' planned trajectories will be less impacted by re-routing actions, ground stops, and ground delays. More efficient planning for fuel-on-board, and minimization of fuel use.
- Safety – A reduction of weather-related accident and injuries is anticipated.
- Flexibility – Users will have greater flexibility in selecting the flight trajectory that best meets their needs, while avoiding the weather.

7 Implementation and Demonstration Activities

7.1 Current Use

Since this module is in the category of Long Term Issues, there are no examples of current operational use. The FAA is conducting research on ADS-B In applications that relate to weather avoidance via cockpit functionality. Such research efforts will help to inform the work to be done under this module.

7.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this module. There is a need to develop such a plan as part of the collaboration process, and as an extension of other modules.

8 Main dependencies

This module is very dependent on the accomplishment of module B1-105. Also, there is a dependency on the development of future concepts and automation capabilities that will utilize the advanced weather information to inform decision making. The GPIs mentioned above (e.g. 1, 6, and 9) are assumed to provide impetus to develop those capabilities. The modules mentioned above (see section 1.5) may offer specific opportunities for joint development of weather integration concepts and capabilities, including standards development where needed.

Module N° B3-85 Airborne Separation (ASEP)

Summary	**Airborne separation (ASEP)**: The flight crew ensures separation from designated aircraft as communicated in new clearances, which relieve the controller from the responsibility for separation between these aircraft. However, the controller retains responsibility for separation from aircraft that are not part of these clearances. **Airborne self-separation (SSEP)**: The flight crew ensures separation of their aircraft from all surrounding traffic. The controller has no responsibility for separation. First applications of ASEP are envisaged in Oceanic airspace and in approach for closely-spaced parallel runways.	
Main Performance Impact	The main performance impact will be in KPA-03 Cost Effectiveness. Secondary benefits will be obtained in KPA-02 Capacity and KPA-05 Environment	
Domain / Flight Phases	En-route phase, oceanic, and approach	
Applicability Considerations	The safety case need to be carefully assessed and the impact on capacity is not well understood, in particular in case of delegation of separation for a particular conflict and in case of self-separation for all aircraft implying new regulation on airborne equipment and equipage training	
Global Concept Component(s)	Conflict Management	
Global Plan Initiatives (GPI)	GPI-16	
Reference Documents	ICAO Doc 9854 – Global ATM Operational Concept PO-ASAS FAA-Eurocontrol doc V7.1 Released Issue 19/06/2001 ICAO ANConf/11-IP5 draft ASAS Circular (2003)	
Main Dependencies	In-Trail-Procedure (ITP) and Interval Management (IM) B0-85 B1-85 ADS-B out and ADS-B In, CPDLC	
Global Readiness Checklist		**Status** (indicate ready with a tick or input date)
	Standards Readiness	2028
	Avionics Availability	2028
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

Airborne separation is described in the Global ATM Operational concept (ICAO Doc 9854)
“**Self-separation**
2.7.23 Self-separation is the situation where the airspace user is the separator for its activity in respect of one or more hazards.
2.7.24 Full self-separation is the situation where the airspace user is the separator for its activity in respect of all hazards. In this case, no separation provision service will be involved; however, other ATM services, including strategic conflict management services, may be used.
Cooperative separation
2.7.26 Cooperative separation occurs when the role of separator is delegated. This delegation is considered temporary, and the condition that will terminate the delegation is known. The delegation can be for types of hazards or from specified hazards. If the delegation is accepted, then the accepting agent is responsible for compliance with the delegation, using appropriate separation modes.”

1.1.1 Baseline

The baseline is provided by the first ASAS application described in the module B0-85 and B1-85. These ASAS-ASEP and SSEP operations will be the next steps.

1.1.2 Change brought by the module

This module will introduce new modes of separation relying on aircraft capabilities including airborne surveillance supported by ADS-B and giving responsibility for separation to the pilot.

1.2 Element 1: ASEP

Airborne separation: The flight crew ensures separation from designated aircraft as communicated in new clearances, which relieve the controller from the responsibility for separation between these aircraft. However, the controller retains responsibility for separation from aircraft that are not part of these clearances.
Typical Airborne Separation applications include:

- In-descent separation: the flight crews maintain a time-based horizontal separation behind designated aircraft.
- Level flight separation: the flight crews maintain a time or distance-based longitudinal separation behind designated aircraft.
- Lateral crossing and passing: the flight crews insure that horizontal separation with designated aircraft is larger than the applicable airborne separation minimum.
- Vertical crossing: the flight crews insure that vertical separation with designated aircraft is larger than the applicable airborne separation minimum.
- Paired Approaches in which the flight crews maintain separation on final approach to parallel runways
- In oceanic airspace in the many procedures are considered as improvement of ATSA-ITP In Trail Procedure
  - ASEP-ITF In Trail Follow
  - ASEP-ITP In Trail Procedure
  - ASEP-ITM In Trail Merge

1.3 Element 2: SSEP

Airborne self-separation: The flight crew ensures separation of their aircraft from all surrounding traffic. The controller has no responsibility for separation.
First applications are in Oceanic airspace and low density airspace.

