

*International Civil Aviation Organization*



**MIDANPIRG CNS/ATM/IC Sub-Group  
(CNS/ATM/IC SG)**

**Sixth Meeting  
(Cairo, Egypt, 31 January – 02 February 2012)**

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**Agenda Item 4: MID Region Air Navigation Performance Based Approach**

**MID REGION OPERATIONAL IMPROVEMENTS**

*(Presented by the Secretariat)*

**SUMMARY**

This paper presents list of operational improvements identified by ICAO which within the framework of the revision of the Global Air Navigation Plan

Action by the meeting is at paragraph 3.

**REFERENCES**

- Aviation System Block Upgrade
- Global Air Navigation Plan

**1. INTRODUCTION**

1.1 The Air Navigation Commission, at the fifth meeting of its 185th session on 01 December 2010, agreed that Contracting States and appropriate international organizations be consulted through State letter ST/13/1-11/10, dated 31 March 2011, on the convening of the Twelfth Air Navigation Conference (AN-Conf/12) to discuss subjects related to air navigation systems.

1.2 ICAO hosted the Global Air Navigation Industry Symposium (GANIS) from 20 to 23 September 2011. The event was considered a great success, with over 500 participants from industry, States and international organizations in attendance and as successor to the GANIS a revised Working Document was issued as a result of the consultation process which followed the Symposium.

**2. DISCUSSION**

2.1 The meeting may wish to note that it is expected from the AN-Conf/12 to set priorities, coalesce around major operational objectives to bring the global aviation community into agreement on an agenda to drive the next ten years of air navigation planning and implementation. Furthermore it would allow ICAO to plan work programmes of panels and Planning and Implementation Regional Groups (PIRGs) toward finalization of operational improvements objectives and provide a stimulus to air navigation planning and implementation.

2.2 AN-Conf/12 will endorse the revised Global Plan that will address in addition to communication, Navigation, surveillance, aeronautical Information Management and avionics roadmaps, the Aviation System Block Upgrade (ASBU) initiative that will take into account Air navigation Service providers, Regulators and user needs.

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

- 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.

2.4 The Aviation System Block upgrades concept will be included into the revision of the Global Air Navigation Plan (GANP) and presented to the Twelfth Air Navigation Conference. The latest version of the ASBU Working Document, containing the detailed explanations of the blocks, is attached as **Appendix A** to this working paper and can be found at the ICAO website at: [www.icao.int/anconf12/asbu](http://www.icao.int/anconf12/asbu)

2.5 In connection with the above, ICAO identified certain operational improvements as at **Appendix B** to this working paper as being the baseline level of implementation necessary for the next steps. These improvements, which relate to Global Plan Initiative in current Global Plan are already supported by existing ICAO SARPS, PANS and guidance material.

### 3. ACTION BY THE MEETING

3.1 The meeting is invited to review **Appendix B** to this working paper and agree on the operational improvements of relevance to the MID Region in a prioritized manner.

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APPENDIX A



**WORKING DOCUMENT**

**FOR THE**

# **Aviation System Block Upgrades**

**THE FRAMEWORK**

**FOR GLOBAL HARMONIZATION**

**ISSUED: 16 NOVEMBER 2011**

**SUCCESSOR TO THE WORKING DOCUMENT FOR  
GLOBAL AIR NAVIGATION INDUSTRY SYMPOSIUM (GANIS)**

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## **Preface to This Edition**

This document is the successor to the GANIS Working Document issued prior to the [Global Air Navigation Industry Symposium](#), which took place in September 2011.

This document is the result of the consultation process which followed the Symposium. All comments received were reviewed by the ASBU Technical Team and the results incorporated into this edition of the “Working Document”.

Future editions of the “Working Document” will contain detailed information on the dependencies between modules along with further refinements to the information contained within.

Please review this edition and provide your comments and feedback as requested in the accompanying State Letter.

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## ICAO Aviation System Block Upgrades

### Introduction

The [37th Session](#) of the International Civil Aviation Organization (ICAO) General Assembly (2010) directed the Organization to double its efforts to meet the global needs for airspace interoperability while maintaining 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 equipment,
- establishes a transition plan, and
- enables global interoperability.

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 the Asia/Pacific, North and Latin America, Russia, Japan and China. Modernization is an enormously complex task but the Industry needs 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 diverse needs of operators, the environment and other issues—it is necessary to renovate ATM systems, to provide the greatest operational and performance benefits.

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

- 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 initiatives providing benefits in many regions of the world. The Block upgrades are largely based 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. Also included was the feedback from several member states, with evolving modernization programmes, received at the recent Global Air Navigation Industry Symposium. 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.

The 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. They will include the development of technology roadmaps, to ensure that standards are mature and to facilitate synchronized implementation between air and ground systems and 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 will generate 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. Following which, it will form the basis of the Global Air Navigation Plan (GANP). The Global Air Navigation Industry Symposium, in September 2011, will allowed industry partners as well as States to gain insight, provide feedback and ultimately commit to the initiative.

The development of block upgrades will be realized by the change of focus from top-down planning to 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.

### **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, which involves ICAO, States and Industry, 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 and, if needed, investment 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.

### 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. There are four components of a Block upgrade:

**Module** - 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 still 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.

**Thread** - 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. A thread describes the evolution of a given capability through the successive block upgrades, from basic to more advanced capability and associated performance, while representing key aspects of the global ATM concept

**Block** – a block is made up of modules that when combined enable significant improvements and provide access to benefits.

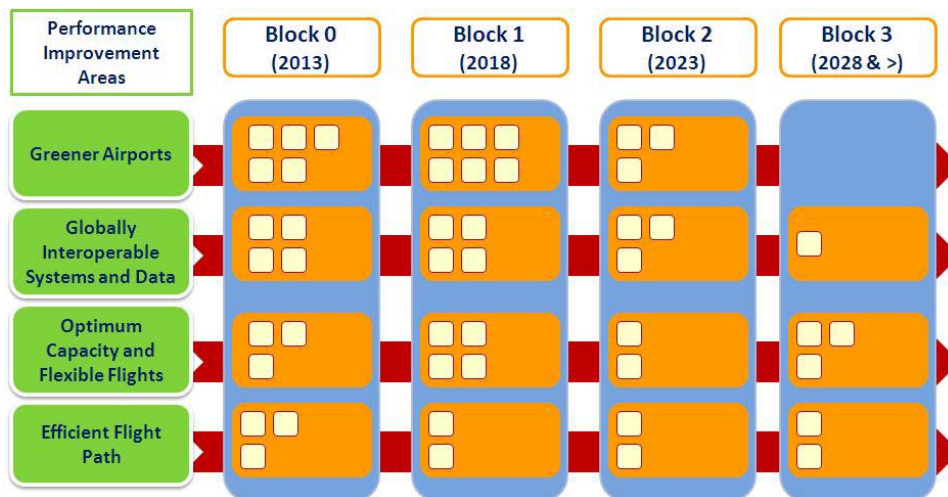
The notion of blocks introduces a form of quantization of the dates in five year intervals. However, detailed descriptions will allow the setting of more accurate implementation dates, often not at the exact reference date of a block upgrade. The purpose is not to indicate when a module implementation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

**Performance Improvement Area (PIA)** - sets of modules in each Block are grouped to provide 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

Table 1 illustrates the relationships between the Modules, Threads, Blocks, and Performance Improvement Areas.



**Table 1. Summary of Blocks Mapped to Performance Improvement Areas**

Note that each Block includes a target date reference. Each of the Modules that form the Blocks must meet a readiness review that includes the availability of standards (to include performance standards, approvals, advisory/guidance documents, etc.), avionics, infrastructure, ground automation and other enabling capabilities. In order to provide a community perspective each Module should have been fielded in two regions and include operational approvals and procedures. This allows States wishing to adopt the Blocks to draw on the experiences gained by those already employing those capabilities.

Figure 1 illustrates the timing of each Block relative to each other. Note that early lessons learned are included in preparation for the Initial Operating Capability date. For the 12<sup>th</sup> Air Navigation Conference it is recognized that Blocks 0 and 1 represent the most mature of the Modules. Blocks 2 and 3 provide the necessary vision to ensure that earlier implementations are on the path to the future.

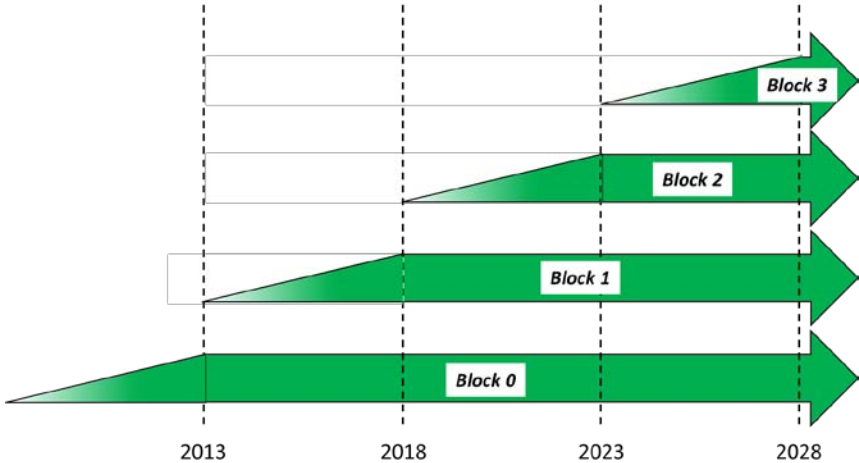


Figure 1. Timing Relationships Between Blocks

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

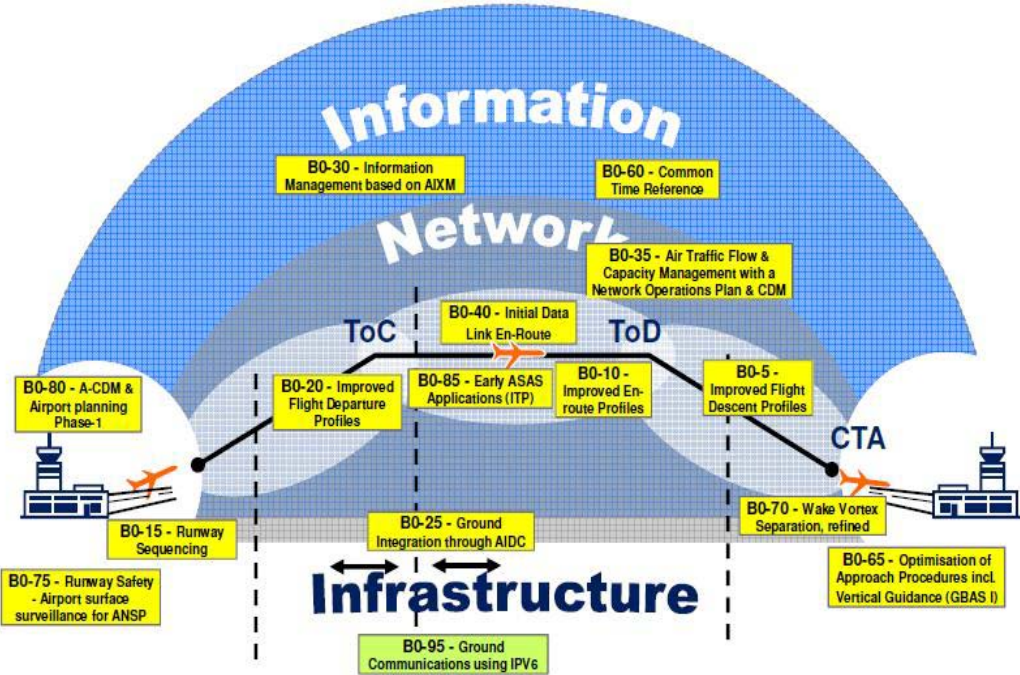


Figure 2. Block 0 in Perspective

## Global Air Navigation Plan

The GANP is a strategic document that has successfully guided the efforts of States, planning and implementation regional groups (PIRGS) 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 from 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.

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.

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

## 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.

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## **APPENDIX A – Summary of Table of Aviation System Block Upgrades**

- *Mapped to Performance Improvement Areas*
- *Showing Threads.*

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Performance Improvement Area 1: Greener Airports

Block 0	Block 1	Block 2	Block 3
<p><b>B0-65</b>  <b>Optimisation of approach procedures including vertical guidance</b>                      This is the first step toward universal implementation of GNSS-based approaches</p>	<p><b>B1-65</b>  <b>Optimised Airport Accessibility</b>                      This is the next step in the universal implementation of GNSS-based approaches</p>		
<p><b>B0-70</b>  <b>Increased Runway Throughput through Wake Tubulence Separation</b>                      Improved throughput on departure and arrival runways through the revision of current ICAO wake vortex separation minima and procedures .</p>	<p><b>B1-70</b>  <b>Increased Runway Throughput through Dynamic Wake Turbulence Separation</b>                      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</p>	<p><b>B2-70 (*)</b>  <b>Advanced Wake Turbulence Separation (Time-based)</b></p>	
<p><b>B0-75</b>  <b>Improved Runway Safety (A-SMGCS Level 1-2 and Cockpit Moving Map)</b>                      Airport surface surveillance for ANSP</p>	<p><b>B1-75</b>  <b>Enhanced Safety and Efficiency of Surface Operations (ATSA-SURF)</b>                      Airport surface surveillance for ANSP and flight crews with safety logic, cockpit moving map displays and visual systems for taxi operations</p>	<p><b>B2-75</b>  <b>Optimised Surface Routing and Safety Benefits (A-SMGCS Level 3-4, ATSA-SURF IA and SVS)</b>                      Taxi routing and guidance evolving to trajectory based with ground / cockpit monitoring and data link delivery of clearances and information. Cockpit synthetic visualisation systems</p>	
<p><b>B0-80</b>  <b>Improved Airport Operations through Airport-CDM</b>                      Airport operational improvements through the way operational partners at airports work together</p>	<p><b>B1-80</b>  <b>Optimised Airport Operations through Airport-CDM Total Airport Management</b>                      Airport operational improvements through the way operational partners at airports work together</p>		
	<p><b>B1-81</b>  <b>Remote Operated Aerodrome Control T</b>                      The performance objective is to provide 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</p>		
<p><b>B0-15</b>  <b>Improved RunwayTraffic Flow through Sequencing (AMAN/DMAN)</b>                      Time-based metering to sequence departing and arriving flights</p>	<p><b>B1-15</b>  <b>Improved Airport operations through Departure, Surface and Arrival Management</b>                      Extended arrival metering, Integration of surface management with departure sequencing bring robustness to runways management and increase airport performances and flight efficiency</p>	<p><b>B2-15</b>  <b>Linked AMAN/DMAN</b>                      Synchronised AMAN/DMAN will promote more agile and efficient en-route and terminal operations</p>	<p><b>B3-15</b>  <b>Integrated AMAN/DMAN/SMAN</b>                      Fully synchronised network management between departure airport and arrival airports for all aircraft in the air traffic system at any given point in time</p>

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

Block 0	Block 1	Block 2	Block 3
<p><b>B0-25</b> <b>Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration</b> Supports the coordination of ground-ground data communication between ATSU based on ATS Inter-facility Data Communication (AIDC) defined by ICAO Document <a href="#">9694</a></p>	<p><b>B1-25</b> <b>Increased Interoperability, Efficiency and Capacity through FF-ICE/1 application before Departure</b> 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</p>	<p><b>B2-25</b> <b>Improved Coordination through multi-centre Ground-Ground Integration: (FF-ICE/1 and Flight Object, SWIM)</b> FF-ICE supporting trajectory-based operations through exchange and distribution of information for multicentre operations using flight object implementation and IOP standards</p>	
<p><b>B0-30</b> <b>Service Improvement through Digital Aeronautical Information Management</b> 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</p>	<p><b>B1-30</b> <b>Service Improvement through Integration of all Digital ATM Information</b> 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</p>		<p><b>B3-25</b> <b>Improved Operational Performance through the introduction of Full FF-ICE</b> All data for all relevant flights systematically shared between air and ground systems using SWIM in support of collaborative ATM and trajectory-based operations</p>
	<p><b>B1-31</b> <b>Performance Improvement through the application of System Wide Information Management (SWIM)</b> Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximise interoperability</p>	<p><b>B2-31</b> <b>Enabling Airborne Participation in collaborative ATM through SWIM</b> Connection of the aircraft an information node in SWIM enabling participation in collaborative ATM processes with access to rich voluminous dynamic data including meteorology</p>	

## Performance Improvement Area 3:

## Optimum Capacity and Flexible Flights – Through Global Collaborative ATM

Block 0	Block 1	Block 2	Block 3
<p><b>B0-10</b>  <b>Improved Operations through Enhanced En-Route Trajectories</b>            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</p>	<p><b>B1-10</b>  <b>Improved Operations through Free Routing</b>            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</p>		
<p><b>B0-35</b>  <b>Improved Flow Performance through Planning based on a Network-Wide view</b>            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</p>	<p><b>B1-35</b>  <b>Enhanced Flow Performance through Network Operational Planning</b>            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</p>	<p><b>B2-35</b>  <b>Increased user involvement in the dynamic utilisation of the network.</b>            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</p>	<p><b>B3-10</b>  <b>Traffic Complexity Management</b>            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</p>
	<p><b>B1-105</b>  <b>Better Operational Decisions through Integrated Weather Information (Planning and Near-Term Service)</b>            Weather information supporting automated decision process or aids involving: weather information, weather translation, ATM impact conversion and ATM decision support</p>		<p><b>B3-105</b>  <b>Better Operational Decisions through Integrated Weather Information (Near and Intermediate Service)</b>            Weather information supporting both air and ground automated decision support aids for implementing weather mitigation strategies</p>

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

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### Block 0

### Block 1

### Block 2

### Block 3

- **B0-85**

**Air Traffic Situational Awareness (ATSA)**

This module comprises two *ATSA (Air Traffic Situational Awareness)* applications which will enhance safety and efficiency by providing pilots with the means to achieve quicker visual acquisition of targets:

- AIRB (Enhanced Traffic Situational Awareness during Flight Operations)
- VSA (Enhanced Visual Separation on Approach).

**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

**B2-85****Airborne Separation (ASEP)**

To create operational benefits through temporary delegation of responsibility to the flight deck for separation provision between suitably equipped designated aircraft, thus reducing the need for conflict resolution clearances while reducing ATC workload and enabling more efficient flight profiles.

**B3-85****Self-Separation (SSEP)**

To create operational benefits through total delegation of responsibility to the flight deck for separation provision between suitably equipped aircraft in designated airspace, thus reducing the need for conflict resolution clearances while reducing ATC workload and enabling more efficient flight profiles

**B0-86****Improved access to Optimum Flight Levels through Climb/Descent Procedures using ADS-B**

The aim of this module is to prevent flights to be trapped at an unsatisfactory altitude for a prolonged period of time. The In Trail Procedure (ITP) uses ADS-B based separation minima to enable an aircraft to climb or descend through the altitude of other aircraft when the requirements for procedural separation cannot be met.

**B0-101****ACAS Improvements**

Implementation of ACAS with enhanced optional features such as altitude capture laws reducing nuisance alerts, linking to the autopilot for automatic following of resolution advisories

**B2-101****New Collision Avoidance System**

Implementation of Airborne Collision Avoidance System (ACAS) adapted to [take account of the] trajectory-based operations [procedures] with improved surveillance function supported by ADS-B and adaptive collision avoidance logic aiming at reducing nuisance alerts and minimizing deviations

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

Block 0	Block 1	Block 2	Block 3
<p><b>B0-05</b> <b>Improved Flexibility and Efficiency in Descent Profiles (CDOs)</b> 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)</p>	<p><b>B1-05</b> <b>Improved Flexibility and Efficiency in Descent Profiles (OPDs)</b> 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)</p>	<p><b>B2-05</b> <b>Optimised arrivals in dense airspace.</b> 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</p>	
<p><b>B0-40</b> <b>Improved Safety and Efficiency through the initial application of Data Link En-Route</b> Implementation of an initial set of data link applications for surveillance and communications in ATC</p>	<p><b>B1-40</b> <b>Improved Traffic Synchronisation and Initial Trajectory-Based Operation.</b> Improve the synchronisation of traffic flows at en-route merging points and to optimize the approach sequence through the use of 4DTRAD capability and airport applications, e.g.; D-TAXI, via the air ground exchange of aircraft derived data related to a single controlled time of arrival (CTA).</p>		<p><b>B3-05</b> <b>Full 4D Trajectory-based Operations</b> 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</p>
<p><b>B0-20</b> <b>Improved Flexibility and Efficiency in Departure Profiles</b> 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)</p>			
	<p><b>B1-90</b> <b>Initial Integration of Remotely Piloted Aircraft (RPA) Systems into non-segregated airspace</b> Implementation of basic procedures for operating RPAs in non-segregated airspace including detect and avoid</p>	<p><b>B2-90</b> <b>Remotely Piloted Aircraft (RPA) Integration in Traffic</b> Implements refined operational procedures that cover lost link (including a unique squawk code for lost link) as well as enhanced detect and avoid technology</p>	<p><b>B3-90</b> <b>Remotely Piloted Aircraft (RPA) Transparent Management</b> RPA operate on the aerodrome surface and in non-segregated airspace just like any other aircraft</p>

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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 indicated that this is Module 65 of Block 0. This taxonomy was used to facilitate the development of the modules but can be disregarded by the reader.