Typical Airborne Self-separation applications include:

- Airborne Self-separation in ATC-controlled airspace.
- Airborne Self-separation in segregated en-route airspace.
- Airborne Self-separation in mixed-equipage en-route airspace.
- SSEP – FFT Free Flight on an Oceanic Track

2 Intended Performance Operational Improvement/Metric to determine success

2.1 Element 1: ASEP

Access and Equity	
Capacity	Increase by allowing reduced separation minima
Cost Effectiveness	
Efficiency	+
Environment	+
Flexibility	+
Global Interoperability	
Participation by the ATM community	
Predictability	
Safety	To be demonstrated
Security	

CBA	To be determined by balancing cost of equipment and training and reduced penalties
Human Performance	Change of role of controllers and pilots need to be carefully assessed

2.2 Element 2: SSEP

Access and Equity	
Capacity	Increase by allowing reduced separation minima
Cost Effectiveness	Has the potential do decrease ATCos workload and even suppression of tactical role of the ATS in low density airspace.
Efficiency	More optimum flight trajectories
Environment	
Flexibility	More flexibility to take in account change in constraint, weather situation
Global Interoperability	
Participation by the ATM community	
Predictability	
Safety	To be demonstrated
Security	

CBA	To be determined by balancing cost of equipment and training and reduced penalties
Human Performance	Change of role of controllers and pilots need to be carefully assessed

3 Necessary Procedures (Air & Ground)

ASAS-ASEP and SSEP procedures need to be defined

4 Necessary Technology (Air & Ground)

Airborne Separation requires

- For ASEP and airborne separation delegation: Air-Ground data-link and ADS-B Out and ADS-In airborne system associated to Airborne Separation Assistance Systems (ASAS). On ground there is a need for specific tools to assess the aircraft capabilities, to support delegation function and to monitor the execution of separation.
- For self-separation (SSEP) in a segregated airspace where only aircraft having self-separation capabilities are authorized, the main capabilities are ASAS. On the ground there is a need to check that the predicted density allows this mode of moderations and that the aircraft are authorized to fly through this airspace. Specific tools could be necessary to mange the transfer from self-separation airspace to conventional airspace.
- For self-separation in a mixed airspace a mix of equipped and non-equipped are authorized. On ground there is a need for specific tools to assess the aircraft capabilities, to support and to monitor the execution of separation by self-separating aircraft, while managing the separation of the others aircraft. This require a full sharing of the trajectory_es between all the actors.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

TBD

6 Implementation and Demonstration Activities

6.1 Current Use

No

6.2 Planned or Ongoing Trials

European project

ASSTAR

SESAR Project 04.07.04.b ASAS-ASEP Oceanic Applications

"The Airborne Separation In Trail Follow (ASEP-ITF) and In Trail Merge (ASEP-ITM) applications have been designed for use in oceanic and other non-radar airspace.

ASEP-ITF transfers responsibility for separation between the ITF Aircraft and a Reference Aircraft from the controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high accuracy and integrity requirements on the avionics (both the ITF and Reference Aircraft positioning, airborne surveillance and ASEP-ITF procedure). ASEP-ITF is intended as a means of improving vertical flexibility, allowing aircraft to make a level change where current procedural separation standards will not allow it, by enabling level changes to the flight level of a Reference Aircraft which is operating at a different flight level, but on the same identical track.

ASEP-ITM transfers responsibility for separation between the ITM Aircraft and a Reference Aircraft from the controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high accuracy and integrity requirements on the avionics (both the ITM and Reference Aircraft positioning, airborne surveillance and ASEP-ITM procedure). ASEP-ITM is intended as a means of improving lateral flexibility, allowing aircraft to change their routing where current procedural separation standards will not allow it, by enabling a lateral manoeuvre to follow, and then maintain, a minimum spacing behind a Reference Aircraft which is operating at a same direction flight level.

Both applications will require the crew to use airborne surveillance information provided on the flight deck to identify the potential opportunity to use the applications and to maintain a reduced separation from the Reference aircraft during the manoeuvres."

SESAR Project 04.07.05 Self Separation in Mixed Mode Environment

One goal of the ASAS development path is to enable self separation (SSEP) in mixed mode operations. The intention is to allow self-separating flights and ANSP separated flights to operate in the same airspace. The project has 2 phases with following objectives:

1st phase: Assess compatibility between 4D-contract and ASEP applications as a step towards autonomous operations.