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# 1 Module N° B0-65: OPTIMISATION OF APPROACH 2 PROCEDURES INCLUDING VERTICAL GUIDANCE

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-01 Access and Equity, <b>KPA-04 Efficiency</b> , KPA-05 Environment, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	Approach	
<b>Applicability Considerations</b>	This module is applicable to all instrument and precision instrument runway ends, and to a limited extent, non-instrument runway ends	
<b>Global Concept Component(s)</b>	AUO – Airspace User Operations AO – Aerodrome Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-5 RNAV and RNP (PBN) GPI-14 Runway Operations GPI-20 WGS84	
<b>Pre-Requisites</b>	NIL	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	
	Avionics Availability	
	Ground System Availability	
	Procedures Available	
Operations Approvals		

## 4 1. Narrative

### 5 1.1 General

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

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

#### 9 1.1.1 Baseline

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

#### 13 1.1.2 Change brought by the module

14 Conventional navigation aids (e.g. ILS, VOR, NDB) have limitations in their ability to support the lowest  
15 minima to every runway. In the case of ILS, limitations include cost, the availability of suitable sites for  
16 ground infrastructure and an inability to support multiple descent paths. VOR and NDB procedures do not  
17 support vertical guidance and have relatively high minima that depend on siting considerations. PBN  
18 procedures require no ground-based Nav Aids and allow designers complete flexibility in determining the  
19 final approach lateral and vertical paths. PBN approach procedures can be seamlessly integrated with PBN

20 arrival procedures, including constant descent operations (CDO), thus reducing aircrew and controller  
21 workload and the probability that aircraft will not follow the expected trajectory.

22 States can implement GNSS-based PBN approach procedures that provide minima for aircraft equipped with  
23 basic GNSS avionics with or without Baro VNAV capability, and for aircraft equipped with SBAS avionics.  
24 GBAS, which is not included in the PBN Manual, requires aerodrome infrastructure but a single station can  
25 support approaches to all runways and GBAS offers the same design flexibility as PBN procedures. This  
26 flexibility provides benefits when conventional aids are out of service due to system failures or for  
27 maintenance. Regardless of the avionics fit, each aircraft will follow the same lateral path. Such approaches  
28 can be designed for runways with or without conventional approaches, thus providing benefits to PBN-  
29 capable aircraft, encouraging equipage and supporting the planning for decommissioning of some  
30 conventional aids.

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

## 35 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Access and Equity</i>	Increased aerodrome accessibility
<i>Capacity</i>	This module removes the requirement for sensitive and safety-critical areas on precision approaches.
<i>Efficiency</i>	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.
<i>Environment</i>	Environmental benefits through reduced fuel burn
<i>Safety</i>	Stabilized approach paths.
<i>CBA</i>	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.

## 36 **3. Necessary Procedures (Air & Ground)**

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

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

## 51 **4. Necessary System Capability**

### 52 **4.1 Avionics**

53 PBN approach procedures can be flown with basic IFR GNSS avionics that support on board performance  
 54 monitoring and alerting (e.g. TSO C129 receivers with RAIM); these support LNAV minima. Basic IFR  
 55 GNSS receivers may be integrated with Baro VNAV functionality to support vertical guidance to LNAV/VNAV  
 56 minima. In States with defined SBAS service areas, aircraft with SBAS avionics (TSO C145/146) can fly  
 57 approaches with vertical guidance to LPV minima, which can be as low as ILS Cat I minima when flown to a  
 58 precision instrument runway, and as low as 250 ft HAT when flown to an instrument runway. Within an SBAS  
 59 service area, SBAS avionics can provide advisory vertical guidance when flying conventional NDB and VOR  
 60 procedures, thus providing the safety benefits associated with a stabilized approach. Aircraft require TSO  
 61 C161/162 avionics to fly GBAS approaches

### 62 **4.2 Ground Systems**

63 SBAS-based procedures do not require any infrastructure at the airport served, but SBAS elements (e.g.  
 64 reference stations, master stations, GEO satellites) must be in place such that this level of service is  
 65 supported. The ionosphere is very active in equatorial regions, making it very technically challenging for the  
 66 current generation of SBAS to provide vertically guided approaches in these regions. All of the above  
 67 approach types are described in the PBN Manual. A GBAS station installed at the aerodrome served can  
 68 support vertically guided Cat I approaches to all runways at that aerodrome. Human Performance

### 69 **4.3 Human Factors Considerations**

70 Human performance is reflected in how straightforward it is to successfully perform a specific task  
 71 consistently, and how much initial and recurrent training is required to achieve safety and consistency. For  
 72 this module there are clear safety benefits associated with the elimination of circling procedures and  
 73 approaches without vertical guidance.

### 74 **4.4 Training and Qualification Requirements**

75 TBD

### 76 **4.5 Others**

77 TBD

## 78 **5. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

79 See Sections 3 and 4 above.

## 80 **6. Implementation and Demonstration Activities**

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

### 89 **6.1 Current Use**

#### 90 **▪ United States**

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

96

97

98     ▪   **Canada**

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

103    ▪   **Australia**

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

109    ▪   **France**

110    France has published 50 PBN procedures with LNAV minima as of June 2011; 3 have LPV minima; none  
111    has LNAV/VNAV minima. The estimates for the end of 2011 are: 80 LNAV, 10 LPV and 1 LNAV/VNAV. The  
112    objective is to have PBN procedures for 100% of France's IFR runways with LNAV minima by 2016, and  
113    100% with LPV and LNAV/VNAV minima by 2020. France has a single GBAS used to support aircraft  
114    certification, but not regular operations. France has no plans for Cat I GBAS.

115    ▪   **Brazil**

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

120    ▪   **India**

121    PBN based RNAV-1 SID and STAR procedures have been implemented in six major airports. AS per PBN  
122    implementation roadmap of India, India is planning to implement 38 LNAV & LNAV/VNAV procedures at  
123    major airport to provide capability of all-weather access to the airports with no reliance on ground aids. At  
124    some airports, these approach procedures will be linked with RNP-1 STARs.

125

126    **6.2    Planned or Ongoing Activities**

127    ▪   **India**

128    India has developed a SBAS system called GAGAN (GPS Aided Geo Augmented Navigation). GAGAN is  
129    capable of delivering RNP 0.1 capability over Indian FIRs and APV1 service over continental airspace. The  
130    certified GAGAN system will be available by June 2013. The GAGAN foot print is adequate to provide  
131    Satellite based augmentation to mot of APAC Region and beyond.

132

133    India has planned to implement GBAS to support Satellite based Navigation in TMA, to increase  
134    accessibility to airports. The first pilot project will be undertaken in 2012 at Chennai.

135

136    **7.       Reference Documents**

137    **7.1       Standards**

138    [Annex 10 Vol I](#). As of 2011 a draft SARPs amendment for GBAS to support Category II/III approaches is  
139    completed and is being validated by States and industry.

140    **7.2       Procedures**

141    PANS-OPS (ICAO Doc 8168) [Vol. I](#) and [Vol. II](#)

142

143

144

145	<b>7.3</b>	<b><i>Guidance Material</i></b>
146	•	PBN Manual ( <a href="#">ICAO Doc 9613</a> )
147	•	GNSS Manual ( <a href="#">ICAO Doc 9849</a> )
148	•	WGS-84 Manual (Doc 9674)
149	•	Manual on Testing of Radio Navigation Aids (Doc 8071), <a href="#">Volume II</a>
150	•	Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5
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# 1 Module N° B0-70: Increased Runway Throughput through 2 Wake Turbulence Separation 3

<b>Summary</b>	Improved throughput on departure and arrival runways through the revision of current ICAO wake turbulence separation minima and procedures .	
<b>Main Performance Impact</b>	<b>KPA-02 – Capacity</b> , KPA-06 Flexibility	
<b>Domain / Flight Phases</b>	Arrival and Departure	
<b>Applicability Considerations</b>	Least Complex – Implementation of re-categorized wake turbulence is mainly procedural. No changes to automation systems are needed.	
<b>Global Concept Component(s)</b>	CM – Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-13- Aerodrome Design; GPI 14 – Runway Operations	
<b>Main Dependencies</b>	Nil	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>2013</b>
	Avionics Availability	<b>N/A</b>
	Ground Systems Availability	<b>N/A</b>
	Procedures Available	<b>2013</b>
	Operations Approvals	<b>2013</b>

## 4 1. Narrative

### 5 1.1 General

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

#### 17 1.1.1 Baseline

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

#### 23 1.1.2 Change brought by the module

24 This Module will result in a change to an ANSP's applied wake mitigation procedures. Based on the  
25 standards developed, safely modifies the separation standards and their application by ANSPs to allow  
26 incremental increases to aerodrome runway throughput capacity. The capacity gains by Element 1 (changing  
27 wake separation standards) is predicted to be 4% for European capacity constrained aerodromes, 7% for

28 U.S. capacity constrained aerodromes with similar gains in other capacity constrained aerodromes  
29 worldwide. Elements 2 (increasing aerodrome arrival operational capacity) and 3 (increasing departure  
30 operational capacity) provide runway capacity improvements to aerodromes having runway configurations  
31 and aircraft traffic mixes that allow specialized ANSP wake mitigation procedures to enhance the runway  
32 throughput capacity. The aerodrome specific specialized procedures have/will result in increased aerodrome  
33 arrival capacity (5 to 10 more operations per hour) during instrument landing operations or increased  
34 aerodrome departure capacity (2 to 4 more operations per hour).

### 35 **1.2 Element 1: Initial 4D Operations (4DTRAD)**

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

43  
44 The work in Element 1 is being accomplished by a joint EUROCONTROL and FAA working group that has  
45 reviewed the current required wake mitigation aircraft separations used in both the USA's and Europe's air  
46 traffic control processes and has determined the current standards can be safely modified to increase the  
47 operational capacity of aerodromes and airspace. In 2010, the working group provided a set of  
48 recommendations for ICAO review that focused on changes to the present set of ICAO wake separation  
49 standards. To accomplish this, the workgroup developed enhanced analysis tools to link observed wake  
50 behaviour to standards and determined safety risk associated with potential new standards relative to  
51 existing standards. ICAO, after receiving the ICAO recommendations, formed the Wake Turbulence Study  
52 Group to review the FAA/EUROCONTROL working group recommendations along with other  
53 recommendations received from ICAO member states. It is expected that by the end of 2012, ICAO will  
54 publish wake separation standard changes to its Procedures for Air Navigation Services.

### 55 **1.3 Element 2: Increasing Aerodrome Arrival Operational Capacity**

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

62  
63 Extensive wake transport data collection efforts and the resulting analyses indicated that the wakes from  
64 aircraft lighter than Boeing 757 and heavier aircraft travelled less than previously thought. Based on this  
65 knowledge, high capacity demand aerodromes in the U.S. that used their CSPR for approach operations  
66 were studied to see if instrument approach procedures could be developed that provide more landing  
67 operations per hour than the single runway rate. A dependent diagonal paired instrument approach  
68 procedure (FAA Order 7110.308) was developed and made available for operational use in 2008 for five  
69 aerodromes that had CSPR configurations that met the runway layout criteria of the developed procedure.  
70 Use of the procedure provided an increase of up to 10 more arrival operations per hour on the aerodrome  
71 CSPR. By the end of 2010 the approval to use the procedure was expanded to two additional aerodromes.  
72 Work is continuing to develop variations of the procedure that will allow its application to more aerodrome  
73 CSPR with fewer constraints on the type of aircraft that must be the lead aircraft of the paired diagonal  
74 dependent approach aircraft.

### 75 **1.4 Element 3: Increasing Aerodrome Departure Operational Capacity**

76 Element 3 is the development of enhanced wake mitigation ANSP departure procedures that safely allow  
77 increased departure capacity on aerodrome CSPR. Procedures being developed are aerodrome specific in  
78 terms of runway layout weather conditions. The Wake Independent Departure and Arrival Operation  
79 (WIDAO) developed for use on CSPR at Charles de Gaulle aerodrome was developed as a result of an  
80 extensive wake turbulence transport measurement campaign at the aerodrome. WIDAO implementation  
81 allows the ANSP to use the inner CSPR for departures independent of the arrivals on the outer CSPR where  
82 before the ANSP was required to apply a wake mitigation separation between the landing aircraft on the  
83 outer CSPR and the aircraft departing on the inner CSPR. Wake Turbulence Mitigation for Departures

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

93 **2. Intended Performance Operational Improvement/Metric to determine success**

94 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	a. Aerodrome capacity and departure/arrival rates will increase as the wake categories are increased from 3 to 6 i b. 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%. c. New procedures will modify 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>Flexibility</i>	ANSP have the choice to configure the aerodrome to operate on 3 or 6 categories, depending on demand.

<i>CBA</i>	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 aerodrome’s runway. Air carrier data shows when operating from a major hub operation at a U.S. aerodrome, 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.  ICAO estimates the potential savings as a result of CDO implementation can be great. It is important to consider that CDO benefits are heavily dependent on each specific ATM environment. If implemented within the ICAO CDO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.  The ANSP may need to develop tools to assist controllers with the additional wake categories and WTMD decision support tools. The tools necessary will depend on the operation at each airport and the number of wake categories implemented.
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95

96 **3. Necessary Procedures (Air & Ground)**

97 The change to the ICAO wake separation standards will involve increasing the number of ICAO wake  
 98 separation aircraft categories from 3 to 6 categories along with the assignment of aircraft types to each of the  
 99 six wake separation categories. It is likely that the ANSP procedures, using the full 6 category set of  
 100 standards, will need some automation support in providing the wake category assignment of an aircraft to the  
 101 controller, so the controller will know which wake separation to apply between aircraft. Implementing Element  
 102 1 will not require any changes to air crew flight procedures. However, there will be changes required in how a  
 103 flight plan is filed in terms of the aircraft’s wake category.  
 104

105 The module implementations impacting the use of an aerodrome’s CSPR for arrivals, only affect the ANSP  
 106 procedures for sequencing and segregating aircraft to the CSPR. Element 2 products are additional

107 procedures for use by the ANSP for situations when the aerodrome is operating instrument flight rules and  
108 there is a need to land more flights than can be achieved by using only one of its CSPR. The procedures  
109 implemented by Element 2 require no changes to the aircrew's procedures for accomplishing an instrument  
110 landing approach to the aerodrome.

111  
112 Module Element 3 implementations only affect the ANSP procedures for departing aircraft on an  
113 aerodrome's CSPR. Element 3 products are additional procedures for use by the ANSP for situations when  
114 the aerodrome is operating under a heavy departure demand load and the aerodrome will be having a  
115 significant number of Boeing 757 and heavier aircraft in the operational mix. The procedures provide for  
116 transitioning to and from reduced required separations between aircraft and criteria for when the reduced  
117 separations should not be used. The procedures implemented by Element 3 require no changes to the  
118 aircrew's procedures for accomplishing a departure from the aerodrome. When a specialized CSPR  
119 departure procedure is being used at an aerodrome, pilots are notified that the special procedure is in use  
120 and that they can expect a more immediate departure clearance.

## 121 **4. Necessary System Capability**

### 122 **4.1 Avionics**

123 No additional technology for the aircraft or additional aircrew certifications is required.

### 124 **4.2 Ground Systems**

125 Some ANSPs may develop a decision support tool to aid in the application of the new set of 6 category ICAO  
126 wake separates. The Element 2 and Element 3 products vary on their dependency to newly applied  
127 technology. For the WTMD implementation, technology is used to predict crosswind strength and direction  
128 and to display that information to the ANSP controllers and supervisors.  
129

## 130 **5. Human Performance**

### 131 **5.1 Human Factors Considerations**

132 TBD

### 133 **5.2 Training and Qualification Requirements**

134 Controllers will require training on additional wake categories and separation matrix. The addition of Element  
135 3, WTMD, will require training for controllers on the use of the new tools to monitor and predict cross-winds.

### 136 **5.3 Others**

## 137 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

138 The product of Element 1 is a recommended set of changes to the ICAO wake separation standards and  
139 supporting documentation.

140  
141 Element 2 products are U.S. aerodrome specific and are approved for use through a national review process  
142 to insure proper integration into the air traffic control system. A companion process (FAA Safety  
143 Management System) reviews and documents the safety of the product, insuring the safety risk associated  
144 with the use of the product is low.

145  
146 Element 3's WIDAO has undergone extensive review by the French ANSP and regulator. It is now  
147 operational at Charles de Gaulle. WTMD is progressing through the FAA operational use approval process  
148 (which includes the Safety Management System process) and is expected to begin its operation at George  
149 Bush Intercontinental Houston Airport (IAH) in 2011.

## 150 **7. Implementation and Demonstration Activities**

### 151 **7.1 Current Use**

152 Awaiting ICAO approval of the revised wake turbulence separation standards (approval expected 2012/13).  
153

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

157  
158 The WIDAO relaxation of wake separation constraints at CDG (first and second sets of constraints) were  
159 approved in November 2008 and March 2009. The final set of CDG constraints was lifted in 2010.

## 160 **7.2 *Planned or Ongoing Trials***

161 Work is continuing to develop variations of the FAAA Order 7110.308 procedure that will allow its application  
162 to more aerodrome CSPR with fewer constraints on the type of aircraft that must be the lead aircraft of the  
163 paired diagonal dependent approach aircraft. It is expected that by the end of 2012, the procedure will be  
164 available in the U.S for use by an additional 6 or more CSPR aerodromes during periods when they use  
165 instrument approach landing procedures.  
166

167 Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that will allow,  
168 when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR  
169 after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required  
170 wake mitigation delay of 2 to 3 minutes. WTMD is being developed for implementation at 8 to 10 U.S.  
171 aerodromes that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757  
172 and heavier aircraft operations. First operational use of WTMD is expected in spring 2011.  
173

## 174 **8. Reference Documents**

### 175 **8.1 *Standards***

176

### 177 **8.2 *Procedures***

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### 179 **8.3 *Guidance Materials***

180 ICAO [Doc 9750](#) Global Air Navigational Plan.

181 ICAO [Doc 9854](#) Global ATM Operational Concept,

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## **Module N° B0-75: Improved Runway Safety (A-SMGCS Level 1-2 and Cockpit Moving Map)**

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# 1 Module N° B0-80: Improved Airport Operations through 2 Airport-CDM 3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-02 capacity; KPA-04 – Efficiency; KPA-05 – Environment;	
<b>Operating Environment/Phases of Flight</b>	Aerodrome, Terminal	
<b>Applicability Considerations</b>	Local for equipped/capable fleets and already established airport surface infrastructure.	
<b>Global Concept Component(s)</b>	AO – Airport Operations IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-8 Collaborative airspace design and management GPI-18 Aeronautical information GPI-22 Communication infrastructure	
<b>Pre-Requisites</b>	NIL	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	Est. 2013
	Avionics Availability	√
	Ground System Availability	Est. 2013
	Procedures Available	Est. 2013
	Operations Approvals	Est. 2013

## 4 1. Narrative

### 5 1.1 General

#### 6 1.1.1 Baseline

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

11 The baseline will be operations without airport collaboration tools and operations.

#### 12 1.1.2 Change brought by the module

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

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

18

19 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Access and Equity</i>	
<i>Capacity</i>	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
<i>Efficiency</i>	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
<i>Environment</i>	<ul style="list-style-type: none"> <li>• Reduced taxi time</li> <li>• Reduced Fuel and Carbon Emissions</li> <li>• Lower aircraft engine run time</li> </ul>

20

<i>CBA</i>	The business case has proven to be positive due to the benefits that flights and the other airport operational stakeholders can obtain. However this may be influenced depending upon the individual situation (environment, traffic levels investment cost etc)  A detailed business case has been produced in support of the EU Regulation which was solidly positive.
------------	--

21 **3. Necessary Procedures (Air & Ground)**

22 Existing procedures, adapted to the collaborative environment. Collaborative Departure Queue Management  
 23 (CDQM) has been found to provide reduced taxi times, and resultant reduced fuel usage and emissions,  
 24 while maintaining full use of departure capacity. Successful operations of the CDQM prototype system has  
 25 shown in field evaluations to allow ATC personnel and flight operators to avoid excess departure queuing,  
 26 thereby reducing taxi times and resulting in direct savings to the flight operators. Additional research and  
 27 development of the Surface CDM Concept of Operations, CDQM and the Collaborative Departure  
 28 Scheduling concept is being further developed.

29 **4. Necessary System Capability**

30 **4.1 Avionics**

31 *No airborne equipment is required.*

32 **4.2 Ground Systems**

33 The difficulty to interconnect ground systems depends on the systems in place locally, but experience proves  
 34 that industrial solutions/support exist. Where available shared surveillance information may enhance  
 35 operations.

36 **4.3 Human Factors Considerations**

37 TBD

38 **4.4 Training and Qualification Requirements**

39 TBD

40 **4.5 Others**

41 TBD

42

## 43 **5. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

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

## 46 **6. Implementation and Demonstration Activities**

### 47 **6.1 Current Use**

#### 48 **Europe**

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

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

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

60  
61 Exchange of real time data between airports and CFMU is operational. The accuracy of this data is proving  
62 to be very beneficial to both the CFMU and airports. The airports are receiving very accurate arrival  
63 estimates for all flights via the Flight Update Message (FUM). The CFMU is benefiting with enhanced take off  
64 time estimates in tactical operations via the Departure Planning Information (DPI) messages. A number of  
65 additional airports will enter into the data exchange with the CFMU over the coming months.

66  
67 Based on the successful implementation of FUM/DPI at Munich airport (operational since June 2007) and the  
68 outcome of live trials in Zurich, Brussels, and other airports in close coordination with the CFMU, the  
69 objective is to develop incentives for all airport stakeholders to adopt the new procedures and take  
70 advantage of the proven benefits.