2nd phase: develop and validate the operating concept for the SSEP applications in mixed mode, i.e. together with conventional, new airborne mode (ASEP-C&P) and new ANSP modes.

The main objective is to validate the integration of 4D, ASAS, and conventional traffic in the separation management task. The focus will be the interaction of conventional and new separation modes and the consequences for capacity, efficiency, safety, and predictability. Moreover, relations between safety and capacity will be studied aiming at decreasing the number of critical incidents despite increasing traffic.

SESAR WP4.7.6 En Route Trajectory and Separation Management – ASAS Separation (Cooperative Separation)

The main objective of this project is to assess the introduction of ASAS separation application in the SESAR context (taking into account all platforms, including military and UAS).
The project will be focused on the possibility to delegate in specific and defined conditions the responsibility for traffic separation tasks to the flight deck of suitable equipped aircraft

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Module N° B3-05: Full 4D Trajectory-based Operations

Summary	This block is focused on developing advanced concepts, and necessary technologies, for using four dimensional trajectories to enhance global ATM decision making. This block builds upon the use of 4D trajectories to optimise arrivals in dense airspace (B5/2) as well as other flight improvements using 4D trajectories under B5/1 "RNP with Vertical Containment". A key emphasis is on integrating all flight information to obtain the most accurate trajectory model for ground automation. This block will consider the development of operational and performance requirements to support these advanced concepts, as well as standards for global exchange of the information.	
Main Performance Impact	KPA-04 Efficiency, KPA-02 Capacity, KPA-06 Flexibility and KPA-10 Safety	
Domain / Flight Phases	En-route, Terminal Area, Traffic Flow Management, Descent	
Applicability Considerations	Applicable to air traffic flow planning, en-route operations, terminal operations (arrival/departure), and arrival operations. Benefits accrue to both flows and individual aircraft. Aircraft equipage is assumed in the areas of: ADS-B In/CDTI; data communication and advanced navigation capabilities.	
Global Concept Component(s)	Airspace Organization and Management (AOM); Demand and Capacity Balancing (DCB); Airspace User Operations (AUO); Traffic synchronization (TS); Conflict management (CM); ATM service delivery management (ATM SDM)	
Global Plan Initiatives (GPI)	GPI-1: Flexible Use of Airspace GPI-6: Air Traffic Flow Management GPI-9: Situational Awareness GPI-10: Terminal Area Design and Management	
Reference Documents	NextGen and SESAR Operational Concepts Others TBD	
Main Dependencies	B2-5, B1-40, B0-20	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2028
	Avionics Availability	2028
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

Full TBO integrates advanced capabilities that will provide vastly improved surveillance, navigation, data communications, and automation for ground and airborne systems with changes in service provider roles and responsibilities. Key aspects of Full TBO are:

- The basis for all operations is an accurate four-dimensional trajectory that is shared among all of the aviation system users.
- Consistent and up-to-date information describing flights and air traffic flows are available system-wide, supporting both user and service provider operations.
- Data Communication is used between the ground and aircraft to improve the accuracy of trajectories, provide precise clearances to the flight, and exchange information without controller involvement.
- Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of navigational aids, enabling the flexibility of point-to-point aircraft operations.
- Required Navigation Performance (RNP) operations introduce the requirement for onboard performance monitoring and alerting. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor its achieved navigation performance for a specific operation, and inform the air crew if the operational requirement is being met.
- En route controllers rely on automation to identify conflicts and propose resolutions allowing them to focus on providing improved services to the users.
- The ability of cockpit automation to fly the aircraft more precisely and predictably reduces routine tasks of controllers.
- Performance-based services that require minimum flight performance levels are provided in designated airspace.
- Flow management automation will propose incremental congestion resolutions that will maintain congestion risk at an acceptable level, using flight-specific alternative intent options to the extent possible.
- Time-based flow management that coordinates arrival flows for high traffic airports.

1.1.1 Baseline

The baseline for this block is the optimised arrivals in dense airspace enabled by block B2/5. Decision support capabilities are available that are integrated to assist ANSPs and users to make better decisions in arrival profile optimisation. A consistent, integrated information base is available to all ANSPs and users to inform ATM decision making.

1.1.2 Improvement brought by the module

Block 3/5 provides extensions to this baseline, In future en route airspace, mixed levels of aircraft performance and air crew authorizations are expected. High-performance aircraft will be capable of flying RNAV routes, accurately conforming to their route of flight, supporting data communications, communicating requests and aircraft state and intent information electronically with the ATC automation, and receiving clearances and other messages electronically from the ATC automation.