71 All information can be found at:

72 [http://www.EUROCONTROL.int/airports/public/standard\\_page/APR2\\_ACDM\\_2.html](http://www.EUROCONTROL.int/airports/public/standard_page/APR2_ACDM_2.html) and [http://www.euro-](http://www.euro-cdm.org/)  
73 [cdm.org/](http://www.euro-cdm.org/)

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

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

80

#### 81 **United States**

82 TBD.

### 83 **6.2 Planned or Ongoing Activities**

#### 84 **United States**

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

87 To evaluate the Human-in-the-Loop system's feasibility and benefits, five airline dispatchers from American  
88 carriers: Continental, Delta, JetBlue, Southwest, and United Airlines used the system to manage a set of  
89 flights through several simulated air traffic scenarios. A current FAA air traffic manager set constraints on  
90 airspace capacities. Recommendations for future experiments included researching other credit allocation  
91 schemes and evaluating alternate constraint resolution methods. The credit assignment software was

92 developed for the U.S. trial at NASA and was integrated into the Federal Aviation Administration's (FAA's)  
93 System-wide Enhancements for Versatile Electronic Negotiation (SEVEN) framework. The FAA has planned  
94 for SEVEN to become operational in the fall 2011 under the Collaborative Trajectory Options Program.

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

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

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

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

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

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

## 131 **7. Reference Documents**

### 132 **7.1 Standards**

133 ICAO CDM Manual (being finalised)  
134 [EUROCAE ED-141 Minimum Technical Specifications for Airport Collaborative Decision Making](#) (Airport-  
135 CDM) [Systems](#)  
136 [EUROCAE ED-145 Airport-CDM Interface Specification](#)  
137 EC: ETSI DRAFT Community Specification – version – TBD

### 138 **7.2 Procedures**

139 TBD

### 140 **7.3 Guidance Material**

141 EUROCONTROL [A-CDM Programme documentation](#), including an [A-CDM Implementation Manual](#)  
142 [FAA NextGen Implementation Plan 2011](#)

# 1 Module N° B0-15: IMPROVE TRAFFIC FLOW THROUGH 2 RUNWAY SEQUENCING (AMAN/DMAN) 3

<b>Summary</b>	Time-based metering to sequence departing and arriving flights.	
<b>Main Performance Impact</b>	KPA-02 Capacity; <b>KPA-04 Efficiency</b> ; KPA-09 Predictability KPA-06 Flexibility	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Element(s)</b>	TS – Traffic Synchronization	
<b>Global Plan Initiative</b>	<b>GPI-6</b> Air Traffic Flow Management	
<b>Main Dependencies</b>		
<b>Global Readiness Checklist</b>		<b>Status</b> (ready or date)
	Standards Readiness	√
	Avionics Availability	√
	Ground System Availability	√
	Procedures Available	√
	Operations Approvals	√

## 4 1. Narrative

### 5 1.1 General

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

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

14 In Block 0 (present – 2013), Basic queue management tool such as arrival/departure sequencing systems  
15 will provide runway sequencing and metering/scheduling support to the ANSP, much like Traffic  
16 Management Advisor (TMA) in the US. Similarly, EuroControl's AMAN aims to achieve equivalent  
17 functionalities as TMA. AMAN is deployed at a handful of key European aerodromes<sup>1</sup>.

18 TMA is currently being used at 20 ARTCCs in the NAS. Meter points, meter fixes, and meter arcs are  
19 supported by TMA near the terminal area as scheduling entities. These scheduling entities enhance the  
20 ability of Air Route Traffic Control Centers (ARTCCs) to conduct time based metering of arrivals over long  
21 distances from the arrival aerodromes and to meter en-route traffic flows. Likewise, Arrival/Departure  
22 Management (AMAN) assists ATC personnel in Terminal Manoeuvre Area with sequencing and scheduling  
23 as they become available.

<sup>1</sup> SESAR Definition Phase Deliverable 2 – Air Transport Framework: The Performance Target, page 65

24 **1.1.1 Baseline**

25 Traffic Management Advisor (TMA) is the current time based metering and runway sequencing tool in service  
26 at all US Air Route Traffic Control Centres (ARTCCs) and the New York Terminal Radar Approach Control  
27 (TRACON). AMAN/DMAN deployment in Europe is limited to only a few aerodromes.

28 **1.1.2 Change brought by the module**

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

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

37 **1.2 Element 1: Time Based Metering**

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

43 **1.3 Element 2: Departure Management**

44  
45 Departure management, like its arrival counterpart, serves to optimize departure operation to ensure the  
46 most efficient utilization of aerodrome and terminal resources. Slots assignment and adjustments will be  
47 supported by departure management automations like DMAN or DFM. Dynamic slot allocation will foster  
48 smoother integration into overhead streams and help the airspace users better meet metering points and  
49 comply with other ATM decisions. Departure management sequences the aircraft, based on the airspace  
50 state, wake turbulence, aircraft capability, and user preference, to fit into the overhead en-route streams  
51 without disrupting the traffic flow. This will serve to increase aerodrome throughput and compliance with  
52 allotted departure time.  
53

54 **2. Intended Performance Operational Improvement/Metric to Determine Success**

55 Metrics to determine the success of the module are proposed at Appendix C

<i>Capacity</i>	Time based metering will optimize usage of terminal airspace and runway capacity.Optimize utilization of terminal and runway resources.
<i>Efficiency</i>	<i>Harmonized arriving traffic flow from en-route to terminal and aerodrome. Harmonization is achieved via sequencing arrival flights based on available terminal and runway resources.</i>  Efficiency is positively impacted as reflected by increased runway throughput and arrival rates.  Streamline departure traffic flow and ensure smooth transition into en-route airspace. Decreased lead time for departure request and time between CFR and departure time. Automated dissemination of departure information and clearances.
<i>Predictability</i>	Decrease uncertainties in aerodrome/terminal demand prediction
<i>Flexibility</i>	Enables dynamic scheduling.

CBA	<p>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.<sup>2</sup></p> <p>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.</p>
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57

### 58 **3. Necessary Procedures (Air & Ground)**

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

64

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

### 67 **4. Necessary System Capability**

#### 68 **4.1 Avionics**

69 Initial operations based on existing aircraft FMS capabilities.

#### 70 **4.2 Ground Systems**

71 The key technological aspects include automation support for the synchronization of arrival sequencing,  
72 departure sequencing, and surface information; improve predictability of arrival flow, further hone sector  
73 capacity estimates, and management by trajectory. Less congested locations might not required extensive  
74 automation support to implement.

75

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

79

### 80 **5. Human Performance**

#### 81 **5.1 Human Factors Considerations**

82 ATM personnel responsibilities will not be affected

#### 83 **5.2 Training and Qualification Requirements**

84 Automation support is needed for Air Traffic Management in airspace with high demands. Thus, training is  
85 needed for ATM personnel.

<sup>2</sup> Exhibit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

86 **5.3 Others**  
87

88 **6. Regulatory/Standardisation Needs and Approval Plan (Air & Ground)**

89 This TBFM and AMAN/DMAN implementation will impact ICAO [Annex 1](#), the PANS-ATM document (ICAO  
90 Doc [4444](#)), Global Air Navigational Plan (ICAO [Doc 9750](#)) and the Global ATM Operational Concepts (ICAO  
91 Doc 9584).  
92

93 **7. Implementation and Demonstration Activities**

94 **7.1 Current Use**  
95

96 **US:** Traffic Management Advisor is currently used in the US as the primary time based metering automation.  
97 NextGen efforts will field Time Based Flow Management, the augmentation to the Traffic Management  
98 Advisor, incrementally. Departure Flow Management has just undergone an extensive field trial in the US.

99 **Europe:** EuroControl will expand the deployment of Arrival and Departure Manager (AMAN/DMAN). DMAN  
100 is deployed at major European hubs such as Charles De Gulle.  
101

102 **7.2 Planned or Ongoing Trials**  
103

104 **US:** DFM will be integrated with extended metering and become part of TBFM in the US.

105 **Europe:** DMAN deployment is expected to cover most major aerodromes in Europe.  
106

107 **8. Reference Documents**

108 **8.1 Standards**

109 **8.2 Procedures**

110 **8.3 Guidance Materials**

111 [European ATM Master Plan](#),

112 [SESAR Definition Phase Deliverable 2 – The Performance Target](#),

113 [SESAR Definition Phase Deliverable 3 – The ATM Target Concept](#),

114 [SESAR Definition Phase 5 – SESAR Master Plan](#)

115 TBFM Business Case Analysis Report

116 NextGen Midterm Concept of Operations v.2.0

117 RTCA Trajectory Concept of Use



1 **Module N° B0-25: Increased Interoperability, Efficiency and**  
 2 **Capacity through Ground-Ground Integration**  
 3

<b>Summary</b>	This module supports the coordination between Air Traffic Service Units (ATSU) based using ATS Interfacility Data Communication (AIDC) defined by ICAO <a href="#">DOC 9694</a> .  It permits also the transfer of communication in data-link environment in particular for Oceanic ATSU. It is a first step in the ground-ground integration	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-04 Efficiency, <b>KPA-07 Global Interoperability</b> , KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All flight phases and all type of ATS units	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	CM - Conflict management IM - Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-16 Decision Support Systems	
<b>Pre-Requisites</b>	Link with B0-40	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	√
	Avionics Availability	No requirement
	Ground systems Availability	√
	Procedures Available	√
	Operations Approvals	√

4 **1. Narrative**

5 **1.1 General**

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

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

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

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

21 With the greater accuracy of messages based on the updated trajectory information contained in the system  
 22 and where possible updated by surveillance data, controllers have more reliable information on the

23 conditions at which aircraft will enter in their airspace of jurisdiction with a reduction of the workload  
 24 associated to flight coordination and transfer. The increased accuracy and data integrity permits the safe  
 25 application of reduced separations.

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

27 These improvements translate directly into a combination of performance improvements.

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

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

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

### 36 1.1.1 Baseline

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

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

### 41 1.1.2 Change brought by the module

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

### 44 1.1.3 Other remarks

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

### 47 1.2 Element:

48 The element consists of Implementation of the set of AIDC messages in the Flight Data Processing System  
 49 (FDPS) of the different ATS units and establishment of Letter of Agreement (LoA) to determine the  
 50 appropriate parameters.

## 51 2. Intended Performance Operational Improvement/Metric to determine success

52 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Reduced controller workload and increased data integrity supporting reduced separations translating directly to cross sector or boundary capacity flow increases.
<i>Efficiency</i>	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.
<i>Global Interoperability</i>	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.
<i>Safety</i>	Better knowledge of more accurate flight plan information

53

<i>CBA</i>	Increase of throughput at ATC unit boundary, reduced ATCo Workload will exceed FDPS software changes cost. The business case is dependent on the environment
------------	--

### 54 **3. Necessary Procedures (Air & Ground)**

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

### 57 **4. Necessary System Capability**

#### 58 **4.1 Avionics**

59 No specific airborne requirements

#### 60 **4.2 Ground Systems**

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

### 63 **5. Human Performance**

#### 64 **5.1 Human Factors Considerations**

65 Ground interoperability reduces voice exchange between ATCOs and decreases workload. System  
66 supporting appropriate HMI for ATCOs is required.

#### 67 **5.2 Training and Qualification Requirements**

68 Training for making the most of the automation support

#### 69 **5.3 Others**

### 70 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

71 ICAO material is available (PANS-ATM, ATN). Regions should consider the inclusion of AIDC use n the  
72 regional plan.

73 In Europe, G/G interoperability is regulated through EU regulations (Regulation (EC) No [552/2004](#) of the  
74 European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic  
75 Management network and by EUROCONTROL standards.

### 76 **7. Implementation and Demonstration Activities**

#### 77 **7.1 Current Use**

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

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

83 Implementations exist in many regions.

84 In Europe it is mandatory for exchange between ATS units.

85 [http://europa.eu/legislation\\_summaries/transport/air\\_transport/l24070\\_en.htm](http://europa.eu/legislation_summaries/transport/air_transport/l24070_en.htm)

86 European Commission has already issued a mandate for this level of IOP (Law 552/2004, 10/04/2004;  
87 Implementing Rule 1032/2006, on the interoperability of the European Air Traffic Management network,  
88 "COTR"; Community Specification OLDI 4.1). Notably OLDI is considered as the European Implementation  
89 of ICAO's AIDC.

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

92 The available set of messages to describe and negotiate consistent transfer conditions via electronic means  
93 across centres' boundaries have been used for trials in Europe in 2010 in the scope of Eurocontrol's FASTI  
94 initiative.

95 India: AIDC implementation is in progress in Indian airspace for improved coordination between ground ATC  
96 centres. Major Indian airports/ATC centres have integrated ATS automation systems having AIDC capability.  
97 AIDC functionality is operational between Mumbai and Chennai ACCs. AIDC will be implemented within India  
98 by 2012. AIDC trials are underway between Mumbai and Karachi (Pakistan) and are planned between India  
99 and Muscat in coordination with Oman.

100 AIDC is in use In Asia-Pacific region Australia, New-Zealand, Indonesia and others.

## 101 **7.2 Planned or Ongoing Activities**

102 In operation

## 103 **8. Reference Documents**

### 104 **8.1 Standards**

- 105 • Doc 4444 Appendix 6 - ATS INTERFACILITY DATA COMMUNICATIONS (AIDC) MESSAGES
- 106 • Doc ATN (Doc 9880). Manual on Detailed Technical Specifications for the Aeronautical  
107 Telecommunication Network (ATN) using ISO/OSI Standards and Protocols  
108 [Part II](#) — Ground-Ground Applications — Air Traffic Services Message Handling Services  
109 (ATSMHS)

### 110 **8.2 Procedures**

111 TBD

### 112 **8.3 Guidance Material**

- 113 • Manual of Air Traffic Services Data Link Applications ([Doc 9694](#)).part 6
- 114 • [GOLD Global Operational Data Link Document](#) (APANPIRG, NAT SPG) June 2010
- 115 • [Pan Regional Interface Control Document for Oceanic ATS Interfacility Data Communications](#) (PAN  
116 ICD) Coordination Draft Version 0.3 — 31 August 2010
- 117 • EUROCONTROL documentation
  - 118 ○ [EUROCONTROL Standard for On-Line Data Interchange \(OLDI\)](#)
  - 119 ○ [EUROCONTROL Standard for ATS Data Exchange Presentation \(ADEXP\)](#)
- 120 • ICAO Asia Pac document [http://www.bangkok.icao.int/edocs/icd\\_aidc\\_ver3.pdf](http://www.bangkok.icao.int/edocs/icd_aidc_ver3.pdf)

121

# 1 Module N° B0-30: Service Improvement through Digital 2 Aeronautical Information Management 3

<b>Summary</b>	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	
<b>Main Performance Impact</b>	KPA-03 Cost-Effectiveness, KPA-05 Environment, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All phases of flight	
<b>Applicability Considerations</b>	Applicable at State level, with increased benefits as more States participate	
<b>Global Concept Component(s)</b>	IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-18 Electronic information services	
<b>Pre-Requisites</b>		
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	✓
	Avionics Availability	✓
	Ground Systems Availability	✓
	Procedures Available	✓
	Operations Approvals	✓

## 4 1. Narrative

### 5 1.1 General

6 The subject has been discussed at the 11<sup>th</sup> ANC which made the following recommendation:

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

8 That ICAO:

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

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

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

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

19 In the short to medium term, the focus is on the definition and harmonised transition from the present  
20 Aeronautical Information Services (AIS) to Aeronautical Information Management (AIM). AIM envisages a  
21 migration from a focus on products to a data centric environment where aeronautical data will be provided in  
22 a digital form and in a managed way. This transition includes both static (AIP) and dynamic (NOTAM) data.  
23 This can be regarded as the first stage of SWIM, which is based on common data models and data

24 exchange formats. The next (long term) SWIM level implies the re-thinking of the data services from a  
25 “network” perspective, which in the first level remains a centralised State service.

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

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

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

### 37 **1.1.1 Baseline**

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

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

### 45 **1.1.2 Change brought by the module**

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

## 50 **2. Intended Performance Operational Improvement/Metric to determine success**

51 Metrics to determine the success of the module are proposed at Appendix C.

<i>Cost Effectiveness</i>	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.
<i>Environment</i>	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.
<i>Global Interoperability</i>	Essential contribution to interoperability
<i>Safety</i>	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.

<i>CBA</i>	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.
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### 53 **3. Necessary Procedures (Air & Ground)**

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

### 57 **4. Necessary System Capability**

#### 58 **4.1 Avionics**

59 No avionics requirements.

#### 60 **4.2 Ground Systems**

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

### 64 **5. Human Performance**

#### 65 **5.1 Human Factors Considerations**

66 The automated assistance is proven to be well accepted and tend to reduce errors in manual transcription of  
67 data.

#### 68 **5.2 Training and Qualification Requirements**

69 Training is required for AIS/AIM personnel. Training material is available.

#### 70 **5.3 Others**

71 Nil

### 72 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

73 No additional need.

### 74 **7. Implementation and Demonstration Activities**

#### 75 **7.1 Current Use**

76 Initial operational capability: in Europe, Canada, US, etc. the initial operations started already between 2003-  
77 2009 based on earlier AIXM versions; migration to AIXM 5.1 is on-going, expected initial operations in 2012.

78 ▪ **Europe:** the European AIS Database (EAD) became operational in June 2003. Electronic AIP (eAIP),  
79 fully digital versions of the paper document and based on a EUROCONTROL eAIP specification have  
80 been implemented (on-line or on a CD) in a number of States (e.g. Armenia, Belgium & Luxemburg,  
81 Hungary, Latvia, Moldova, Netherlands, Portugal, Slovak Republic, Slovenia, Switzerland, etc.). Both are  
82 essential milestones in the realization of the digital environment. The EAD had been developed using the  
83 Aeronautical Information Conceptual Model (AICM) and Aeronautical Information Exchange Model  
84 (AIXM). Also Azerbaijan, Belarus, Estonia, have implemented the eAIP. Digital Notam implementation in  
85 Europe will start in 2012.

86 ▪ **US:** tbc.

87 ▪ **Other regions:** Djibouti, Japan, Taiwan, United Arab Emirates have implemented the eAIP.

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

#### 90 **7.2 Planned or Ongoing Activities**

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

95	<b>8.</b>	<b>Reference Documents</b>
96	<b>8.1</b>	<b>Standards</b>
97		TBD
98	<b>8.2</b>	<b>Procedures</b>
99		TBD
100	<b>8.3</b>	<b>Guidance Material</b>
101	▪	<a href="#">Doc 8126</a> <i>Aeronautical Information Services Manual</i> , incl. AIXM and eAIP as per Edition 3
102	▪	Doc 8697 <i>Aeronautical Chart Manual</i>
103	▪	Manuals on AIM quality system and AIM training
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# 1 Module N° B0-10: Improved Operations through Enhanced En-Route Trajectories

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity; KPA-02 Capacity; <b>KPA-04 Efficiency</b> ; KPA-05 Environment; KPA-06 Flexibility; KPA-09 Predictability	
<b>Operating Environment/Phases of Flight</b>	En-route, TMA	
<b>Applicability Considerations</b>	Applicable to en-route airspace. Benefits can start locally. The larger the size of the concerned airspace the greater the benefits, in particular for flextrack aspects. Benefits accrue to individual flights and flows.  Application will naturally span over a long period as traffic develops. Its features can be introduced starting with the simplest ones.	
<b>Global Concept Component(s)</b>	AOM – Airspace Organisation & Management AUO – Airspace Users Operations DCB – Demand-Capacity Balancing	
<b>Global Plan Initiatives (GPI)</b>	GPI-1 Flexible use of airspace GPI-4 Align upper airspace classifications GPI-7 Dynamic and Flexible Airspace Route Management GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>		
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	✓
	Avionics Availability	✓
	Ground Systems Availability	✓
	Procedures Available	✓
	Operations Approvals	✓

## 4 1. Narrative

### 5 1.1 General

6 In many areas, flight routings offered by air traffic control (ATC) services are static and are slow to keep pace  
7 with the rapid changes of users operational demands, especially for long-haul city-pairs. In certain parts of  
8 the world, legacy regional route structures have become outdated and are becoming constraining factors  
9 due to their inflexibility.

10 The navigational capabilities of modern aircraft make a compelling argument to migrate away from the fixed  
11 route structure towards a more flexible alternative. Constantly changing upper winds have a direct influence  
12 on fuel burn and, proportionately, on the carbon footprint. Therein lies the benefit of daily flexible routings.  
13 Sophisticated flight planning systems in use at airlines now have the capability to predict and validate

14 optimum daily routings. Likewise, ground systems used by ATC have significantly improved their  
15 communication, surveillance and flight data management capabilities.

16 Using what is already available on the aircraft and within ATC ground systems, the move from Fixed to Flex  
17 routes can be accomplished in a progressive, orderly and efficient manner.

### 18 **1.1.1 Baseline**

19 The baseline for this module is varying from a State/region to the next. However, while some aspects have  
20 already been the subject of local improvements, the baseline generally corresponds to a an airspace  
21 organisation and management function which is at least in part characterised by: individual State action,  
22 fixed route network, permanently segregated areas, conventional navigation or limited use of RNAV, rigid  
23 allocation of airspace between civil and military authorities. Where it is the case, the integration of civil and  
24 military ATC has been a way to eliminate some of the issues, but not all.

### 25 **1.1.2 Change brought by the module**

26 This module is aimed at improving the profiles of flights in the en-route phase through the deployment and  
27 full application of procedures and functionalities on which solid experience is already available, but which  
28 have not been always systematically exploited and which are of a nature to make a better use of the  
29 airspace.

30 The module is the opportunity to exploit PBN capabilities in order to eliminate design constraints and operate  
31 more flexibly, while facilitating the overall handling of traffic flows.

32 The module is made of the following elements:

- 33 ▪ Airspace Planning: possibility to plan, coordinate and inform on the use of airspace. This includes CDM  
34 applications for En-Route Airspace to anticipate on the knowledge of the airspace use requests, take into  
35 account preferences and inform on constraints.
- 36 ▪ FUA: flexible use of airspace to allow both the use of airspace otherwise segregated, and the reservation  
37 of suitable volumes for military usage; this includes the definition of conditional routes.
- 38 ▪ Flexible routing (Flex Tracking): route configurations designed for specific traffic pattern.

39 This module is a first step towards more optimised organisation and management of the airspace but which  
40 would require more sophisticated assistance. Initial implementation of PBN, RNAV for example, takes  
41 advantage of existing ground technology and avionics and allows extended collaboration of ANSPs with  
42 partners: military, airspace users, neighbouring States.

## 43 **1.2 Element 1: Airspace Planning**

44 Airspace planning entails activities to organise and manage airspace prior to the time of flight. Here it is more  
45 specifically referred to activities to improve the strategic design by a series of measures to better know the  
46 anticipated use of the airspace and adjust the strategic design by pre-tactical or tactical actions.

## 47 **1.3 Element 2: FUA**

48 Flexible use of airspace is an airspace management concept, according to which airspace should not be  
49 designated as either purely civil or purely military airspace, but should rather be considered as one  
50 continuum in which all users' requirements have to be accommodated to the maximum extent possible.  
51 There are activities which require the reservation of a volume of airspace for their exclusive or specific use  
52 for determined periods, owing to the characteristics of their flight profile or their hazardous attributes and the  
53 need to ensure effective and safe separation from non participating air traffic. Effective and harmonised  
54 application of FUA needs clear and consistent rules for civil-military coordination which should take into  
55 account all users' requirements and the nature of their various activities. Efficient civil-military coordination  
56 procedures should rely on rules and standards to ensure efficient use of airspace by all users. It is essential  
57 to further cooperation between neighbouring States and to take into account cross border operations when  
58 applying the concept of FUA.

59 Where various aviation activities occur in the same airspace but meet different requirements, their  
60 coordination should seek both the safe conduct of flights and the optimum use of available airspace.

61 Accuracy of information on airspace status and on specific air traffic situations and timely distribution of this  
62 information to civil and military controllers has a direct impact on the safety and efficiency of operations.

63 Timely access to up-to-date information on airspace status is essential for all parties wishing to take  
64 advantage of airspace structures made available when filing or re-filing their flight plans.

65 The regular assessment of airspace use is an important way of increasing confidence between civil and  
66 military service providers and users and is an essential tool for improving airspace design and airspace  
67 management.

68 FUA should be governed by the following principles:

69 (a) coordination between civil and military authorities should be organised at the strategic, pre-tactical and  
70 tactical levels of airspace management through the establishment of agreements and procedures in order to  
71 increase safety and airspace capacity, and to improve the efficiency and flexibility of aircraft operations;

72 (b) consistency between airspace management, air traffic flow management and air traffic services should be  
73 established and maintained at the three levels of airspace management in order to ensure, for the benefit of  
74 all users, efficiency in airspace planning, allocation and use;

75 (c) the airspace reservation for exclusive or specific use of categories of users should be of a temporary  
76 nature, applied only during limited periods of time based on actual use and released as soon as the activity  
77 having caused its establishment ceases;

78 (d) States should develop cooperation for the efficient and consistent application of the concept of FUA  
79 across national borders and/or the boundaries of flight information regions, and should in particular address  
80 cross-border activities; this cooperation shall cover all relevant legal, operational and technical issues;

81 (e) air traffic services units and users should make the best use of the available airspace.

## 82 **1.4 Element 3: Flexible Routing**

83 Flexible routing is a design of routes (or tracks) designed to match the traffic pattern and other variable  
84 factors such as weather. The concept, used over the North-Atlantic since decades can be expanded to  
85 address seasonal or week end flows, accommodate special events, and in general better fit the weather  
86 conditions, by offering a set of routes which provide routings closer to the user preferences for the traffic  
87 flows under consideration.

88 When already in place, flex tracks systems can be improved in line with the new capabilities of ATM and  
89 aircraft, such as PBN and ADS.

90 A current application of the element is DARPS, Dynamic Air route Planning System, used in the Pacific  
91 Region with flexible tracks and reduced horizontal separation to 30 NM using RNP 4 and automatic  
92 dependent surveillance (ADS) and controller pilot data link communications (CPDLC).

93 Convective weather causes many delays in today's system due to the labor intensive voice exchanges of  
94 complex reroutes during the flight. New data communications automation will enable significantly faster and  
95 more efficient delivery of reroutes around convective weather. This operational improvement will expedite  
96 clearance delivery resulting in reduced delays and miles flown during convective weather.

## 97 **2. Intended Performance Operational Improvement/Metric to determine success**

98 Metrics to determine the success of the module are proposed at Appendix C.

<i>Access and Equity</i>	Better access to airspace by a reduction of the permanently segregated volumes.
<i>Capacity</i>	The availability of a greater set of routing possibilities allows to reduce potential congestion on trunk routes and at busy crossing points. The flexible use of airspace gives greater possibilities to separate flights horizontally. PBN helps to reduce route spacing and aircraft separations. This in turn allows reducing controller workload by flight.
<i>Efficiency</i>	The different elements concur to 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. The module will reduce the number of flight diversions and cancellations. It will also better allow to avoid noise sensitive areas.

<i>Environment</i>	Fuel burn and emissions will be reduced; however, the area where emissions and contrails will be formed may be larger.
<i>Flexibility</i>	The various tactical functions allow to react rapidly to changing conditions.
<i>Predictability</i>	Improved planning allows stakeholders to anticipate on expected situations and be better prepared.

<i>CBA</i>	The ground costs are significantly lower than the benefits to airspace users.
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99 **2.1 Element 1: Airspace Planning**

100 Airspace planning has a positive impact on all of the above KPAs. It provides with the anticipation to respond  
101 to the strategic and tactical evolution of the demand for access to airspace by all types of airspace users and  
102 to tailor the design of airspace to aircraft operations.

103 **2.2 Element 2: FUA**

104 Developing a strategy based on FUA would enable airline benefits such as the ability to file and fly a  
105 preferred trajectory and decreased fuel consumption and CO2 emissions. Further, FUA would enable full  
106 utilization of existing aircraft and Air Traffic Management (ATM) technologies.

107 As an example, over half of the UAE airspace is military. Currently, civil traffic is concentrated on the  
108 northern portion of the UAE.

109 Opening up this airspace could potentially enable yearly savings in the order of:

- 110 ▪ 4.9 million litres of fuel
- 111 ▪ 581 flight hours.

112 In the U.S. a study for NASA by Datta and Barington showed maximum savings of dynamic use of SUA of  
113 \$7.8M (1995 \$).

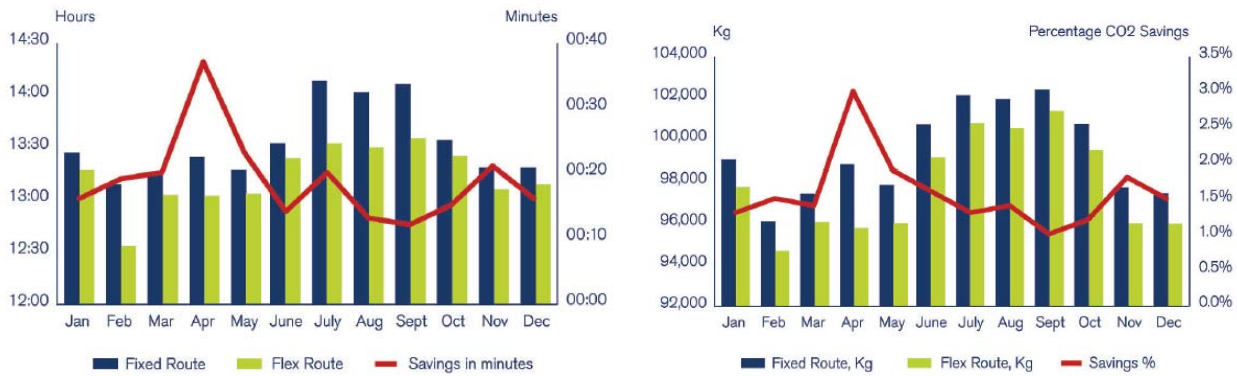
114 **2.3 Element 3: Flexible Routing**

115 Early modelling of flexible routing suggests that airlines operating a 10-hour intercontinental flight can cut  
116 flight time by six minutes, reduce fuel burn by as much as 2% and save 3,000 kilograms of CO2 emissions.  
117 These improvements in efficiency directly help the industry in meeting its environmental targets.

118 Some of the benefits that have accrued from Flex Route programs in sub-region flows include:

- 119 ▪ Reduced flight operating costs (1% to 2% of operating costs on long-haul flights)
- 120 ▪ Reduced fuel consumption (1% to 2% on long-haul flights)
- 121 ▪ More efficient use of airspace (access to airspace outside of fixed airway structure)
- 122 ▪ More dynamic flight planning (airlines able to leverage capability of sophisticated flight planning systems)
- 123 ▪ Reduced carbon footprint (reductions of over 3,000 kg of CO2 on long-haul flights)
- 124 ▪ Reduced controller workload (aircraft spaced over a wider area)
- 125 ▪ Increased passenger and cargo capacity for participating flights (approximately 10 extra passengers on  
126 long-haul flights)

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**Comparison of Flight Time and Fuel Burn using Fixed and Flex Routes using Sao Paulo-Dubai flights throughout the year 2010 (Source: IATA iFLEX Preliminary Benefit Analysis)**

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In the U.S. RTCA NextGen Task Force Report it was found that benefits would be about 20% reduction in operational errors; 5-8% productivity increase (near term; growing to 8-14% later); capacity increases (but not quantified). Annual operator benefit in 2018 of \$39,000 per equipped aircraft (2008 dollars) growing to \$68,000 per aircraft in 2025 based on FAA Initial investment Decision. For the high throughput high capacity benefit case (in 2008 dollars): total operator benefit is \$5.7 B across program lifecycle (2014-2032, based on FAA Initial Investment Decision).

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### 3. Necessary Procedures (Air & Ground)

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Required procedures exist for the main. They may need to be complemented by local practical guidance and processes; however, the experience from other regions can be a useful reference source to be customised to the local conditions.

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The development of new and/or revised ATM procedures is automatically covered by the definition and development of listed elements. However, given the interdependencies between some of the modules, care needs to be taken so that the development of the required ATM procedures provides for a consistent and seamless process across these modules.

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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.

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#### 3.1 Element 1: Airspace Planning

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See general remarks above.

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#### 3.2 Element 2: FUA

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The [ICAO Circular 330](#) AN/189 Civil/Military Cooperation in Air Traffic Management offers guidance and examples of successful practices of Civil and Military Cooperation. It realizes that successful cooperation requires collaboration that is based on communication, education, a shared relationship and trust.

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#### 3.3 Element 3: Flexible Routing

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A number of operational issues and requirements will need to be addressed to enable harmonized deployment of Flex Route operations in a given area such as:

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- Some adaptation of Letters of Agreement;
- Revised procedures to consider the possibility of transfer of control at other than published fixes;
- Use of lat/longs or bearing and distance from published fixes, as sector or FIR boundary crossing points;
- Review of controller manuals and current operating practices to determine what changes to existing practices will need to be developed to accommodate the different flows of traffic which would be introduced in a Flex Route environment;
- Specific communication and navigation requirements for participating aircraft will need to be identified;
- Developing procedures that will assist ATC in applying separation minima between flights on the fixed airway structure and Flex Routes both in the strategic and tactical phases;

- 166     ▪ Procedures to cover the transition between the fixed network and the Flex Route airspace both  
167 horizontally and vertically. In some cases, a limited time application (e.g. during night) of Flex Route  
168 operations could be envisaged. This will require modification of ATM procedures to reflect the night  
169 traffic patterns and to enable the transition between night Flex Route operations and daytime fixed  
170 airway operations;
- 171     ▪ Training package for ATC.

## 172     **4.       Necessary System Capability**

### 173     **4.1     Avionics**

174     Deployment of PBN is ongoing. The benefits provided to flights can facilitate its dissemination, but it will  
175 remain linked to how aircraft can fly.

176     Enhanced flight planning systems (FPS) today are predicated on the determination of the most efficient flight  
177 profile. The calculations of these profiles can be driven by cost, fuel, time, or even a combination of the  
178 factors. All airlines deploy FPS at different levels of sophistication and automation in order to assist flight  
179 dispatchers/planners to verify, calculate and file flight plans.

180     Additionally, the flight dispatcher would need to ensure the applicability of overflight permissions for the  
181 overflown countries. Regardless of the route calculated, due diligence must always be exercised by the  
182 airline in ensuring that NOTAMs and any restrictive flight conditions will always be checked and validated  
183 before a flight plan is filed. Further, most airlines are required to ensure a flight following or monitoring  
184 program to update the crews with any changes in the flight planning assumptions that might have changed  
185 since the first calculation was made.

### 186     **4.2     Ground Systems**

187     Technology is available. Even CDM can be supported by a form of internet portal. However, since aviation  
188 operations are global, standardisation of the information and its presentation will be increasingly required  
189 (see thread 30 on SWIM).

190     Basic FUA concept can be implemented with the existing technology. Nevertheless for a more advanced use  
191 of conditional routes, a robust collaborative decision system will be required.

192     An important capability is, for flexible routing, the capability for the flight planning and the flight data  
193 processing system to support the air traffic controller with the means to understand/visualise the flight paths  
194 and their interactions, as well as to communicate with adjacent controllers.

195     As States and ANSPs evaluate their FDPS to determine what, if any, modifications will be required to  
196 accommodate the implementation of Flex Route operations the following air and ground technology will need  
197 to be assessed:

- 198     ▪ Conflict detection algorithms will need to be evaluated to determine if conflicts between aircraft operating  
199 on the fixed structure and aircraft operating on Flex Routes and conflicts between two aircraft operating  
200 on Flex Routes will be detected.
- 201     ▪ The automatic exchange of flight data, co-ordination and transfer of control procedures and processes  
202 between ACCs will need to be evaluated.
- 203     ▪ In areas where Flex Routes are being introduced for the first time, the FDPS will need to be capable of  
204 recognizing fixes that are not part of the fixed structure such as latitude/longitude and bearing and  
205 distance information.
- 206     ▪ The FDPS will need to be able to recognize and process a direct route.
- 207     ▪ The possibility of transfer of control at other than published fixes and the use of lat/longs or bearing and  
208 distance from published fixes, as sector or FIR boundary crossing points will need to be considered.
- 209     ▪ States and ANSPs will need to determine what elements of the flight plan will need to be extracted by  
210 the FDPS to support the implementation of Flex Routes.
- 211     ▪ Flight progress strips produced by the FDPS must be capable of extrapolating Flex Route information  
212 and producing flight progress strips that support the ATC Flex Route operations.
- 213     ▪ FDPS will need to be capable of facilitating re-routings within Flex Route airspace

- 214   ▪ Some States and ANSPs may want to consider having a different type of target symbol displayed on the  
215   situation display to indicate a flight is operating on a Flex Route.

## 216   **5.     Human Performance**

### 217   **5.1    Human Factors Considerations**

218   The roles and responsibilities of controller/pilot are not affected

### 219   **5.2    Training and Qualification Requirements**

220   The required training is available and the change step is achievable from a human factors perspective.

### 221   **5.3    Others**

222   Nil

## 223   **6.     Regulatory/standardisation needs and Approval Plan (Air & Ground)**

224   ICAO material is available.

225   Regions should consider the possible mandating of PBN as a means to accelerate the end of the transition  
226   and as a result to eliminate the need to provide for different levels of equipage capability.

### 227   **6.1    Element 1: Airspace Planning**

228   See general remarks above.

### 229   **6.2    Element 2: FUA**

230   Until today, the Chicago Convention in its Article 3 expressly excludes the consideration of State aircraft from  
231   the scope of applicability.

232   Exemption policies for specific State aircraft operations and services are currently used as a method to cope  
233   with the discrepancy of civil and military aviation needs. Some States already realise that for State aircraft a  
234   solution lays in an optimum compatibility to civil aviation, although military requirements have to be met.

235   ICAO provisions related to coordination between civil and military in support to the Flexible Use of Airspace  
236   can be found in several Annexes, PANS and Manuals.

237   Annex 11 — Air Traffic Services allows States to delegate responsibility for the provision of ATS to another  
238   State. However, States retain sovereignty over the airspace so delegated, as confirmed by their adherence  
239   to the Chicago Convention. This factor may require additional effort or coordination in relation to civil/military  
240   cooperation and an appropriate consideration in bilateral or multilateral agreements.

### 241   **6.3    Element 3: Flexible Routing**

242   LoA/LoCs: Letters of agreement (LoA) and/or letters of coordination (LoC) might be required to reflect the  
243   specificities of Flex Route operations. Local hand-off procedures, timings and frequency allocations must be  
244   clearly detailed. Allocation schemes are also useful in designing major unidirectional flows, such as the EUR-  
245   Caribbean flows.

### 246   **6.4    Common Enabler: PBN Procedures**

247   Within an airspace concept, PBN requirements will be affected by the communication, surveillance and ATM  
248   environments, the navaid infrastructure, and the functional and operational capabilities needed to meet the  
249   ATM application. PBN performance requirements also depend on what reversionary, non-RNAV means of  
250   navigation are available and what degree of redundancy is required to ensure adequate continuity of  
251   functions.

252   The selection of the PBN specification(s) for a specific area or type of operation has to be decided in  
253   consultation with the airspace users. Some areas need only a simple RNAV to maximize the benefits, while  
254   other areas such as nearby steep terrain or dense air traffic may require the most stringent RNP. Since RNP  
255   AR Approaches require significant investment and training, ANSPs should work closely with airlines to  
256   determine where RNP AR Approach should be implemented.

257 International public standards for PBN and RNP are still evolving. International PBN/RNP is not widespread.  
258 According to the ICAO/IATA Global PBN Task Force, International Air Traffic Management (ATM) and State  
259 flight standards rules and regulations lag behind airborne capability.

260 There is a need for worldwide harmonization of RNP requirements, standards, procedures and practices,  
261 and common Flight Management System functionality for predictable and repeatable RNP procedures, such  
262 as fixed radius transitions, radius-to-fix legs, Required Time of Arrival (RTA), parallel offset, vertical  
263 containment, 4D control, ADS-B, data link, etc.

264 A Safety Risk Management Document (SRMD) may be required for every new or amended procedure. That  
265 requirement will extend the time required to implement new procedures, especially PBN-based flight  
266 procedures.

## 267 **7. Implementation and Demonstration Activities**

### 268 **7.1 Current Use**

269 Most of the proposed elements have already been implemented in at least a region.

270 In particular, one will note the following realisations which can be taken as examples of how to achieve the  
271 module.

#### 272 **7.1.1 Element 1: Airspace Planning**

- 273 ▪ **Europe:** Airspace planning is implemented in European States with Airspace Management cells, and at  
274 European scale through the Network Operations Plan (NOP) which provide advanced notice on the (de)-  
275 activation of segregated airspace and conditional routes.

#### 276 LARA

277 LARA (Local and Sub-Regional Airspace Management Support System) is an initiative aimed at  
278 improving performance based Airspace Management (ASM).

279 LARA provides a software application to support ASM. It is focused on automation at local and  
280 regional levels for civil-military and military-military coordination. It is intended to provide a more  
281 efficient and transparent decision-making process between civil and military stakeholders for ATM  
282 performance enhancement. It will also provide information for civil-military coordination at network  
283 level to support the MILO function (Military Liaison - MILO - function at CFMU). The LARA  
284 application will support the following:

285 - airspace planning: to manage airspace bookings; to incorporate Air Traffic Flow and Capacity  
286 Management (ATFCM) data into the airspace planning process; to facilitate the analysis and creation  
287 of a national/regional Airspace Plan; to assess network scenario proposals and to facilitate  
288 coordination for decision-making on a national level.

289 - airspace status: to provide real-time, airspace common situation awareness.

290 - statistics: in collating airspace data and measuring airspace utilisation through meaningful civil-  
291 military KPIs, LARA will archive the data for further analysis.

292 A demonstrator was developed and successfully tested in January 2008. In 2009 LARA first  
293 prototype and various incremental versions based on it were delivered. Support to a FABEC trial has  
294 been initiated.

#### 295 **7.1.2 Element 2: FUA**

296 FUA has been implemented in Europe in the 90s and regularly improved on an as-needed basis. It leans on  
297 the airspace planning features described above, and coordination mechanisms to address the tactical  
298 coordination actions.

299 CDM is implemented in the US NASCSC.

#### 300 **7.1.3 Element 3: Flexible Routing**

- 301 ▪ **North-Atlantic:** Implemented with two daily sets of Organised Track Systems

- 302 ▪ **Japan:** Coordination of Airspace Use: In the coordination of rerouting for avoidance of airspace capacity  
303 saturation or adverse weather conditions, ATMC and Airline Operators share and use "Rerouting List" of



304 the flight routes between city pairs, which has been established and updated after making the necessary  
 305 coordination with Airline Operators and ATC facilities. Using the Rerouting list makes coordination simple  
 306 and the coordination is effective to decrease the demand of the congesting airspace and to identify the  
 307 variation of air traffic flow. The major Airline Operators are able to coordinate by ATM Workstations.  
 308 ATMC coordinates usage of the areas for IFRs with the Military Liaison Officers, and then IFRs are able  
 309 to fly through the areas under following ATC instructions. Also taking into account requirement which  
 310 IFRs enter the area for avoiding adverse weather, ATMC is able to coordinate with Military Liaison  
 311 Officers for using Military Training/Testing Areas temporarily.