It is anticipated that some en route airspace, will be designated for high-performance aircraft only, allowing the ATC system to engage operations that fully leverage the capabilities of those aircraft. Aircraft will communicate state and intent information to the ATC automation and closely follow their intended routes of flight. As a result, the automated problem prediction and resolution capabilities will be able to maximize user benefits by supporting user-preferred flight plans, minimizing changes to those plans as aircraft traverse the NAS, and improving services provided.

The controller's primary responsibilities will be to respond to problems predicted by the ATC automation, and to maintain accurate flight information in the ATC automation. Predicted problems will include

- Aircraft to aircraft conflicts
- Aircraft to special use or other types of restricted airspaces

- Aircraft to severe weather forecast areas
- Aircraft to metering constraint problems including miles in trail restrictions.

ATC personnel workload will be reduced with the implementation of full 4D Trajectory Based Operations. ATC personnel will now manage traffic by exception; ATC personnel will response to predicted non-conformance or deviation, rather than ensuring compliance with ATM decisions. The ATC personnel will also ensure that all relevant ATM information are accurate, consistent, and up-to-date.

The aircraft's capability to accurately fly its cleared route of flight, coupled with the state and intent information sent from the aircraft to the ATC automation, will increase the accuracy of trajectory modelling and problem prediction. Accurate trajectory modelling improves the overall predictability of the airspace system.

1.1.3 Other remarks

This module continues the evolution in procedures and automation capabilities, both ground-based and aircraft-based, for using accurate trajectories to benefits the system.

1.2 Element 1: Accurate Trajectory Modelling

This element is focused on getting the most accurate trajectory model in the system for use by all automation functions. This entails putting every clearance given to the aircraft into the automation, using automation generated resolutions to make it easier for the controllers to enter the clearance, and receiving flight specific data from the aircraft to include in the trajectory calculation and any resolution options.

1.3 Advanced Aircraft Capabilities

This element will focus on aircraft-based capabilities that will assist pilots with weather and other aircraft avoidance, and thus enhance safety. Such capabilities as ADS-B In, air-to-air information exchange, and integration of weather into cockpit-based automation tools will be considered. This element will also focus on globally-harmonized standards development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

1.4 Problem Detection and Resolution

This element will continue the evolution to the utilization of ATM decision support tools, by ANSPs and users, which provide manoeuvres for flying the most economical descent profiles. Based on experiences gained from development and deployment of initial capabilities, extensions will be developed to generate more efficient and operationally acceptable arrival profile solutions. This element will also explore direct automation-to-automation negotiation capabilities to streamline the development of mutually acceptable ATM solutions.

1.5 Traffic Flow Management and Time-Based Metering

This element will harmonize the Traffic Flow Management automation which continuously predicts the demand and capacity of all system resources, and will identify when the congestion risk for any resource (airport or airspace) is predicted to exceed an acceptable risk. Traffic Management will take action in the form of just in time reroutes and metering times to congested resources. The problem resolution element will create a manoeuvre that meets all system constraints.

1.6 Connections to Other Blocks/Elements

The development of this block should be coupled with the development of the following major blocks (at a minimum) to ensure enhanced operations:

B3-10 – Traffic Complexity Management

B3-105 – Advance Weather Decision Making

See section 2 below for expected KPA impact in this regard.

2 Intended Performance Operational Improvement/Metric to determine success

This module supports the following KPAs:

- Capacity: better use of en route airspace. Additional flights can be accommodated in en route airspace because of reduced controller workload. Less conservative decisions about permitting aircraft to utilize the airspace results in more aircraft being able to traverse the affected area. Similarly, terminal arrival/departure capacity will be enhanced by improved ability to plan for flows in and out of the airport.
- Efficiency: users will fly more fuel efficient arrival descent profiles. Users will be better able to plan and receive their preferred trajectory.
- Safety: reduction of conflicts between aircraft and more lead time in resolving those conflicts that exist. Pilots will have improved access to information in the cockpit, thereby enhancing situational awareness and aircraft avoidance.
- Flexibility: users will have better advanced knowledge of the anticipated traffic situation, and will thus have greater flexibility in selecting the flight trajectory that best meets their needs.

3 Necessary Procedures (Air & Ground)

For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation. The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and will necessitate procedure development, including the roles of ANSPs. International standards for information exchange between systems to support these operations need to be developed. This includes development of global standards for the exchange of trajectory information between ground and air.

4 Necessary Technology (Air & Ground)

For this longer-term module, the needed technology is still in development. For ground-based technology, research is on-going into decision support tools that produce fuel efficient resolutions, and support the automated development of candidate mitigation strategies. Work is also needed to incorporate data from aircraft systems into ground trajectory models to ensure the most accurate trajectory. Aircraft-based capabilities, such as ADS-B/CDTI, exist, but applications are still being developed to support the objectives of this module.