312 ▪ **IATA:** IATA in conjunction with Emirates Airlines and Delta Airlines proposes to conduct a proof of  
 313 concept of Flex Route capability on the Dubai – Sao Paulo and Atlanta – Johannesburg city-pairs  
 314 respectively. The goal of the proof of concept trial is to gather performance data, measure tangible  
 315 results and identify areas where mitigation may be required to address operational, procedural, and  
 316 technical issues. Dependent on the results of the proof of concept trial, an operational trial with broader  
 317 participation may be initiated in the future. This will allow airlines and ANSPs to take advantage of past  
 318 experience and provide valuable guidance on what can be achieved, as they seek to implement Flexible  
 319 Routing.

320 ▪ **US:**

321 FAA published a number of PBN procedures to deliver more direct routes, saving time and fuel and  
 322 reducing emissions. Specifically, the FAA published 50 required RNP authorization required and  
 323 published 12 RNAV routes.

324 Alaska Airlines is saving more than 217 flight miles per day and nearly 200,000 gallons of fuel per year  
 325 by using parallel flight routes, or Q routes, between Seattle, Portland and Vancouver on one end, and  
 326 airports in the San Francisco Bay and Los Angeles basin areas on the other. The initial parallel routes  
 327 were developed in 2004 in partnership with the FAA.

328 ▪ **Oceanic areas:**

329 Pacific Region: DARPS, Dynamic Air route Planning System, used with flexible tracks and reduced  
 330 horizontal separation to 30 NM using RNP 4 and automatic dependent surveillance (ADS) and  
 331 controller pilot data link communications (CPDLC).

## 332 **7.2 Planned or Ongoing Activities**

333 ▪ **ASPIRE**

334 Using ATOP conflict probe capabilities and improved communications techniques with the operators, a  
 335 limited number of oceanic trajectory optimization demonstration flights were performed in 2008 in  
 336 partnership with Air Europa. These demonstrations resulted in fuel savings of 0.5 percent-1 percent,  
 337 validating the concept. During 2009, the additional partners participated in 119 oceanic optimization  
 338 flights over the Atlantic. According to initial data analysis, the estimated fuel savings from reroutings on  
 339 these flights averaged 1.4 percent, equivalent to about 230 gallons of fuel and more than 2 tons of  
 340 carbon dioxide reductions per flight.

341 The 2008-09 demonstrations were limited to westbound routes and lateral rerouting. In 2010, the lateral  
 342 reroute procedures tests continued, and the FAA initiated investigations on the benefits of vertical  
 343 rerouting and eastbound routes. In addition, Automatic Dependent Surveillance-Contract climb and  
 344 descent procedures were conducted in an operational trial over the Pacific Ocean to examine a  
 345 reduction in oceanic separation from 30 miles to 15 miles, in an effort to better accommodate more  
 346 efficient and user-preferred routes.

347 The ASPIRE initiative was launched in 2008 by the United States, Australia and New Zealand. Japan  
 348 joined it in October 2009 and Singapore in January 2010. United Airlines, Qantas and Air New Zealand  
 349 flew the original demonstrations. Japan Airlines' first demonstration flight, a Boeing 747 operating from  
 350 Honolulu to Osaka, explored NextGen concepts such as user-preferred route and dynamic airborne  
 351 rerouting capabilities, plus a number of weight- and energy-saving techniques. In gate-to-gate  
 352 demonstrations of emissions reduction on transpacific routes, the average fuel saving during en route  
 353 operations was 2.5 percent.

354 In its annual report for 2009, issued before Japan joined, ASPIRE estimated that if all 156 transpacific  
 355 flights per week between Australia, New Zealand, the United States and Canada operated under  
 356 conditions adopted for its demonstrations, airlines would save more than 10 million gallons of fuel and  
 357 avoid more than 100,000 tons of carbon emissions per year. Air New Zealand in October 2009 cited

358 ASPIRE as a significant contributor to a fuel saving of 10 percent and a reduction of more than 385,000  
359 tons of carbon emissions in its 2009 financial year compared with the previous year.

360 ▪ DARP: Dynamic Airborne Reroute Procedure (DARP)

361 Flights take advantage of the six hourly update of the upper air wind and temperature forecast to  
362 effectively re-plan the flight en-route through a procedure called a DARP. This process can be completed  
363 as forecasts become available. Use of DARP commences with an aircraft data link request for a DARP  
364 to the Air New Zealand Flight Dispatch Office in Auckland. Immediately the latest wind/temperature  
365 forecast becomes available, the Flight Dispatch Officer recalculates the optimum track from a  
366 predetermined point just ahead of the current aircraft airborne position. Once calculated the revised  
367 route is uplinked to the aircraft for the crew to consider. The crew then downlink a request for the revised  
368 route to the Oceanic Control Centre and once approved, accept the revised route into the active side of  
369 the Flight Management Computer (FMC). Savings vary greatly from day to day dependent on the  
370 accuracy of the original forecast, the average AKL-SFO flight would save 70 US Gallons.

## 371 **8. Reference Documents**

### 372 **8.1 Standards**

373 ▪ PANS-ATM (Doc 4444), Procedures for Air Navigation Services — Air Traffic Management Chapter 5

### 374 **8.2 Procedures**

375 Nil

### 376 **8.3 Guidance Material**

377 ▪ [Doc 9426](#), Air Traffic Services Planning Manual

378 ▪ [Doc 9689](#), Manual on Airspace Planning Methodology for the Determination of Separation Minima

379 ▪ [Doc 9613](#), Performance-based Navigation (PBN) Manual

380 ▪ [Doc 9554](#), Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to  
381 Civil Aircraft Operations

382 ▪ [Doc 9750](#), Global Air Navigation Plan

383 ▪ [Doc 9854](#), Global Air Traffic Management Operational Concept

384 ▪ ICAO Global Collaborative Decision Making (CDM) Guidelines (under development)

385 ▪ [ICAO Circular 330](#) AN/189 Civil/Military Cooperation in Air Traffic Management

# 1 Module N° B0-35: Improved Flow Performance through 2 Planning based on a Network-Wide view

3

<b>Summary</b>	Collaborative ATFM measures 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.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity; <b>KPA-02 Capacity</b> ; KPA-04 Efficiency; KPA-05 Environment; KPA-09 Predictability	
<b>Operating Environment/Phases of Flight</b>	Pre-flight phases, some action during actual flight.	
<b>Applicability Considerations</b>	Region or sub-region	
<b>Global Concept Component(s)</b>	DCB – Demand-Capacity Balancing TS – Traffic Synchronisation AOM – Airspace Organisation and Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-1 Flexible use of airspace GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>		
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>2013</b>
	Avionics Availability	<b>NA</b>
	Ground Systems Availability	✓
	Procedures Available	<b>2013</b>
	Operations Approvals	<b>2013</b>

## 4 1. Narrative

### 5 1.1 General

6 The techniques and procedures brought by this module capture the experience and state-of-the-art of the  
7 current ATFM systems in place in some regions, and which have developed as they were facing demand-  
8 capacity imbalances. Global ATFM Seminars and bi-lateral contacts have allowed to disseminate good  
9 practices.

10 Experience clearly shows the benefits related to managing flows consistently and collaboratively over an  
11 area of a sufficient geographical size to take into account sufficiently well the network effects. The ICAO  
12 concept of a CTMO concept for ATFM/DCB should be further exploited wherever possible. System  
13 improvements are also about better procedures in these domains, and creating instruments to allow  
14 collaboration among the different actors.

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

18 Strategic ATFCM activity takes place during the period from several months until a few days before a flight.  
19 During this phase, comparison is made between the expected air traffic demand and the potential ATC

20 capacity. Objectives are set for each ATC unit in order for them to provide the required capacity. These  
21 objectives are monthly reviewed in order to minimise the impact of the missing capacity on the airspace  
22 users. In parallel, an assessment of the number and routings of flights, which aircraft operators are planning,  
23 enables ATFM to prepare a routing scheme, balancing the air traffic flows in order to ensure maximum use of  
24 the airspace and minimise delays.

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

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

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

### 38 **1.1.1 Baseline**

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

### 44 **1.1.2 Change brought by the module**

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

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

- 53 ▪ Departure slots ensuring that a flight will be able to pass the sectors along its path without generating  
54 overflows;
- 55 ▪ Rate of entry into a given piece of airspace for traffic along a certain axis;
- 56 ▪ Requested time at a way-point or an FIR/sector boundary along the flight;
- 57 ▪ Miles-in-trail figures to smooth flows along a certain traffic axis;
- 58 ▪ Re-routing of traffic to avoid saturated areas;
- 59 ▪ sequencing of flights on the ground by applying departure time intervals (MDI);
- 60 ▪ level capping;
- 61 ▪ delaying of specific flights on the ground by a few minutes ("Take Off Not Before").

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

66

67

68 **2. Intended Performance Operational Improvement/Metric to determine success**

69 Metrics to determine the success of the module are proposed at Appendix C.

<i>Access and Equity</i>	Improved access by avoiding disruption of air traffic in periods of demand higher than capacity; ATFM processes take care of equitable distribution of delays.
<i>Capacity</i>	Better utilisation of available capacity, network-wide; in particular the trust of ATC not being faced by surprise to saturation tends to let it declare/use increased capacity levels; ability to anticipate difficult situations and mitigate them in advance.
<i>Efficiency</i>	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.
<i>Environment</i>	Reduced fuel burn as delays are absorbed on the ground, with shut engines; rerouting however generally put flight on a longer distance, but this is generally compensated by other airline operational benefits.
<i>Participation by the ATM community</i>	Common understanding of operational constraints, capabilities and needs.
<i>Predictability</i>	Increased predictability of schedules as the ATFM algorithms tends to limit the number of large delays.
<i>Safety</i>	Reduced occurrences of undesired sector overloads.

<i>CBA</i>	The business case has proven to be positive due to the benefits that flights can obtain in terms of delay reduction.
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70

71 **3. Necessary Procedures (Air & Ground)**

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

74 New procedures are required to link much closer the ATFM with ATS in the case of using miles-in-trail.

75 **4. Necessary System Capability**

76 **4.1 Avionics**

77 No avionics requirements.

78 **4.2 Ground Systems**

79 When serving several FIRs, ATFM systems are generally deployed as a specific unit, system and software  
80 connected to the ATC units and airspace users to which it provides its services. Regional ATFM units have  
81 been the subject of specific developments.

82 Some vendors propose light ATFM systems.

83 **5. Human Performance**

84 **5.1 Human Factors Considerations**

85 Controllers are protected from overloads and have a better prediction of their workload. ATFM does not  
86 interfere in real-time with their ATC tasks.

87

88 **5.2 Training and Qualification Requirements**

89 Flow managers in the flow management unit and controllers in ACCs using the remote flow management  
90 information or applications needs specific training.

91 Airline dispatchers using the remote flow management information or applications need training.

92 Training material is available.

93 **5.3 Others**

94 Nil

95 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

98 **7. Implementation and Demonstration Activities**

99 **7.1 Current Use**

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

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

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

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

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

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

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

132 **▪ US: Detailed Example – National Playbook (USA)**

133 Originating from a collaborative workgroup recommendation to enhance common situational awareness,  
134 the National Playbook is comprised of pre-validated routes for a variety of weather scenarios. It provides  
135 common, collaboratively developed options (routes) for stakeholders to standardize reroutes around  
136 severe weather conditions. Each option, identified by a specific name is comprised of multiple individual

137 routes addressing different geographical areas. Each named "Play" in the playbook varies in length,  
 138 complexity and options within it based on the weather scenario it is designed to address. Development,  
 139 revision, and use of each "play" results from collaboration across the operators and ANSP elements  
 140 (individual facilities impacted). The routes are available on a designated web site and are updated every  
 141 56 days, concurrent with the chart cycle.

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

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

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

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

176 ▪ **India:** Central ATFM is being implemented in two phases in INDIA. In Phase 1, ATFM will be  
 177 implemented within Indian Airspace initially at six major airports by 2012 and extending to all airports  
 178 within Indian airspace by 2013. In phase 2 an integrated Regional ATFM extending to adjacent countries  
 179 airspace is envisaged. APANPIRG/22 has endorsed India's proposal to implement C-ATFM in a phased  
 180 manner.

## 181 **7.2 Planned or Ongoing Activities**

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

- 184 - Enhanced Flight Plan Filing Facilitation
- 185 - Use of Free Routing for flight in special Airspace volumes
- 186 - Shared Flight Intentions
- 187 - Use of Aircraft Derived Data to enhance ATM ground system performance
- 188 - Automated Support for Traffic Load Management and for Traffic Complexity Assessment
- 189 - Network Performance Assessment
- 190 - Moving Airspace Management into day of operation
- 191 - Enhanced Real-time Civil-Military Coordination of Airspace Utilisation
- 192 - Flexible Sectorisation management; Modular Sectorisation adapted to Variations in traffic flow

- 193 - Enhanced ASM/ATFCM coordination Process
- 194 - Short Term ATFCM Measures
- 195 - Interactive Network Capacity Planning
- 196 - SWIM enabled NOP
- 197 - Management of Critical Events
- 198 - Collaborative Management of Flight updates
- 199 - ATFM Slot Swapping
- 200 - Manual User Driven Prioritisation Process

201 **8. Reference Documents**

202 **8.1 Standards**

203 TBD

204 **8.2 Procedures**

205 TBD

206 **8.3 Guidance Material**

- 207 ▪ ICAO Global Collaborative Decision Making (CDM) Guidelines (under development)



# 1 Module N° B0-85: Air Traffic Situational Awareness (ATSA)

2

<b>Summary</b>	This module comprises two <i>ATSA (Air Traffic Situational Awareness)</i> applications which will enhance safety and efficiency by providing pilots with the means to achieve quicker visual acquisition of targets: <ul style="list-style-type: none"> <li>• <i>AIRB (Enhanced Traffic Situational Awareness during Flight Operations)</i></li> <li>• <i>VSA (Enhanced Visual Separation on Approach)</i>.</li> </ul>	
<b>Main Performance Impact</b>	KPA-04 – Efficiency; KPA-09 – Safety	
<b>Operating Environment/Phases of Flight</b>	En-route, Terminal and Approach.	
<b>Applicability Considerations</b>	These are cockpit based applications which do not require any support from the ground hence they can be used by any suitably equipped aircraft. This is dependent upon aircraft being equipped with ADS-B out.  Avionics availability at low enough costs for GA is not yet available.	
<b>Global Concept Component(s)</b>	CM – Conflict Management; TS – Traffic Synchronisation	
<b>Global Plan Initiatives (GPI)</b>	GPI-9 Situational Awareness; GPI-15 Match IMC and VMC operating capacity.	
<b>Pre-Requisites</b>	<b>Status</b> (ready now or estimated date).	
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	N/A
	Procedures Available	√
	Operations Approvals	Est. AIRB 2011 / VSA 2012

## 3 1. Narrative

### 4 1.1 General

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

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

12  
13 Approaches flown where flight crews maintain own separation from the preceding aircraft may increase  
14 landing capacity and/or increase the number of movements achievable at many airports compared to rates  
15 obtained when ATC separation is applied. Through the use of an airborne traffic display, the “Enhanced  
16 Visual Separation on Approach” application (ATSA-VSA) will enhance this type of operation by providing  
17 improved and reliable visual acquisition of preceding aircraft and by extending the use of own separation  
18 clearances on approach.

#### 19 1.1.1 Baseline

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

21 **1.1.2 Change brought by the module**

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

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

31 the display during the instrument scan to supplement their visual scan. The display enables detection of  
32 traffic by the flight crew and aids in making positive identification of traffic advised by ATC. The information  
33 provided on the display also reduces the need for repeated air traffic advisories and is expected to increase  
34 operational efficiencies.

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

49  
50 Voice communications associated with traffic information are expected to be reduced. Safety of operations  
51 improvement is expected as it is anticipated that this procedure will decrease the likelihood of wake  
52 turbulence encounters. Some efficiency benefits are also expected to be derived when the preceding and  
53 succeeding aircraft are approaching the same runway because of a reduction in the number of missed  
54 approaches.  
55

56 **1.1.3 Other remarks**

57 **1.2 Element 1: ATSA-AIRB**

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

60  
61 ATSA-AIRB application can be used in all types of airspaces, from class A to class G. The use of this  
62 application is independent of the type of ATC surveillance (if any) and of the type of air traffic services  
63 provided in the airspace in which the flight is conducted.

64 **1.3 Element 2: ATSA-VSA**

65 The application is mainly intended for air transport aircraft but it can be used by all suitably equipped aircraft  
66 during approach to any airports where own separation is used.  
67  
68  
69  
70

71 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Efficiency</i>	
<i>Safety</i>	

72

<i>CBA</i>	<p>The benefit is largely driven by higher flight efficiency and consequent savings in contingency fuel.</p> <p>The benefit analysis of the EUROCONTROL CRISTAL ITP project of the CASCADE Programme and subsequent update had shown that ATSAW AIRB and ITP together are capable of providing the following benefits over N. Atlantic</p> <ul style="list-style-type: none"> <li>- saving 36 million Euro (50k Euro per aircraft) annually and</li> <li>- reducing carbon dioxide emissions by 160,000 tonnes annually.</li> </ul> <p>The majority of these benefits are attributed to AIRB. Findings will be refined after the completion of the pioneer operations starting in December 2011.</p>
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73 **3. Necessary Procedures (Air & Ground)**74 **4. Necessary System Capability**75 **4.1 Avionics**

76 ADS-B OUT is needed on the majority of the aircraft population. There is a potential need to certify ADS-B  
77 OUT data.

78 **4.2 Ground Systems**

79 In some environments (e.g. USA) there is a need for ground infrastructure to deliver ADSB-R and TIS-B.  
80

81 **5. Human Performance**82 **5.1 Human Factors Considerations**

83 TBD

84 **5.2 Training and Qualification Requirements**

85 TBD

86 **5.3 Others**

87 TBD

88

89 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

90 The ASA MOPS DO-317A / ED-194 will be published by end 2011.  
91

92 **7. Implementation and Demonstration Activities**

93 **7.1 Current Use**

94 EUROPE – This application will be used operationally from Dec 2011 (by Swiss International Airlines) in the  
95 context of the ATSAW Pioneer project of the EUROCONTROL CASCADE Programme. The other pioneer  
96 airlines (Delta, US Airways, Virgin Atlantic, British Airways) will follow.

97 **7.2 6.2 Planned or Ongoing Activities**

98 EUROPE – Pioneer projects to be progressed.

99 **8. Reference Documents**

100 **8.1 Standards**

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

103 RTCA Document DO-314/EUROCAE Document ED-160, Safety, Performance and Interoperability  
104 Requirements Document for Enhanced Visual Separation on Approach (ATSA-VSA)

105 **8.2 Procedures**

106 **8.3 Guidance Material**

107 EUROCONTROL Documents – Flight Crew Guidance on Enhanced Traffic Situational Awareness during  
108 Flight Operations; Flight Crew Guidance on Enhanced Visual Separation on Approach; ATSAW Deployment  
109 Plan.

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# 1 Module N° B0-86: Improved Access to Optimum Flight Levels 2 through Climb/Descent Procedures using ADS-B 3

<b>Summary</b>	The aim of this module is to prevent flights to be trapped at an unsatisfactory altitude for a prolonged period of time. The In Trail Procedure (ITP) uses ADS-B based separation minima to enable an aircraft to climb or descend through the altitude of other aircraft when the requirements for procedural separation cannot be met.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA -04 Efficiency and KPA-05 Environment.	
<b>Operating Environment/Phases of Flight</b>	En-Route	
<b>Applicability Considerations</b>	Oceanic and potentially continental en-route	
<b>Global Concept Component(s)</b>	CM, AUO, AOM	
<b>Global Plan Initiatives (GPI)</b>	GPI-9, GPI-7	
<b>Pre-Requisites</b>	NIL	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	√
	Avionics Availability	√
	Infrastructure Availability	√
	Ground Automation Availability	√
	Procedures Available	√
Operations Approvals	√	

## 4 1. Narrative

### 5 1.1 General

6 The use of ITP facilitates en-route climb or descent to enable better use of optimal flight levels in  
7 environments where a lack of ATC surveillance and/or the large separation minima currently implemented  
8 was a limiting factor. The In Trail Procedure (ITP) is designed to enable an aircraft to climb or descend  
9 through the altitude of other aircraft when the requirements for procedural separation would not be met. The  
10 system benefit of ITP is significant fuel savings and the uplift of greater payloads through the reduction in  
11 contingency fuel carriage requirements. This will be the first airborne surveillance application to generate  
12 operational benefits through the reduction in separation standards.

13 The ability of an aircraft to climb through the altitude of another aircraft when normal separation procedures  
14 would not allow this prevents an aircraft being trapped at an unsatisfactory altitude and thus incurring non-  
15 optimal fuel burn for prolonged periods. This immediately results in reduced fuel-burn and emissions. Once  
16 the procedure has been field proven, it will also allow for a reduction in the contingency fuel carriage  
17 requirement, which in turn will result in reduced fuel-burn and emissions. ITP also provides safety benefits by  
18 providing a tool to manage contingency scenarios such as emergency descent; climbing out of turbulence  
19 and avoiding weather.

#### 20 1.1.1 Baseline

21 ITP using ADS-B is in operational use and hence can be considered to be a baseline.  
22

23 **1.1.2 Change brought by the module**

24 ITP reduces fuel-burn and emissions by allowing aircraft to overcome altitude constraints due to aircraft  
25 flying at higher or lower altitudes and fly at the most efficient altitude. ITP also provides safety benefits by  
26 providing a tool to manage contingency scenarios such as climbing out of turbulence and potentially avoiding  
27 weather.

28 **1.1.3 Other remarks**

29 ITP using ADS-B will require both aircraft to have ADS-B OUT capability, while the manoeuvring aircraft will  
30 require ADS-B IN.

31 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	improvement in capacity on a given air route
<i>Efficiency</i>	increased efficiency on oceanic and potentially continental en-route.
<i>Environment</i>	reduced emissions

32

<i>CBA</i>	
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33 **3. Necessary Procedures (Air & Ground)**

34 Procedures for ITP using ADS-B have been developed and a PANS-ATM Amendment is in progress.  
35 Additional information will be available in an ICAO circular – “Safety Assessment for the development of  
36 Separation Minima and Procedures for In-Trail Procedure (ITP) using Automatic Dependant Surveillance –  
37 Broadcast (ADS-B) Version 1.5.3”

38 **4. Necessary System Capability**

39 **4.1 Avionics**

40 The aircraft performing the in-train procedure will require an ADS-B IN capability compliant with DO-312/ED-  
41 159. The other aircraft involved in the procedure will require an ADS-B OUT capability compliant with DP-  
42 312-/ED-159. CPDLC by FANS 1A will also be required.

43 **4.2 Ground Systems**

44 NIL

45 **5. Human Performance**

46 **5.1 Human Factors Considerations**

47 TBD

48 **5.2 Training and Qualification Requirements**

49 TBD

50 **5.3 Others**

51 TBD

52

53 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

54 For ITP using ADS-B, the following documents apply:

- 55 a. AC 20-172
- 56 b. TSO C195
- 57 c. FAA Memo; Interim Policy and Guidance Automatic Dependent Surveillance Broadcast  
58 (ADS-B) Aircraft Surveillance Systems Supporting Oceanic In-Trail Procedures (ITP). Dated:  
59 May 10, 2010.
- 60 d. DO-312/ED-159
- 61 e. ASA MOPS DO-317A/ED-194

## 62 7. Implementation and Demonstration Activities

### 63 7.1 *Current Use*

64 The EUROPEAN (ISAVIA, NATS, EUROCONTROL, AIRBUS, SAS) CRISTAL ITP trial validated the  
65 concepts for ITP.

66 ITP is a part of trials to be undertaken under the ASPIRE programme. ASPIRE is a joint programme between  
67 AirServices Australia, the Airways Corporation of New Zealand, CAA of Singapore and the Japan Civil  
68 Aviation Bureau.

### 69 7.2 *Planned or Ongoing Activities*

70 ITP is operational in one Oceanic Region. In the context of the ATSAW Pioneer project of the  
71 EUROCONTROL CASCADE Programme Swiss, Delta, US Airways, Virgin Atlantic and British Airways will  
72 perform ITP related trials from December 2011 over N. Atlantic, expected to transition to operations subject  
73 to aircrafts be equipped with ADS-B in.

74

## 75 8. Reference Documents

### 76 8.1 *Standards*

- 77 • EUROCONTROL ATSAW Deployment Plan(Draft)
- 78 • [RTCA DO-312](#): "Safety, Performance and Interoperability Requirements Document for the In-Trail  
79 Procedure in Oceanic Airspace (ATSA-ITP) Application".
- 80 • [EUROCAE ED-159](#): "Safety, Performance and Interoperability Requirements Document for ATSA-  
81 ITP Application"

### 82 8.2 *Procedures*

### 83 8.3 *Guidance Material*

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# 1 Module N° B0-101: ACAS Improvements

2

<b>Summary</b>	Implementation of ACAS with the logic Version 7.1 and with enhanced optional features such as altitude capture laws reducing nuisance alerts, linking to the autopilot for automatic following of resolution advisories.	
<b>Main Performance Impact</b>	KPA-04 Efficiency, <b>KPA-10 Safety</b>	
<b>Domain / Flight Phases</b>	En-route flight phases and approach flight phases.	
<b>Applicability Considerations</b>	Safety and operational benefits increase with the proportion of equipped aircraft.	
<b>Global Concept Component(s)</b>	CM – Conflict Management.	
<b>Global Plan Initiatives (GPI)</b>	GPI-2 reduced vertical separation minima GPI-9 situational awareness GPI-16 Decision support systems and alerting systems	
<b>Pre-Requisites</b>	No	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	√
	Avionics Availability	√
	Ground Systems Availability	N/A
	Procedures Available	√
	Operations Approvals	√

## 3 1. Narrative

### 4 1.1 General

5 This module is dealing with the short term improvements to the performance of the existing airborne collision  
6 avoidance system – ACAS. ACAS is the last resort safety net for pilots. Although ACAS is independent from  
7 the means of separation provision, ACAS is part of the ATM system.

#### 8 1.1.1 Baseline

9 ACAS is subject to global mandatory carriage for aeroplanes with a MTCM greater than 5.7 tons. The current  
10 version of ACASII is 7.0.

#### 11 1.1.2 Change brought by the module

12 This module implements several optional improvements to airborne collision avoidance system in order to  
13 minimize “nuisance alerts” while maintaining existing levels of safety.

### 14 1.2 Element: Improved ACAS operations

15 The TCAS version 7.1 introduces significant safety and operational benefits for ACAS operations.

16 Safety studies indicate that ACAS II reduces risk of mid-air collisions by 75 – 95% in encounters with aircraft  
17 that are equipped with either a transponder (only) or ACAS II respectively. ACAS II SARPS are aligned with  
18 RTCA/EUROCAE MOPS. The SARPS and the MOPS have been upgraded in 2009/2010 to resolve safety  
19 issues and to improve operational performance. The RTCA DO185B and EUROCAE ED143 include these  
20 improvements also known as TCAS V7.1.

21 The TCAS v7.1 introduces new features namely the monitoring of own aircraft’s vertical rate during a  
22 Resolution Advisory (RA) and a change in the RA annunciation from “Adjust Vertical Speed, Adjust” to “Level

23 Off". It was confirmed that the new version of the CAS logic would definitely bring significant safety benefits,  
24 though only if the majority of aircraft in any given airspace are properly equipped. ICAO agreed to mandate  
25 the improved ACAS (TCAS version 7.1) for new installations as of 1/1/2014 and for all installations no later  
26 than 1/1/2017.

27 During a TCAS encounter, prompt and correct response to RAs is the key to achieve maximum safety  
28 benefits. Operational monitoring shows that pilots do not always follow their RA accurately (or even do not  
29 follow at all). Roughly 20% of RAs in Europe are not followed.

30 TCAS safety & operational performance highly depends on the airspace in which it operates. Operational  
31 monitoring of TCAS shows that unnecessary RAs can occur when aircraft approach their cleared flight level  
32 separated by 1000 ft with a high vertical rate. Roughly 50% of all RAs in Europe are issued in 1000 ft level-  
33 off geometries. ANConf.11 recognized the issue and requested to investigate automatic means to improve  
34 ATM compatibility.

35 In addition, two optional features can enhance ACAS performance:

- 36 1) Coupling TCAS and Auto-Pilot/Flight Director to ensure accurate responses to RAs either  
37 automatically or manually thanks to flight director (APFD function)
- 38 2) Introducing a new altitude capture law to improve TCAS compatibility with ATM (TCAP function)

## 39 2. Intended Performance Operational Improvement/Metric to determine success

40 Metrics to determine the success of the module are proposed at Appendix C.

<i>Efficiency</i>	ACAS improvement will reduce unnecessary RA and then reduce trajectory perturbation
<i>Safety</i>	ACAS increase safety, as collision avoidance system and case of failure of the separation provision.

<i>CBA</i>	TBD
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## 41 3. Necessary Procedures (Air & Ground)

42 ACAS procedures are defined in PANS-ATM (Doc 4444) and in PANS-OPS (Doc 8168)

## 43 4. Necessary System Capability

### 44 4.1 Avionics

45 RTCA DO185B / EUROCAE DO143 MOPS are available for TCAS implementation.

46 RTCA DO325 Annex C is being modified to accommodate the 2 functions (APFD and TCAP). It should be  
47 ready by Q1 2013.

### 48 4.2 Ground Systems

49 Not Applicable

## 50 5. Human Performance

51 As explained earlier, ACAS performance is influenced by human behaviour.

### 52 5.1 Human Factors Considerations

53 ACAS is a last resort function implemented on aircraft with a flight crew of 2 pilots. The operational  
54 procedure (PANS-OPS and PANS-ATM) has been developed and refined for qualified flight crews.

55 Airbus has been able to certify APFD function on A380 including human performance aspects.

### 56 5.2 Training and Qualification Requirements

57 Training guidelines are described in the ACAS Manual ([Doc 9863](#)). Recurrent training is recommended.

58 **5.3 Others**

59 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

60 ICAO mandate for ACAS (TCAS version 7.1) is as follows:

- 61 • New installations as of 1/1/2014
- 62 • All installations no later than 1/1/2017

63 Europe has promulgated earlier dates for the ACAS mandate: new installations as of 1/3/2012 and all  
64 installations no later than 1/12/2015.

65 The optional functions (APFD and/or TCAP) could be implemented at the same time.

66 **7. Implementation and Demonstration Activities**

67 **7.1 Current Use**

68 TCAS v7.1 is already fitting new aircraft, e.g., AIRBUS A380. Operational monitoring by States and  
69 international organisations in a position to do so is recommended.

70 **7.2 Planned or Ongoing Trials**

71 Airbus has already developed, evaluated and certified APFD function on A380. Airbus has developed and  
72 evaluated TCAP function on A380. Certification is expected by the end of 2012.

73 SESAR project provided evidences that the two functions would bring significant operational and safety  
74 benefits in the European environment, in particular by extension to non Airbus aircraft.

- 75 1) TCAP: with a theoretical 100% equipage in Europe, the likelihood to receive an RA during a 1000 ft  
76 level-off encounter is divided by up to 32; for 50% equipage, the likelihood is already divided by 2  
77 which confirms the improved compatibility with ATM.

78 Performance assessment in the US airspace should be conducted in 2012.

- 79 2) APFD: the results are expressed in risk ratios which is the key safety metric indicator for TCAS  
80 equipage. Risk ratio = (risk of collision with TCAS)/(risk of collision without TCAS): with a theoretical  
81 100% equipage, the risk ratio is reduced from 33% (current situation) to 15.5%. With a 50%  
82 equipage the risk ratio is already reduced to 22%

83 **8. Reference Documents**

84 **8.1 Standards**

- 85 • Annex 10 [Volume IV](#) (Including Amendment 85- July 2010)
- 86 • [RTCA DO185B, EUROCAE ED143 – April 2009](#)
- 87 • *RTCA DO325 Annex C estimated for Q1 2013*
- 88 • Annex 6, [Part I](#) – carriage requirements

89 **8.2 Procedures**

- 90 • PANS-ATM *Doc 4444* and PANS-OPS [Volume I](#) (Doc 8168)

91 **8.3 Guidance Material**

- 92 • ACAS Manual ([Doc 9863](#))

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# 1 Module N° B0-05: Improved Flexibility and Efficiency in 2 Descent Profiles (CDOs)

<b>Summary</b>	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). 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.	
<b>Main Performance Impact</b>	KPA-03 – Cost-effectiveness; <b>KPA-04 – Efficiency</b> ; KPA-09 - Predictability	
<b>Operating Environment/Phases of Flight</b>	Approach/Arrivals and En-Route.	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	AOM – Airspace Organisation and Management AO – Aerodrome Operations TS – Traffic Synchronisation, AOM	
<b>Global Plan Initiatives (GPI)</b>	GPI-10- Terminal Area Design and Management; GPI-11- RNP and RNAV Standard instrument Departures (SIDS)and Standard Terminal Arrivals (STARs);	
<b>Pre-Requisites</b>	NIL	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	√
	Avionics Availability	√
	Ground System Availability	√
	Procedures Available	√
	Operations Approvals	√

## 3 1. Narrative

### 4 1.1 General

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

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

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

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

### 18 **1.1.1 Baseline**

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

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

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

### 26 **1.1.2 Change brought by the module**

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

30 The core capabilities that should be leveraged are RNAV; RNP where needed; continuous descent  
31 operations (CDO); where possible, increased efficiencies in terminal separation rules in airspace; effective  
32 airspace design and classification; ATC flow and ATC co-operative surveillance (radar or ADS-B).  
33 Opportunities to reduce emissions and aircraft noise impacts should also be leveraged where possible.

## 34 **1.2 Element 1: Continuous Descent Operations**

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

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

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

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

## 49 **1.3 Element 2: Performance Based Navigation**

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

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

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

- 57 • RNAV specification: navigation specification based on area navigation that does not include the  
58 requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, e.g.  
59 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.

**2. Intended Performance Operational Improvement/Metric to determine success**

<i>Efficiency</i>	Efficiency a. cost savings and environmental benefits through reduced fuel burn b. authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted c. reduction in the number of required radio transmissions d. optimal management of the top-of-descent in the en-route airspace
<i>Environment</i>	As per efficiency
<i>Safety</i>	Safety a. more consistent flight paths and stabilized approach paths b. reduction in the incidence of controlled flight into terrain (CFIT) c. separation with the surrounding traffic (especially free-routing) d. reduction in the number of conflicts.

63

<b>CBA</b>	<p>The following savings are an example of potential savings as a result of CDO implementation. <i>It is important to consider that CDO benefits are heavily dependent on each specific ATM environment.</i></p> <p>Nevertheless, if implemented within the ICAO CDO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.</p> <p>Example of savings after CDO implementation in Los Angeles TMA (KLAX)</p> <ul style="list-style-type: none"> <li>• CDOs RIIVR2/SEAVU2/OLDEE1 &amp; 4 ILS'                         <ul style="list-style-type: none"> <li>○ Implemented September 25, 2008, and in use full time at KLAX.</li> </ul> </li> <li>• About 300-400 aircraft per day fly RIIVR2/SEAVU2/OLDEE1 STARs representing approximately half of all jet arrivals into KLAX                         <ul style="list-style-type: none"> <li>○ 50% reduction in radio transmissions.</li> </ul> </li> <li>• Significant fuel savings – average 125 pounds per flight.                         <ul style="list-style-type: none"> <li>○ 300 flights/day * 125 pounds per flight * 365 days = 13.7 million pounds/year</li> <li>○ More than 2 million gallons/year saved = more than 41 million pounds of CO2 avoided.</li> </ul> </li> </ul> <p>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.</p> <p>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.</p>
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**3. 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.

68 It therefore provides background and implementation guidance for:

- 69 a) air navigation service providers;
- 70 b) aircraft operators;
- 71 c) airport operators; and
- 72 d) aviation regulators.

73 The ICAO Performance-based Navigation Manual (ICAO [Document 9613](#)) provides general guidance on  
74 PBN implementation.

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

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

80 The management of the top-of-descent (TOD) with CDO in en-route airspace (especially in the context of  
81 free-routing) will have to be analyzed because CDO will imply an imposed TOD.

## 82 **4. Necessary System Capability**

### 83 **4.1 Avionics**

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

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

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

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

### 97 **4.2 Ground Systems**

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

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

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

## 108 **5. Human Performance**

### 109 **5.1 Human Factors Considerations**

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



## 113 **5.2 Training and Qualification Requirements**

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

## 117 **5.3 Others**

118 TBD

## 119 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

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

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

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

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

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

138  
 139 Progress should be measured against the key performance indicators recommended by the Working  
 140 Group(s), as approved. PBN does not:

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

## 147 **7. Implementation and Demonstration Activities**

### 148 **7.1 Current Use**

149 TBD

### 150 **7.2 Planned or Ongoing Activities**

151 TBD

## 152 **8. Reference Documents**

### 153 **8.1 Standards**

154 For flight plan requirements in Amendment 1, ICAO Document 4444; PANS/ATM v15

### 155 **8.2 Procedures**

### 156 **8.3 Guidance Material**

- 157 • The ICAO Continuous Descent Operations (CDO) Manual (ICAO [Document 9931](#))

- 158
- The ICAO Performance-based Navigation Manual (ICAO [Document 9613](#))
- 159
- FAA Advisory Circular ([AC 90-105](#) - Approval Guidance for RNP Operations and Barometric Vertical
- 160
- Navigation in the U.S. National Airspace System) which provides system and operational approval
- 161
- guidance for operators (only reflects the US situation).
- 162

# 1 Module N° B0-40: Improved Safety and Efficiency through the 2 initial application of Data Link En-Route 3

<b>Summary</b>	Implementation of an initial set of data link applications for surveillance and communications in ATC.	
<b>Main Performance Impact</b>	<b>KPA-02 Capacity</b> ; KPA-04 Efficiency; KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	En-route flight phases, including areas where radar systems cannot be installed such as remote or oceanic airspace.	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	IM – Information Management SDM – Service Delivery Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-9 Situational awareness GPI-17 Implementation of data link applications GPI-18 Electronic information services	
<b>Main Dependencies</b>	(excerpt from dependency diagram to be included in V3). Predecessor of: B1-40 (but can also be combined with it)	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	✓
	Avionics Availability	✓
	Ground Systems Availability	✓
	Procedures Available	✓
	Operations Approvals	✓

## 4 1. Narrative

### 5 1.1 General

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

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

16 A second element is Controller Pilot Data Link Communications (CPDLC) comprising a first set of data link  
17 applications allowing pilots and controllers to exchange ATC messages concerning Communications  
18 management, ATC Clearances and stuck microphones. CPDLC reduces misunderstandings and controller  
19 workload giving increased safety and efficiency whilst providing extra capacity in the ATM system. .

20 **1.1.1 Baseline**

21 Prior to this module, air-ground communications use voice radio (VHF or HF depending on the airspace),  
22 known for its limitations in terms of quality, bandwidth and security. There are also wide portions of the globe  
23 with no radar surveillance. ATC instructions, position reports and various information have to be transmitted  
24 through HF radios where voice quality is really bad most of the times, leading to significant workload to  
25 controllers and pilots (including HF radio operators), poor knowledge of the traffic situation outside radar  
26 coverage, large separation minima, and misunderstandings. In high density airspace controllers currently  
27 spend 50% of their time talking to pilots on the VHF voice channels where frequencies are a scarce  
28 resource; this also represents a significant workload for controllers and pilots and generates  
29 misunderstandings.

30 **1.1.2 Change brought by the module**

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

34 An important goal of the global ATM concept within the area of data link is to harmonise the regional  
35 implementations and to come to a common technical and operational definition, applicable to all flight  
36 regions in the world. This is planned to be achieved through Block 1 changes. Data link implementations  
37 today are based on different standards, technology and operational procedures although there are many  
38 similarities.

39 **1.2 Element 1: ADS-C over Oceanic and Remote Areas**

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

45 **1.3 Element 2: Continental CPDLC**

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

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

54 **2. Intended Performance Operational Improvement/Metric to determine success**

55 **2.1 Element 1: ADS-C over Oceanic and Remote Areas**

56 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	A better localisation of traffic and reduced separations allow increasing the offered capacity.
<i>Efficiency</i>	Routes/tracks and flights can be separated by reduced minima, allowing to apply flexible routings and vertical profiles closer to the user-preferred ones.
<i>Flexibility</i>	ADS-C permits to make route changes easier
<i>Safety</i>	Increased situational awareness; ADS-C based safety nets like CLAM, RAM, DAIW; better support to SAR

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<i>CBA</i>	<p>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).</p> <p>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.</p>
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58 **2.2 Element 2: Continental CPDLC**

59 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Reduced communication workload and better organisation of controller tasks allow to increase sector capacity
<i>Safety</i>	Increased situational awareness; reduced occurrences of misunderstandings; solution to stuck mike situations

<i>CBA</i>	<p>The European business case has proven to be positive due to</p> <ul style="list-style-type: none"> <li>• the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts).</li> <li>• Reduced controller workload and increased capacity.</li> </ul> <p>A detailed business case has been produced in support of the EU Regulation which was solidly positive.</p> <p>To be noted, there is a 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.</p>
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61 **3. Necessary Procedures (Air & Ground)**

62 Procedures have been described and are available in ICAO documents.

63 **4. Necessary System Capability**

64 **4.1 Avionics**

65 Standards for the enabling technology are available in ICAO documents and industry standards.

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

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

75 **4.2 Ground Systems**

76 For ground systems, the necessary technology includes the ability to process and display the ADS-C position  
 77 messages. CPDLC messages need to be processed and displayed to the relevant ATC unit. Enhanced  
 78 surveillance through multi-sensor data fusion facilitates transition to/from radar environment.

79 **5. Human Performance**

80 **5.1 Human Factors Considerations**

81 ADS-C is a means to provide the air traffic controller with a direct representation of the traffic situation, and  
82 reduces the task of controllers or radio operators to collate position reports.

83 In addition to providing another channel of communications, the data link applications allow in particular air  
84 traffic controllers to better organise their tactical tasks. Both pilots and controllers benefit from a reduced risk  
85 of misunderstanding of voice transmissions.