5 Regulatory/standardisation needs and Approval Plan (Air & Ground)

This module requires:

- Development of global standards for trajectory information exchange.
- Certification decision on aircraft-based aircraft display and dissemination. Dissemination includes air-to-ground as well as air-to-air exchange of those observations via ADS-B.

6 Business Case specific to the module

The major qualitative business case elements of this module are as follows:

- Capacity: additional flights can be accommodated in en route airspace because of reduced controller workload.
- Efficiency: users will fly more fuel efficient arrival descent profiles.
- Safety: reduction of conflicts between aircraft and more lead time in resolving those conflicts that exist.
- Flexibility: users will have greater flexibility in selecting the flight trajectory that best meets their needs.

7 Implementation and Demonstration Activities

7.1 Current Use

Since this block is in the category of Long Term Issues, there are no examples of current operational use. The FAA is conducting research on ADS-B In applications that relate to aircraft avoidance via cockpit functionality. Such research efforts will help to inform the work to be done under this block.

7.2 Planned or Ongoing Trials

No global demonstration trials are currently planned for this module. There is a need to develop such a plan as part of the collaboration on this module

8 Main dependencies

This module is dependent on the accomplishment of block B2-5. Also, there is a dependency on the development of future concepts and automation capabilities that will create resolution manoeuvres for detected problems. The resolution manoeuvres must be validated in actual field operations. Aircraft capabilities need to be present on a sufficient percentage of aircraft to gain the benefits. The GPIs mentioned above (e.g. 1, 6, and 9) are assumed to provide impetus to develop those capabilities.

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Module N° B3-90: Remotely Piloted Aircraft (RPA) Transparent Management

Summary	Block 3 builds on block 2 by; continuing to improve the certification process for RPAS in all classes of airspace, working on developing a reliable C2 link, certifying autonomous responses to potential incursions, developing and certifying Airborne Detect and Avoid (ABDAA) algorithms, and integration of RPA into aerodrome procedures.	
Main Performance Impact	N/A – as this is a new development which must be accommodated within the Global ATM System.	
Domain / Flight Phases	En-route, High Seas, Terminal Area (arrival and departure), Aerodrome (taxi, take-off, and landing), and Supporting Infrastructure	
Applicability Considerations	Global	
Global Concept Component(s)	Airspace Operations and Management (AOM), Conflict Management (CM), Airspace User Operations (AUO)	
Global Plan Initiatives (GPI)	GPI-6, Air traffic flow management, GPI-9 Situational awareness, GPI-13, Aerodrome design and management. GPI-21, Navigation systems. GPI-23, Aeronautical radio spectrum	
Reference Documents	ICAO Circular 328-AN/190 and FAA NAS Access Plan	
Main Dependencies	B2-90	
Global Readiness Checklist		**Status (ready or date)**
	Standards Readiness	2028
	Avionics Availability	2028
	Infrastructure Availability	2028
	Ground Automation Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

1 Narrative

1.1 General

Based on block 2 upgrades and procedures

1.1.1 Baseline

The baseline contains procedures that accommodate and allow for the evolution of RPA’s into the airspace. This includes the improvements addressed in Block 2-90, which are:

- Access to most airspace for select airframes without specific authorization or experimental aircraft waiver
- RPAS certification procedures
- New special purpose transponder code for lost link
- Standardized lost link procedures
- Revised separation criteria and/or handling procedures (i.e. moving airspace)
- ADS-B on most RPA classes
- Detect and Avoid technologies improvements
- Automatic position reporting to ATC capability for lost link over high seas

Block 3	Class B, C	Class A Airspace	High Seas Class A Airspace	Class D, E, F, and G
Authorization	Strict compliance with standard regulations is required.			
C2 Link Failure Procedures	Shall follow standardized procedures. A special purpose transponder code will be established.		Shall follow standardized procedures. Must broadcast or contract position reports to ATC	RPA must be equipped for Air born Detect and avoid in case a lost link is experienced during flight
Communications	Continuous two-way communications as required for the airspace. UAS will squawk 7600 in case of communications failure.		Primary communications are via terrestrial data link; for lost communications RPA pilot will use telephonic communications. RPA will be capable of air-to-air communications.	N/A
Separation Standards	New separation standards may be required		Separation criteria will be analysed and special separation criteria might be developed. With ADS-B self-separation for passing manoeuvres at the same altitude will be permitted f	RPAS is responsible for maintaining safe separation
ATC Instructions	RPAS will comply with ATC instructions as required			N/A
RPA Observers	Not required if RPAS is equipped for GBDAA flight in a GBDAA approved area, or is equipped for ABDAA	Not required		N/A
Medical	Remote pilots shall have an appropriate medical certificate			
Presence of Other Aircraft	RPA shall not increase safety risk to the air navigation system			
Visual Separation	Visual separation will be permitted if RPAS is equipped for GBDAA flight in a GBDAA approved area, or is equipped for ABDAA		TBD	RPA must use GBDAA or ABDAA for separation at all times
Responsibility of Remote Pilot	Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization			
Populated Areas	RPAS shall not conduct operations over populated areas	Operations over populated areas permitted if there is sufficient height to glide to an unpopulated area in an emergency		RPAS shall not be conduct operations over populated areas
ATC Services	Consistent with Annex 11, Appendix 4			N/A
Flight Plan	RPA operations will be conducted on an IFR or VFR flight plan. VFR flight plans will only be conducted if the RPAS is equipped for GBDAA flight in a GBDAA approved area, or is equipped for ABDAA.			
Meteorological Conditions	Restrictions to be determined by the State			
Transponder	Shall have and use ADS-B			N/A
Safety	Identify the hazards and mitigate the safety risks; adhere to the authorization			
NOTAMs	NOTAM requirements, if any, to be determined by the State			

1.1.2 Improvement brought by the module

- **Certification for RPA's flying in all classes of airspace:** Here the RPA operates in the non-segregated airspace just like any other aircraft. Certification has been defined based on standards, and the safety case has been proven for each aircraft type. The Air Traffic Management (ATM) procedures (identification of aircraft type, separation standards, and lost communications procedures are well defined in Block 3 to allow for this type of operations.
- **Reliable C2 link:** This improvement continues from the work done in block 2 and the procedures and standards will be fully vetted and certified during this block.
- **Certified autonomous response:** The ability to respond autonomously in any situation to provide both self-separation and collision avoidance maneuvers. This is needed to ensure safety even during a lost link event. The pilot can still have the ability to override the autonomous actions whenever the C2 link is operational.
- **Certified ABDAA algorithms:** During this block the procedures and standards for autonomous operations, based on an ABDAA solution and algorithm set, will be developed and certified.

Aerodrome procedures: (refer - ICAO Cir 328, Unmanned Aircraft Systems (UAS))

- During this block, RPA will be integrated into aerodrome operations. Consideration may have to be given to the creation of airports that would support RPA operations only. The unique characteristics of the RPA need to be considered, some of the areas to be considered are:
  - Applicability of aerodrome signs and markings for RPAs
  - Integration of RPA with manned aircraft operations on the maneuvering area of an aerodrome
  - Issues surrounding the ability of RPA to avoid collisions while maneuvering
  - Issues surrounding the ability of RPA to follow ATC instructions in the air or on the maneuvering area (e.g. "follow green Cessna 172" or "cross behind the Air France A320")
  - Applicability of instrument approach minima to RPA operations
  - Necessity of RPA observers at aerodromes to assist the remote pilot with collision avoidance requirements
  - Implications for aerodrome requirements of RPA infrastructure, such as approach aids, ground handling vehicles, landing aids, launch/recovery aids, etc.
  - Rescue and fire fighting requirements for RPA (and remote pilot station, if applicable)
  - RPA launch/recovery at sites other than aerodromes
  - Integration of RPA with manned aircraft in the vicinity of an aerodrome
  - Aerodrome implications for RPAS-specific equipment (e.g. remote pilot stations)

1.1.3 Other remarks

2 Element RPA/RPA transparent integration into all airspace

2.1 Intended Performance Operational Improvement/Metric to determine success

- **Certification for RPA's flying in all classes of airspace:** One metric might be number of ATM violations by RPA
- **Reliable C2 link:** Reliable C2 link metrics would include the level of reliability. Another metric could be actual reliability vs. acceptable reliability.
- **Certified autonomous response**: Operational performance and improvements will be measured by the number of self-separation and collision avoidance maneuvers made in a given number of operations/time in operations.
- **Certified ABDAA algorithms:** Operational performance and improvement will be measured by testing the algorithms to insure complete compliance to standards and procedures.

2.2 Necessary Procedures (Air & Ground)

- Certified ATM procedures for RPAS to operate in all classes of airspace
- Procedures that allow for multiple RPA's in the same airspace at the same time
- Procedures that allow RPA's to operate out of all classes of airports
- Procedures that allow for autonomous operations including autonomous responses in any situation
- Where RPAs are operating alongside manned aircraft there needs to be ground and air procedures that insure harmonious operations.

2.3 Necessary Technology (Air & Ground)

- Certified ABDAA algorithms
- GBDAA to supplement where applicable
- Reliable C2 links
- Certified autonomous algorithms
- Equipage of all aircraft, with proven detect and avoid technology
- Equipage of RPAS with necessary equipment to work within existing aerodrome parameters to the greatest extent practicable.