86 Data communications allow reducing the congestion of the voice channel with overall understanding benefits  
87 and more flexible management of air-ground exchanges. This implies an evolution in the dialog between  
88 pilots and controllers which must be trained to use data link rather than radio.

89 Automation support is needed for both the pilot and the controller. Overall their respective responsibilities will  
90 not be affected.

91 **5.2 Training and Qualification Requirements**

92 Automation support is needed for both the pilot and the controller which therefore will have to be trained to  
93 the new environment and to identify the aircraft/facilities which can accommodate the data link services in  
94 mixed mode environments.

95 **5.3 Others**

96 Nil

97 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

98 Specifications are already available in RTCA and EUROCAE documents.

99 **7. Implementation and Demonstration Activities**

100 **7.1 Current Use**

- 101 ▪ **Remote & Oceanic areas:** ADS-C is used primarily over remote and oceanic areas. Dependent  
102 surveillance (ADS-C) is already successfully used in a number of regions of the world, for example in the  
103 CAR/SAM region (COSESNA, Brazil, etc) or in the South Pacific for FANS 1/A aircraft in combination  
104 with CPDLC messages. Also, in the NOPAC (North PACific) route system it has allowed a reduction of  
105 separation minima.
- 106 ▪ **Australia:** Australia has been operationally using CPDLC since the late 1990's and has provided ADS-C  
107 / CPDLC capability to all en-route controller positions since 1999. Integrated ADS-C and CPDLC based  
108 on FANS1A are used both in domestic en-route and oceanic airspace
- 109 ▪ **Atlantic:** In March 2011, NAV CANADA and NATS implemented Reduced Longitudinal Separation  
110 Minima (RLongSM) of five minutes for properly equipped aircraft on tracks across the Atlantic. RLongSM  
111 requires aircraft to be equipped with GNSS, ADS-C and CPDLC. Along with other procedural  
112 improvements, this will allow more aircraft to access optimal altitudes. The expected result is an  
113 estimated \$1 million in customer fuel savings in the first year, along with 3,000 metric tons of emissions  
114 savings.
- 115 ▪ **India:** ADS-C and CPDLC based on FANS 1/A has been in operation in Bay of Bengal and Arabian Sea  
116 Oceanic areas since 2005. India along with other South Asian countries has introduced 50 nm RLS  
117 (Reduced Longitudinal Separation) in 2 RNAV ATS routes from July 2011 for aircraft with data link  
118 capability. The RLS will be introduced in 8 RNAV routes from December 2011. BOBASMA (Bay of  
119 Bengal Arabian Sea Safety monitoring Agency) has been established in Chennai, India to support RLS  
120 operations and is endorsed by RASMAG/15.
- 121 ▪ **Europe:** CPDLC data link services are being implemented, namely Data Link Communications Initiation  
122 Capability (DLIC), ATC Communications Management service (ACM), ATC Clearances and Information  
123 service (ACL) and ATC Microphone Check service (AMC). To support them, the ATN B1 package is  
124 currently being deployed in 32 European Flight Information Regions and Upper Flight Information  
125 Regions above FL285 (known as the LINK2000+ service deployment). European Commission legislation

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

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

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

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

142 Note: The decision of implementation is accompanied by an economic appraisal, business case and  
 143 other guidance material available at the following address:  
 144 [http://www.eurocontrol.int/link2000/public/site\\_preferences/display\\_library\\_list\\_public.html#6](http://www.eurocontrol.int/link2000/public/site_preferences/display_library_list_public.html#6) .

- 145 ▪ **US:** Domestic Airspace: Beginning in 2014 Departure Clearance Services will be deployed using FANS-  
 146 1/A+. In 2017, En-route Services will begin deployment to domestic en-route airspace.

## 147 **7.2 Planned or Ongoing Trials**

- 148 ▪ **Africa, ACAC:** tbc.

## 149 **8. Reference Documents**

### 150 **8.1 Standards**

- 151 ▪ EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305,  
 152 ED110B/DO280ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280
- 153 ▪ [EC Regulation No. 29/2009](#): the Datalink Services Implementing Rule

### 154 **8.2 Procedures**

155 Nil

### 156 **8.3 Guidance Material**

- 157 ▪ Manual of Air Traffic Services Data Link Applications ([DOC 9694](#))
- 158 ▪ New OPLINK Ops Guidance under development

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

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-04 – Efficiency; KPA-05 – Environment; KPA-10 - Safety	
<b>Operating Environment/Phases of Flight</b>	Departure and En-Route	
<b>Applicability Considerations</b>	<p>Regions, States or individual Locations most in need of these improvements. For simplicity and implementation success, complexity can be divided into three tiers:</p> <p>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.</p> <p>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.</p> <p>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.</p>	
<b>Global Concept Component(s)</b>	AUO – Airspace user operations TS – Traffic synchronization AOM – Airspace organization and management	
<b>Global Plan Initiatives (GPI)</b>	GPI 5- RNAV/RNP (Performance. Based Navigation) GPI-10- Terminal Area Design and Management GPI-11- RNP and RNAV SIDs and STARs	
<b>Pre-Requisites</b>	NIL	
		<b>Status</b> (ready now or estimated date).
<b>Global Readiness Checklist</b>	<i>Standards Readiness</i>	√
	<i>Avionics Availability</i>	√
	<i>Infrastructure Availability</i>	√
	<i>Ground Automation Availability</i>	√
	<i>Procedures Available</i>	√
	<i>Operations Approvals</i>	√

4 **1. Narrative**

5 **1.1 General**

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

9 As traffic demand increases, the challenges in terminal areas center around volume, convective  
 10 weather, reduced-visibility conditions, adjacent airports and special activity airspace in close

11 proximity whose procedures utilize the same airspace, and policies that limit capacity, throughput,  
12 and efficiency.

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

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

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

24

### 25 **1.1.1 Baseline**

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

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

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

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

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

### 45 **1.1.2 Change brought by the module**

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

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

56

57 **1.1.3 Other remarks**

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

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

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

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

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

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

78 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Efficiency</i>	Cost savings through reduced fuel burn and efficient aircraft operating profiles. Reduction in the number of required radio transmissions.
<i>Environment</i>	Authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted. Environmental benefits through reduced emissions.
<i>Safety</i>	More consistent flight paths. Reduction in the number of required radio transmissions. Lower pilot and Air Traffic Control workload.
<i>CBA</i>	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.

79 **3. Necessary Procedures (Air & Ground)**

80 The ICAO Performance-based Navigation Manual (ICAO [Document 9613](#)) provides general  
81 guidance on PBN implementation.

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

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

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

90 It therefore provides background and implementation guidance for:

- 91 a) air navigation service providers;
  - 92 b) aircraft operators;
  - 93 c) airport operators; and
  - 94 d) aviation regulators.
- 95

96 **4. Necessary System Capability**

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

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

113

114 **5. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

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

118 For example, noise contour production may be based on a specific departure procedure (NADP1  
119 or NADP2-type). Noise performance can be improved in some areas around the airport, but it may  
120 affect existing noise contours elsewhere. Similarly CCO can enable several specific strategic  
121 objectives to be met and should therefore be considered for inclusion within any airspace concept  
122 or redesign. Guidance on airspace concepts and strategic objectives is contained in [Doc 9613](#).  
123 Objectives are usually collaboratively identified by airspace users, ANSPs, airport operators as well  
124 as by government policy. Where a change could have an impact on the environment, the  
125 development of an airspace concept may involve local communities, planning authorities and local  
126 government and may require formal impact assessment under regulations. Such involvement may

127 also be the case in the setting of the strategic objectives for airspace. It is the function of the  
128 airspace concept and the concept of operations to respond to these requirements in a balanced,  
129 forward-looking manner, addressing the needs of all stakeholders and not of one of the  
130 stakeholders only (e.g. the environment). [Doc 9613](#), Part B, Implementation Guidance, details the  
131 need for effective collaboration among these entities

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

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

138

## 139 **6. Implementation and Demonstration Activities**

140 TBD

### 141 **6.1 Current Use**

### 142 **6.2 Planned or Ongoing Activities**

## 143 **7. Reference Documents**

### 144 **7.1 Standards**

### 145 **7.2 Procedures**

146 ICAO Doc 4444, *PANS-ATM*

### 147 **7.3 Guidance Material**

148 ICAO Doc xxxx, *Continuous Climb Operations (CCO) Manual – under development*

149 ICAO [Doc 9613](#), *Performance-based Navigation (PBN) Manual*

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# **BLOCK 1**

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# 1 Module N° B1-65: Optimised Airport Accessibility

2

<b>Summary</b>	<p>This is the further transition in the universal implementation of GNSS-based approaches.</p> <p>PBN and GLS (CAT II/III) procedures enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency. Key aspects included:</p> <ul style="list-style-type: none"> <li>• Increased availability and reliability through Multi-Frequency/Constellation use of GNSS</li> <li>• GNSS-based CAT II/III approach capability</li> </ul> <p>Curved/segmented approaches with RNP to XLS transition</p>	
<b>Main Performance Impact</b>	<b>KPA-04 Efficiency</b> , KPA-05 Environment, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	Approach and landing	
<b>Applicability Considerations</b>	This module is applicable to all runway ends.	
<b>Global Concept Component(s)</b>	AUO – Airspace User Operations AO – Aerodrome Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-5 RNAV and RNP (PBN) GPI-14 Runway Operations GPI-20 WGS84	
<b>Pre-Requisites</b>	B0-65	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	Est. 2014
	Avionics Availability	Est. 2018
	Ground System Availability	√
	Procedures Available	√
	Operations Approvals	Est. 2018

## 3 1. Narrative

### 4 1.1 General

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

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

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

15 **1.1.1 Baseline**

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

20 **1.1.2 Change brought by the module**

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

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

26 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Efficiency</i>	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.
<i>Environment</i>	Environmental benefits through reduced fuel burn
<i>Safety</i>	Stabilized approach paths.
<i>CBA</i>	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.

27 **3. Necessary Procedures (Air & Ground)**

28 The PBN Manual, the GNSS Manual, Annex 10 and PANS-OPS Volume I provide guidance on system  
29 performance, procedure design and flight techniques necessary to enable PBN approach procedures. The  
30 WGS-84 Manual provides guidance on surveying and data handling requirements. The Manual on Testing of  
31 Radio Navigation Aids (Doc 8071), [Volume II](#) — Testing of Satellite-based Radio Navigation Systems  
32 provides guidance on the testing of GNSS (Cat I only at this time). This testing is designed to confirm the  
33 ability of GNSS signals to support flight procedures in accordance with the standards in Annex 10. ANSPs  
34 must also assess the suitability of a procedure for publication, as detailed in PANS-OPS, [Volume II](#), Part I,  
35 Section 2, Chapter 4, Quality Assurance. The Quality Assurance Manual for Flight Procedure Design (Doc  
36 9906), Volume 5 – Flight Validation of Instrument Flight Procedures provides the required guidance for PBN  
37 procedures. Flight validation for PBN procedures is less costly than for conventional aids for two reasons: the  
38 aircraft used do not require complex signal measurement and recording systems; and, there is no  
39 requirement to check signals periodically.

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

42 **4. Necessary System Capability**

43 **4.1 Avionics**

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

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

## 61 **4.2 Ground Systems**

62 Cat II/III GBAS Ground Stations.

## 63 **4.3 Human Factors Considerations**

64 Human performance is reflected in how straightforward it is to successfully perform a specific task  
 65 consistently, and how much initial and recurrent training is required to achieve safety and consistency. For  
 66 this module there are clear safety benefits associated with the elimination of circling procedures and  
 67 approaches without vertical guidance.

## 68 **4.4 Training and Qualification Requirements**

69 TBD

## 70 **4.5 Others**

71 TBD

## 72 **5. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

73 See Sections 3 and 4 above.

## 74 **6. Implementation and Demonstration Activities**

### 75 **6.1 Current Use**

### 76 **6.2 Planned or Ongoing Activities**

#### 77 **▪ United States**

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

#### 84 **▪ Canada**

85 By 2018 Canada expects to expand PBN approach service based on demand from aircraft operators. As of  
 86 2011 Canada does not have plans to implement GBAS.

#### 87 **▪ Australia**

88 By 2018 Australia expects a considerable expansion of PBN approach service. Subject to the successful  
 89 introduction of the CAT 1 GBAS service into Sydney, Australia will further validate GBAS operational benefits  
 90 in consultation with key airline customers with a view to expanding the network beyond Sydney in the period  
 91 2013 to 2018. Other activities to be considered in relation to the expansion and development of the GBAS  
 92 capability in Australia include development of a CAT II/III capability during the 3 years following 2011.

93 **▪**

94 **▪**

95   ▪ **France**

96   The objective is to have PBN procedures for 100% of France's IFR runways with LNAV minima by 2016, and  
97   100% with LPV and LNAV/VNAV minima by 2020. France has no plans for Cat I GBAS and it is unlikely that  
98   there will be Cat II/III GBAS in France by 2018 because there is not a clear business case.

99   ▪ **Brazil**

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

102

103   **7.    Reference Documents**

104    **7.1   Standards**

- 105      •   Annex 10

106    **7.2   Procedures**

- 107      •   PANS-OPS

108    **7.3   Guidance Material**

- 109      •   PBN Manual (ICAO [Doc 9613](#))  
110      •   GNSS Manual (ICAO [Doc 9849](#))  
111      •   WGS-84 Manual (Doc 9674)  
112      •   Manual on Testing of Radio Navigation Aids (Doc 8071), [Volume II](#) (Cat-I only)  
113      •   Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5

114

# 1 Module N° B1-70: Increased Runway Throughput through 2 Dynamic Wake Turbulence Separation 3

<b>Summary</b>	Improved throughput on departure and arrival runways through the dynamic management of wake turbulence separation minima based on the real-time identification of wake turbulence hazards.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-04 Efficiency, KPA-05 Environment, KPA-06 Flexibility.	
<b>Domain / Flight Phases</b>	Aerodrome	
<b>Applicability Considerations</b>	Least Complex – Implementation of re-categorized wake turbulence is mainly procedural. No changes to automation systems are needed.	
<b>Global Concept Component(s)</b>	CM - Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-13- Aerodrome Design; GPI 14 – Runway Operations	
<b>Main Dependencies</b>		
<b>Global Readiness Checklist</b>		<b>Status (ready or date)</b>
	Standards Readiness	Est. 2018
	Avionics Availability	N/A
	Ground System Availability	Est. 2018
	Procedures Available	Est. 2018
	Operations Approvals	Est. 2018

## 4 1. Narrative

### 5 1.1 General

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

#### 20 1.1.1 Baseline

21 ANSP applied wake mitigation procedures and associated standards were developed over time, with the last  
22 comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved 6 category wake  
23 turbulence separation standards. The ICAO 2013 standards allow greater runway utilization than the prior  
24 1990's inherently conservative wake separation standards; however, the 2013 standards can be enhanced  
25 to define safe, runway capacity efficient wake turbulence separations for typical aircraft operating at an  
26 airport. By the end of 2013, some airports were approved to use modified ANSP wake separation procedures  
27 on their CSPR, if certain runway layout and instrumentation criteria were met. Also by the end of 2013, some  
28 airports will be using ANSP wake separation CSPR departure procedures based on predicted and monitored  
29 crosswinds.

30 **1.1.2 Change brought by the module**

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

50 **1.1.3 Other Remarks**

51 The work accomplished in Block 1 builds on the upgrades of Block 0 and will be the basis for further  
52 enhancement in wake mitigation procedures and standards that will occur in Block 2 developments. The  
53 Wake Turbulence Separation - Refined Module is a progression of steps to have available to global aviation,  
54 means to acquire more capacity from existing airport runway structure and to place new airport runways for  
55 minimizing wake turbulence landing and departure restrictions. The effort in Block 1 will not provide the major  
56 capacity increases needed to meet the overall demand envisioned for the 2025 time frame. However it does  
57 provide incremental capacity increases using today's runways and minor modifications to air traffic control  
58 procedures. Block 1 and subsequent Block 2 will address developing wake mitigation procedures and  
59 separation standards that will assure the wake safety of innovations (Trajectory Based, High Density,  
60 Intended Performance Operational Improvement/Metric to determine success. Flexible Terminal) in air traffic  
61 control while at the same time provide the least wake safety constraints on the air traffic control innovation.  
62 The upgrades of block 1 will incorporate the experience obtained with the Block 0 upgrades.  
63

64 **1.2 Element 1: Implement Leader/Follower - Pair Wise Static Matrix Wake Separation**  
65 **Standards**

66 The work in Element 1 is being accomplished by a joint EUROCONTROL and FAA working group that in  
67 Block 0 reviewed the wake mitigation aircraft separations used in both the USA's and Europe's air traffic  
68 control processes and determined the standards can be safely modified to increase the operational capacity  
69 of airports and airspace. A 6 category wake separation standard recommendation was developed by the  
70 working group and provided to ICAO. It is expected that by the end of 2012, ICAO will publish the  
71 recommendation as changes to its Procedures for Air Navigation Services.  
72

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

### 86 **1.3 Element 2: Increasing Airport Arrival Operational Capacity at Additional Airports**

87 ANSP wake mitigation procedures applied to instrument landing operations on CSPR are designed to protect  
88 aircraft for a very wide range of airport parallel runway configurations. Prior to 2008, instrument landing  
89 operations conducted to an airport's CSPR had to have the wake separation spacing equivalent to  
90 conducting instrument landing operations to a single runway. When an airport using its CSPR for arrival  
91 operations had to shift its operations from visual landing procedures to instrument landing procedures, it  
92 essentially lost one half of its landing capacity (i.e. from 60 to 30 landing operations per hour).  
93

94 Block 0 Element 2 upgrade provided a dependent diagonal paired instrument approach wake separation  
95 procedure (FAA Order 7110.308) for operational use in 2008 at five airports that had CSPR configurations  
96 meeting the runway layout criteria of the developed procedure. Use of the procedure provided an increase of  
97 up to 10 more arrival operations per hour on the airport CSPR during airport operations requiring instrument  
98 approaches. By the end of 2010 the approval to use the procedure was expanded to two additional airports.  
99 An enhanced version of FAA Order 7110.308 will be approved in 2012 for use by up to 6 more U.S. airports  
100 who use their CSPR for arrival operations.  
101

102 Block 1 work will expand the use of the dependent instrument landing approach procedure to capacity  
103 constrained airports that use their CSPR for arrival operations but do not have the runway configuration to  
104 satisfy the constraints of FAA Order 7110.308. The mechanism for this expansion is the Wake Turbulence  
105 Mitigation for Arrivals (WTMA) capability that will be added to FAA ATC systems. WTMA relies on predicted  
106 and monitored winds along the airport approach path to determine if wakes of arriving aircraft will be  
107 prevented by cross winds from moving into the path of aircraft following on the adjacent CSPR. The WTMA  
108 capability may be expanded during Block 1 to include predicting when steady crosswinds would blow wakes  
109 out of the way of aircraft following directly behind the generating aircraft – allowing the ANSP to safely  
110 reduce the wake separation between aircraft approaching a single runway. It is expected that by the end of  
111 2018, the WTMA capability will be in use at an additional 6 or more CSPR airports whose physical layout  
112 precluded use of the non-wind dependent 7110.308 Block 0 developed procedures.  
113

114 Critical component of the WTMA capability is wind information along the airport's approach corridor. Use of  
115 WTMA will be limited by the timely availability of this information. During Block 1 time frame, it is expected  
116 that aircraft wind information observed and transmitted during their approach to the airport will be  
117 incorporated into the WTMA wind prediction model as a replacement for the much more latten National  
118 Weather Service forecasted winds information. Use of aircraft wind data will significantly increase WTMA's  
119 capability to forecast and monitor wind changes, allowing WTMA wake separations to be used during times  
120 when before, due to uncertainty of wind information, use of the reduced wake separations was precluded.  
121

### 122 **1.4 Element 3: Increasing Airport Departure Operational Capacity at Additional Airports**

123 Element 3 is the development of technology aided enhanced wake mitigation ANSP departure procedures  
124 that safely allow increased departure capacity on an airport's CSPR.  
125

126 Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that allows, when  
127 runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR after a  
128 Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required wake  
129 mitigation delay of 2 to 3 minutes. WTMD applies a runway cross wind forecast and monitors the current  
130 runway crosswind to determine when the WTMD will provide guidance to the controller that the 2 to 3 minute  
131 wake mitigation delay can be eliminated and when the delay must again be applied. WTMD was developed  
132 for implementation at 8 to 10 U.S. airports that have CSPR with frequent favourable crosswinds and a  
133 significant amount of Boeing 757 and heavier aircraft operations. Operational use of WTMD began in 2011.  
134

135 Block 1 will enhance the WTMD capability to predict when crosswinds will be sufficient to prevent the wake  
136 of a departing aircraft from transporting into the path of an aircraft departing on the adjacent CSPR. WTMD  
137 will be modified to receive and process aircraft wind information observed during their departure from the  
138 airport, as a replacement for the much more latten National Weather Service forecasted winds information.  
139 Use of aircraft wind data will significantly increase WTMD's capability to forecast and monitor wind changes,  
140 allowing WTMD wake separations to be used during times when before, due to uncertainty of wind information,  
141 use of the reduced wake separations was precluded.  
142

143

**2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	<p><b>Element 1</b> To assess the operational improvement by the introduction of CDO, States can use, as appropriate, a combination of the following metrics:</p> <p><b>Element 2</b> 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.</p>
<i>Flexibility</i>	<p><b>Element 1</b> Dynamic Scheduling. ANSPs have the choice of optimizing the arrival/departure schedule via pairing number of unstable approaches</p>
<i>Efficiency/Environment</i>	<p><b>Element 3</b> Changes brought by this element will enable more accurate crosswind prediction.</p>

144

<i>CBA</i>	<p>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.</p> <p>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.</p> <p>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.</p>
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### 149 3. Necessary Procedures (Air & Ground)

150

#### 151 Element 1

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

160

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

163

#### 164 Element 2

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

171

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

175

#### 176 Element 3

177 Block 1 Element 3 implementations only affect the ANSP procedures for departing aircraft on an airport's  
178 CSPR. Element 3 products are additional procedures for use by the ANSP for situations when the airport is  
179 operating under a heavy departure demand load and the airport will be having a significant number of Boeing  
180 757 and heavier aircraft in the operational mix. The procedures provide for transitioning to and from reduced  
181 required separations between aircraft and criteria for when the reduced separations should not be used.  
182 Block 1 upgrade does not change these procedures, it only increases the frequency and duration that the  
183 procedures can be applied The procedures implemented by Element 3 require no changes to the aircrew's  
184 procedures for accomplishing a departure from the airport. When a specialized CSPR departure procedure is  
185 being used at an airport, pilots are notified that the special procedure is in use and that they can expect a  
186 more immediate departure clearance.