2.4 Regulatory/standardisation needs and Approval Plan (Air & Ground)

TBD

2.5 Business Case specific to the element

2.6 Implementation and Demonstration Activities

2.6.1 Current Use

TBD

2.6.2 Planned or Ongoing Trials

TBD

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Appendix C - Glossary

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Appendix C- List of Acronyms

A

ATFCM. Air traffic flow and capacity management

AAR. Airport arrival rate

ABDAA. Airborne detect and avoid algorithms

ACAS. Airborne collision avoidance system

ACC. Area control centre

A-CDM. Airport collaborative decision-making

ACM. ATC communications management

ADEXP. ATS data exchange presentation

ADS-B. Automatic dependent surveillance—broadcast

ADS-C. Automatic dependent surveillance — contract

AFIS. Aerodrome flight information service

AFISO Aerodrome flight information service officer

AFTN. Aeronautical fixed telecommunication network

AHMS. Air traffic message handling System

ICM. Aeronautical information conceptual model

AIDC. ATS inter-facility data communications

AIP. Aeronautical information publication

AIRB. Enhanced traffic situational awareness during flight operations

AIRM. ATM information reference model

AIS. Aeronautical information services

AIXM. Aeronautical information exchange model

AMA. Airport movement area

AMAN/DMAN. Arrival/departure management

AMC. ATC microphone check

AMS(R)S. Aeronautical mobile satellite (route) service

ANM. ATFM notification message

ANS. Air navigation services

ANSP. Air navigation services provider

AO. Aerodrome operations/Aircraft operators

AOC. Aeronautical operational control

AOM. Airspace organization management

APANPIRG. Asia/Pacific air navigation planning and implementation regional group

ARNS. Aeronautical radio navigation Service

ARNSS. Aeronautical radio navigation Satellite Service

ARTCCs. Air route traffic control centers

AS. Aircraft surveillance

ASAS. Airborne separation assistance systems

ASDE-X. Airport surface detection equipment

ASEP. Airborne separation

ASEP-ITF. Airborne separation in trail follow

ASEP-ITM. Airborne separation in trail merge

ASEP-ITP. Airborne separation in trail procedure

ASM. Airspace management

A-SMGCS. Advanced surface movement guidance and control systems

ASP. Aeronautical surveillance plan

ASPA. Airborne spacing

ASPIRE. Asia and South Pacific initiative to reduce emissions

ATC. Air traffic control

ATCO. Air traffic controller

ATCSCC. Air traffic control system command center

ATFCM. Air traffic flow and capacity management

ATFM. Air traffic flow management

ATMC. Air traffic management control

ATMRPP. Air traffic management requirements and performance panel

ATN. Aeronautical Telecommunication Network

ATOP. Advanced technologies and oceanic procedures

ATSA. Air traffic situational awareness

ATSMHS. Air traffic services message handling services

ATSU. ATS unit

AU. Airspace user

AUO. Airspace user operations

B

Baro-VNAV. Barometric vertical navigation

BCR. Benefit/cost ratio

B-RNAV. Basic area navigation

C

CSPO. Closely spaced parallel operations

CPDLC. Controller-pilot data link communications

CDO. Continuous descent operations

CBA. Cost-benefit analysis

CSPR. Closely spaced parallel runways

CM. Conflict management

CDG. Paris - Charles de Gaulle airport

CDM. Collaborative decision-making

CFMU. Central flow management unit

CDQM. Collaborative departure queue management

CWP. Controller working positions

CAD. Computer aided design

CTA. Control time of arrival

CARATS. Collaborative action for renovation of air traffic systems

CFIT. Controlled flight into terrain

CDTI. Cockpit display of traffic information

CCO. Continuous climb operations

CAR/SAM. Caribbean and South American region

COSESNA. Central American civil aviation agency.

D

DAA. Detect and avoid

DCB. Demand capacity balancing

DCL. Departure clearance

DFM Departure flow management

DFS. Deutsche Flugsicherung GmbH

DLIC. Data link communications initiation capability

DMAN. Departure management

DMEAN. Dynamic management of European airspace network

D-OTIS. Data link-operational terminal information service

DPI. Departure planning information

DPI. Departure planning information

D-TAXI. Data link TAXI

E

EAD. European AIS database

e-AIP. Electronic AIP

EGNOS. European GNSS navigation overlay service

ETMS. Enhance air traffic management system

EVS. Enhanced vision systems

F

FABEC Functional Airspace Block Europe Central

FAF/FAP. Final approach fix/final approach point

FANS. Future air navigation systems

FDP. Flight data processing

FDPS. Flight data processing system

FF-ICE. Flight and flow information for the collaborative environment

FIR. Flight information region

FIXM. Flight information exchange model

FMC. Flight management computer

FMS. Flight management system

FMTP. Flight message transfer protocol

FO. Flight object

FPL. Filed flight plan

FPS. Flight planning systems

FPSM. Ground delay program parameters selection model

FRA. Free route airspace

FTS. Fast time simulation

FUA. Flexible use of airspace

FUM. Flight update message

G

GANIS. Global Air Navigation Industry Symposium

GANP. Global air navigation plan

GAT. General air traffic

GBAS. Ground-based augmentation system

GBSAA. Ground based sense and avoid

GEO satellite. Geostationary satellite

GLS. GBAS landing system

GNSS. Global navigation satellite system

GPI. Global plan initiatives

GPS. Global positioning system

GRSS. Global runway safety symposium

GUFI. Globally unique flight identifier

H

HAT. Height above threshold

HMI. Human-machine interface

HUD. Head-up display

I

IDAC. Integrated departure-arrival capability

IDC. Interfacility data communications

IDRP. Integrated departure route planner

IFR. Instrument flight rules

ILS. Instrument landing system

IM. Interval Management

IOP. Implementation and Interoperability

IP. Internetworking protocol

IRR. Internal rate of return

ISRM. Information service reference model

ITP. In-trail-procedure

K

KPA. Key performance areas

L

LARA. Local and sub-regional airspace management support system

LIDAR. Aerial laser scans

LNAV. Lateral navigation

LoA. Letter of agreement

LoC. Letter of coordination

LPV. Lateral precision with vertical guidance OR localizer performance with vertical guidance

LVP. Low visibility procedures

M

MASPS. Minimum aviation system performance standards

MILO. Mixed integer linear optimization

MIT. Miles-in-trail

MLS. Microwave landing system

MLTF. Multilateration task force

MTOW. Maximum take-off weight

N

NADP. Noise abatement departure procedure

NAS. National airspace system

NAT. North Atlantic

NDB. Non-directional radio beacon

NextGen. Next generation air transportation system

NMAC. Near mid-air collision

NOP. Network operations procedures (plan)

NOTAM. Notice to airmen

NPV. Net present value

O

OLDI. On-line data interchange

OPD. Optimized profile descent

OSED Operational service & environment definition

OTW. Out the window

P

P(NMAC). Probability of a near mid-air collision

PACOTS. Pacific organized track system

PANS-OPS. Procedures for air navigation services - aircraft operations

PBN - Performance-based navigation

PENS Pan-European Network Service

PETAL. Preliminary EUROCONTROL test of air/ground data link

PIA. Performance improvement area

P-RNAV. Precision area navigation

R

RA. Resolution advisory

RAIM. Receiver autonomous integrity monitoring

RAPT. Route availability planning tool

RNAV Area navigation

RNP. Required navigation performance

RPAS. Remotely-piloted aircraft system

RTC. Remote tower centre

S

SARPs. Standards and recommended practices

SASP. Separation and airspace safety panel

SATCOM. Satellite communication

SBAS. Satellite-based augmentation system

SDM. Service delivery management

SESAR. Single European sky ATM research

SEVEN. System-wide enhancements for versatile electronic negotiation

SFO. San Francisco international airport

SIDS. Standard instrument departures

SMAN. Surface management

SMS. Safety management systems

SPRs. Special programme resources

SRMD. Safety risk management document

SSEP. Self-separation

SSR. Secondary surveillance radar

STA. Scheduled time of arrival

STARS. Standard terminal arrivals

STBO. Surface trajectory based operations

SURF. Enhanced traffic situational awareness on the airport surface

SVS. Synthetic visualisation systems

SWIM. System-wide information management

T

TBD. To be determined

TBFM. Time based flow management

TBO. Trajectory-based operations

TCAS. Traffic alert and collision avoidance system

TFM. Traffic flow management

TIS-B. Traffic information service-broadcast

TMA. Trajectory management advisor

TMIs. Traffic management initiatives

TMU Traffic management unit

TOD. Top of Descent

TRACON. Terminal radar approach control

TS. Traffic synchronisation

TSA. Temporary segregated airspace

TSO. Technical standard order

TWR. Aerodrome control tower

U

UA. Unmanned aircraft

UAS. Unmanned aircraft system

UAV. Unmanned aerial vehicle

UDPP. User driven prioritisation process

V

VFR. Visual flight rules

VLOS. Visual line-of-sight

VNAV. Vertical navigation

VOR. Very high frequency (VHF) omnidirectional radio range

VSA. Enhanced visual separation on approach

W

WAAS. Wide area augmentation system

WAF. Weather avoidance field

WGS-84. World geodetic system - 1984

WIDAO. Wake independent departure and arrival operation

WTMA. Wake turbulence mitigation for arrivals

WTMD. Wake turbulence mitigation for departures

WXXM. Weather exchange model

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