### 187 4. Necessary System Capability

#### 188 4.1 Avionics

189 Module 70, Block 1 upgrade requires no additional technology to be added to the aircraft or additional  
190 aircrew certifications. Block 1 upgrades will utilize aircraft avionics enhancements that are expected to occur  
191 during that timeframe from other Modules (i.e. ADS-B).

#### 192 4.2 Ground Systems

193 ANSPs, if they choose to use the Leader/Follower Pair-Wise Static wake separation standards Element 1  
194 upgrade will develop a decision support tool to support in the application the standards. The Element 2 and  
195 Element 3 Block 1 upgrades require the ANSP, if the ANSP chooses to use the reduced wake separations  
196 on its CSPR, add the capability to predict crosswind strength and direction and to display that information to  
197 the ANSP controllers and supervisors. This capability will be provided by a combination of X-band radar and  
198 Lidar scanner technology.

199

200 **5. Human Performance**

201 **5.1 Human Factors Considerations**

202 TBD

203 **5.2 Training and Qualification Requirements**

204 Training will required for controllers in the use of new Pair Wise Static matrix of aircraft type wake separation  
205 pairings and Wake Mitigation decision support tools.

206 **5.3 Others**

207 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

208 **Element 1**

209 The product of Element 1 is a recommended set of Leader/Follower Pair-Wise Static additional wake  
210 separation changes to the ICAO wake separation standards and supporting documentation. Once approved,  
211 ICAO's revised wake separation standards will allow all ANSPs to base their wake mitigation procedures on  
212 the ICAO approved standards. ICAO approval of the Leader/Follower Pair-Wise Static wake separation  
213 standards is estimated to occur in the 2015/16 time frame.  
214  
215

216 **Element 2 and 3**

217 Element 2 and 3 products are U.S. airport specific and are approved for use through a national review  
218 process to insure proper integration into the air traffic control system. A companion process (FAA Safety  
219 Management System) reviews and documents the safety of the product, insuring the safety risk associated  
220 with the use of the product is low.  
221

222 There is no air approval plan required for the implementation of the Wake Turbulence Standards – Refined  
223 Module Block 1.  
224

225 **7. Implementation and Demonstration Activities**

226 **7.1 Current Use**

227 The WTMD system will be operationally demonstrated at three U.S. airports beginning in 2011.  
228

229 **7.2 Planned or Ongoing Trials**

230 Concurrent with the ICAO approval process, FAA is developing documentation and its automation systems'  
231 adaptation changes that will allow implementation of the wake separation standard changes. The ICAO  
232 approval is expected in 2015/16.  
233

234 Work is continuing on developing crosswind based wake separation procedures and technology upgrades  
235 for arrival operations to and airport's CSPR. Human-in-the-loop simulations using the procedures and the  
236 associated controller display support will be conducted in 2012. Depending on the outcome of the  
237 simulations, the development of the capability may continue.  
238

239 Wake Turbulence Mitigation for Departures (WTMD) is a development project by the U.S. that will allow,  
240 when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind CSPR  
241 after a Boeing 757 or heavier aircraft departs on the downwind runway – without waiting the current required  
242 wake mitigation delay of 2 to 3 minutes. WTMD is being developed for implementation at 8 to 10 U.S.  
243 airports that have CSPR with frequent favourable crosswinds and a significant amount of Boeing 757 and  
244 heavier aircraft operations. First operational use of WTMD is expected in spring 2011.  
245

246	<b>8. Reference Documents</b>
247	<b>8.1 Standards</b>
248	<b>8.2 Procedures</b>
249	<b>8.3 Guidance Material</b>
250	ICAO <a href="#">Doc 9854</a> Global ATM Operational Concept,
251	ICAO <a href="#">Doc 9750</a> Global Air Navigational Plan
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# 1 Module N° B1-75: Enhanced Safety and Efficiency of 2 Surface Operations (A-SMGCS/ATSA-SURF-IA) 3

<b>Summary</b>	This module 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.	
<b>Main Performance Impact</b>	KPA-10 Safety (reduced runway incursions) KPA-4 Efficiency (shared ground ops situational awareness)	
<b>Domain / Phase of Flight</b>	Aerodrome operations	
<b>Applicability Considerations</b>	Applicable to small through large aerodromes and all classes of aircraft; cockpit capabilities work independently of ground infrastructure or other aircraft equipage, but other aircraft equipage and/or ground surveillance broadcast will improve benefit.	
<b>Global Concept Component(s)</b>	AO - Aerodrome Operations CM - Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-9 Situational Awareness GPI-13 Aerodrome Design and Management GPI-16 Decision Support Systems and Alerting Systems	
<b>Pre-Requisites</b>	B0-75 (Surface Surveillance);	
<b>Global Readiness Checklist</b>		<b>Status</b> (indicate ready with a tick or input date)
	Standards Readiness	✓ (Partial)
	Avionics Availability	Est. 2015-2017
	Infrastructure Availability	Est. 2015
	Ground Automation Availability	Est. 2015
	Procedures Available	Est. 2015
	Operations Approvals	Est. 2015

## 4 1. Narrative

### 5 1.1 General

6 This module builds upon the work completed in B0-75 Runway Safety, by the introduction of new capabilities  
7 that enhance surface situational awareness and surface movement capabilities:

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

#### 11 1.1.1 Baseline

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

18 Enhanced surface situational awareness is based upon the use of an aerodrome surface primary radar  
19 system and display. This permits the surveillance of all aircraft and ground vehicles without any need for  
20 cooperative surveillance equipment installed on the aircraft/vehicles. This improvement allows ANSP  
21 personnel to better maintain awareness of ground operations during periods of low visibility. In addition, the  
22 presence of safety logic allows for limited detection of runway incursions.

### 23 **1.1.2 Change brought by the module**

24 This module implements additional capabilities to the aerodrome surveillance capability by taking advantage  
25 of cooperative surveillance that provides a means to identify targets with specific flight identification. Cockpit  
26 operations receive a display of the surface map, with “ownship” and other traffic depicted. Cockpit visual  
27 scanning is further improved by the addition of Enhanced Vision Systems (EVS), which provides better visual  
28 awareness of surroundings during periods of reduced visibility (e.g. night, weather obscuration). In addition,  
29 ground vehicles operating in the movement area will be equipped initially to be visible to tower and cockpit  
30 systems, and eventually be equipped with map and traffic capabilities similar to the cockpit.

### 31 **1.2 Element 1: Enhanced ANSP Surface Surveillance Capability with Safety Logic**

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

38 The addition of cooperative surveillance of aircraft and vehicles adds a significant positive benefit to the  
39 performance of safety logic, as the tracking and short-term trajectory projection capabilities are improved  
40 with the higher quality surveillance. Alerting with flight identification information also improves the service  
41 provider’s response to situations that require resolution such as reduced number of runway incursion  
42 incidents and improved response times to correction of possible unsafe surface situations. The addition of  
43 this capability also provides for a marginal improvement in routine management of taxi operations and more  
44 efficient sequencing of aircraft departures.

### 45 **1.3 Element 2: Enhanced Cockpit Surface Surveillance Capability with Indications 46 and Alerts**

47 Surface moving map capabilities in the aircraft cockpit assist the flight crew with navigation and traffic  
48 situational awareness. This basic capability is provided by the addition of an electronic display which can  
49 depict the aerodrome chart, thus replacing paper charts with an electronic presentation.

50 Initial enhancements include the ability to depict the ownship aircraft location on the aerodrome chart, based  
51 on Area Navigation avionics (e.g. Global Navigation Satellite System) installed on the aircraft. Additional  
52 enhancements allow for other aerodrome traffic to be depicted on the display. This information may be direct  
53 aircraft-to-aircraft (e.g., via ADS-B In avionics on the own ship combined with ADS-B Out avionics on other  
54 aircraft), or may be provided via a Traffic Information Service-Broadcast (TIS-B) from the ANSP based on  
55 ANSP surveillance.

56 The final enhancement to cockpit capability is the addition of safety logic to the avionics, which allows for  
57 detection of potential unsafe situations (e.g. runway already occupied) independent of any ground system,  
58 the presentation of these situations (e.g., by highlighting the occupied runway), and by providing a visual and  
59 aural alert.

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

64 All of these capabilities can also be applied to support drivers of equipped ground vehicles.

### 65 **1.4 Element 3: Enhanced Vision Systems for Taxi Operations**

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

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

74 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Efficiency</i>	a. Reduced Taxi Times b. Fewer navigation errors requiring correction by ANSP
<i>Safety</i>	a. Fewer navigation errors b. Reduced number of runway incursions c. Improved response times to correction of unsafe surface situations

<i>CBA</i>	The business case for this element can be 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. Visual scanning augmentation in the cockpit acting in conjunction with service provider capabilities enhances operations on the surface. Efficiency gains are expected to be marginal and modest in nature.  Improving flight crew situational awareness of own-ship position during periods of reduced visibility will reduce errors in the conduct of taxi operations, which lead to both safety and efficiency gains.
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75 **3. Necessary Procedures (Air & Ground)**

76 As service provider surface surveillance capability with Safety Logic is deployed, situational awareness by  
 77 service provider personnel is enhanced. While specific procedures are required for use of the new  
 78 equipment, they do not significantly change surface operating practices. An exception to this is service  
 79 provider personnel response to safety logic alerting; detailed procedures on proper response to alerts must  
 80 be incorporated into training, procedures development and operations.

81 When incorporating enhancements to cockpit surface surveillance capability by incorporating “Indications  
 82 and Alerts”, adherence to aircraft flight manual approved procedures for the use of the equipment is required.  
 83 These procedures outline limitations to the use of the equipment and the proper incorporation of new  
 84 capabilities into the existing taxi procedures and techniques (e.g. appropriate heads-up and heads-down  
 85 times, integration with effective Cockpit Resource Management, etc.). Flight crew response to alerting  
 86 capabilities requires incorporation into appropriate initial and recurrent training.

87 Drivers of ground vehicles in the movement area equipped with surface situational awareness and alerting  
 88 capabilities will require similar procedures for use, including initial and recurrent training.

89 The addition of enhanced vision systems for taxi operations requires adherence to aircraft flight manual  
 90 approved procedures for the use of the equipment.

91 **4. Necessary System Capability**

92 **4.1 Avionics**

93 The aircraft choosing to equip for operating in this environment will add enhanced cockpit surface  
 94 surveillance capability with indications and alerts including aerodrome moving map display capability, area  
 95 navigation position source (e.g. Global Navigation Satellite System), ADS-B/traffic information service  
 96 broadcast receiver, and cockpit safety logic. ADS-B Out avionics will be required for direct aircraft-to-aircraft  
 97 surveillance. With the addition of enhanced vision systems for use during taxi operations, an enhanced fight  
 98 vision system in the aircraft will be required.

99 **4.2 Ground Systems**

100 Enhanced service provider surface surveillance with Safety Logic requires an aerodrome multilateration  
101 capability, automatic dependent surveillance with broadcast ground stations, and ground automation  
102 systems that incorporate aerodrome safety logic. Some of these more advanced technologies may require  
103 compatible runway/taxiway lighting on the aerodrome surface in particular to accommodate the avionics.  
104

105 **5. Human Performance**

106 **5.1 Human Factors Considerations**

107 Human performance is a critical aspect in resolving runway incursions, it must be accounted for by a surface  
108 safety system's logic to determine how far in advance of the predicted runway incursion or other factor the  
109 system must identify it so that action can be taken to avoid it. Measuring human performance in responding  
110 to a surface safety system's alert under key operational conditions will yield results that can be used to  
111 inform surface safety logic human performance criteria decision-making so that performance requirements  
112 for aircraft and tower-based surface safety systems, which support accurate and timely detection of  
113 situations that could result in an incident, can be established.

114 **5.2 Training and Qualification Requirements**

115 Since automation support is needed for both the pilot and the controller, they therefore have to be trained to  
116 the new environment and to identify the aircraft which can accommodate the expanded services available in  
117 particular when operating in a mixed mode environment.

118 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

119 Standards require those for aerodrome multilateration systems, ADS-B ground systems, and Safety Logic,  
120 which have been approved for operational use in the Europe, the US and other member states. Guidance on  
121 these systems can be found in the ICAO Surveillance Multilateration Manual.

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

124 **7. Implementation and Demonstration Activities**

125 **7.1 Current Use**

126 Many aerodromes around the world already use Multilateration techniques. Deployment to additional  
127 aerodromes, using differing combinations of surveillance technology, is planned through 2018 and beyond.  
128 Initial A-SMGCS Level 2 based on surveillance detection of runway incursions is implemented at a number of  
129 European airports.

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

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



## 136 **7.2 Planned or Ongoing Trials**

137 The US NextGEN and EUROCONTROL CASCADE Program are supporting deployment to additional  
 138 aerodromes, using various combinations of primary and secondary surveillance. This includes low cost  
 139 ground surveillance programs, which may unite a more affordable primary radar system with ADS-B. In initial  
 140 operational capabilities are expected in the 2012-2016 timeframe.

## 141 **8. Reference Documents**

### 142 **8.1 Standards**

- 143 • Community Specification on A-SMGCS Levels 1 and 2
- 144 • ICAO Surveillance Multilateration Manual
- 145 • ICAO [Doc 9830](#) Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual
- 146 • [ICAO Doc 7030/5](#) EUR/NAT Regional Supplementary Procedures, Section 6.5.6 and 6.5.7
- 147 • FAA Advisory Circulars:
- 148 • [AC120-86 Aircraft Surveillance Systems and Applications](#)
- 149 • [AC120-28D Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout](#)
- 150 • [AC120-57A Surface Movement Guidance and Control System](#)
- 151 • Avionics standards developed by RTCA SC-186/Eurocae WG-51 for ADS-B
- 152 • Aerodrome map standards developed by RTCA SC-217/Eurocae WG-44

### 153 **8.2 Procedures**

154 Much is contained in other guidance materials.

### 155 **8.3 Guidance material**

- 156 • [FAA NextGen Implementation Plan](#)
- 157 • [European ATM Master Plan](#)

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# 1 Module N° B1-80: Optimised Airport Operations through A- 2 CDM Total Airport Management

3

<b>Summary</b>	This module enhances the planning and management of airport operations and allows their full integration in the air traffic management by implementing collaborative Airport Operations Planning (AOP) based on performance targets compliant with those of the surrounding airspace, as well as the notion of an Airport Operations Centre (APOC) allowing the different stakeholders to better communicate, co-ordinate and execute their activities.	
<b>Main Performance Impact</b>	KPA-02 Capacity; KPA-03 Cost-Effectiveness; <b>KPA-04 Efficiency;</b>	
<b>Operating Environment/Flight Phases</b>	Surface in, turn around, surface out	
<b>Applicability Considerations</b>	AOP: for use at all the airports (sophistication will depend on the complexity of the operations and their impact on the network). APOC: will be implemented at major/complex airports (sophistication will depend on the complexity of the operations and their impact on the network). Not applicable to aircraft.	
<b>Global Concept Component(s)</b>	AO – Airport Operations IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-13 Aerodrome design and management	
<b>Pre-Requisites</b>	B0-80, B0-35	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est. 2018</b>
	Avionics Availability	NA
	Ground System Availability	<b>Est. 2018</b>
	Procedures Available	<b>Est. 2018</b>
	Operations Approvals	<b>Est. 2018</b>

## 4 1. Narrative

### 5 1.1 General

6 Many stakeholders / partners are involved in the airport processes. Each has its own sub-process and  
7 operates to independent non-aligned performance targets. Optimization of individual process has the  
8 potential to lead to a sub optimal and inefficient total airport performance.

9 Uncoordinated operations at an airport, often translate into additional holding times on the surface and in the  
10 air due to delays and subsequently greater cost of operations and impact on the environment. This not only  
11 affects the airport efficiency and overall performance but also impacts the efficiency of the total ATM  
12 network.

13 Poor predictability and communication of flight operations (e.g., arrival, departure times, and surface delays)  
14 increases gate to gate times and decreases efficiency of airport resources like aircraft stands, ground  
15 equipment and manpower utilisation

16 Imbalance between actual demand and capacity increases delays and holding times (airborne as well on the  
17 ground), resulting in additional fuel burn impacting local air quality and emissions.

18 Today, information on airport operations such as surface surveillance, and aircraft readiness is not fully  
 19 integrated into the flow planning of the overall ATM System.

20 The improvement of the planning and management of airport operations and their full and seamless  
 21 integration in the overall ATM system through exchange of information between stakeholders are crucial to  
 22 achieve the performance targets set in the most congested and complex regions of the world..

23 **1.1.1 Baseline**

24 The baseline for this module is Airport CDM as described in module N°B0-80 and Air Traffic Flow and  
 25 Capacity Management as described in module N° B0-35.

26 **1.1.2 Change brought by the module**

27 This module provides enhancement to the planning and management of airport operations and allows their  
 28 full integration in the air traffic management through the implementation of the following:

- 29 • A collaborative Airport Operations Plan (AOP) which encompasses 'local' airport information as well as  
 30 content which is 'shared' with the ATM system in order to permit airports to be fully integrated into the  
 31 overall ATM network.
- 32 • An Airport Performance framework with specific performance targets fully integrated into the AOP and  
 33 compliant with the regional / national performance targets.
- 34 • A decision making process permitting stakeholders to communicate and co-ordinate, to develop and  
 35 maintain dynamically joint plans and to execute those in their respective area of responsibility. In  
 36 support of the decision making process, information will be integrated and collated into a consistent and  
 37 pertinent view for the different operational units on the airport and elsewhere in ATM. To support the  
 38 process, a real-time monitoring system, a decision support tool, and a set of collaborative procedures will  
 39 ensure a fully integrated management of airside airport processes, taking the impact on landside  
 40 processes into account supported by up-to-date and pertinent meteorological information.

41 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	<p><b>Moderate</b> – capacity will not be increased. However, through comprehensive planning the most efficient use of the airport resources will be achieved. In some implementations this may allow for an increase in the percentage of scheduled demand against available capacity.</p> <p>Through the operational management of performance, reliability of the schedule will increase (in association with initiatives being developed in other modules). This will allow airspace users to reduce the 'buffers' in their planned schedules to allow for reduction in delays.</p>
<i>Cost-Effectiveness</i>	<p><b>Major</b> – through collaborative procedures, comprehensive planning and pro-active action to foreseeable problems a major reduction in on-ground and in-air holding is expected thereby reducing fuel consumption. The planning and pro-active actions will also support efficient use of resources, however some minor increase in resources may be expected to support the solution/s.</p>
<i>Efficiency</i>	<p><b>Major</b> – through collaborative procedures, comprehensive planning and pro-active action to foreseeable problems a major reduction in on-ground and in-air holding is expected thereby reducing fuel consumption. The planning and pro-active actions will also support efficient use of resources, however some minor increase in resources may be expected to support the solution/s.</p>
<i>Environment</i>	<p><b>Significant</b> – through collaborative procedures, comprehensive planning and pro-active action to foreseeable problems a major reduction in on-ground and in-air holding is expected thereby reducing Noise and Air</p>

	pollution in the vicinity of the airport.
<i>Predictability</i>	<b>Major</b> –Through the operational management of performance, reliability and accuracy of the schedule and demand forecast will increase (in association with initiatives being developed in other modules).
<i>Safety</i>	<b>Minor</b> – no impact is expected on existing safety measures. By working collaboratively some safety improvement is likely through the reduction of aircraft on the movement area through better planning, however this would be difficult to measure.

<i>CBA</i>	TBD
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42

43 **3. Necessary Procedures (Air & Ground)**

44 Procedures to instantiate and update the AOP, collaboratively manage the airport operations and allow  
45 communication between all the airport stakeholders and the ATM System are needed.

46 **4. Necessary System Capability**

47 **4.1 Avionics**

48 **4.2 Ground Systems**

49 The following supporting systems need to be developed and implemented:

- 50 • A data repository supporting the AOP and allowing communication with the airport stakeholders and the
- 51 ATM System
- 52 • Airport Performance Monitoring tools
- 53     o With real-time capabilities
- 54 • Decision support tools to manage the airport operations

55

56 **5. Human Performance**

57 **5.1 Human Factors Considerations**

58 TBD

59 **5.2 Training and Qualification Requirements**

60 TBD

61 **5.3 Others**

62 TBD

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68 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

69 TBD

70 **7. Implementation and Demonstration Activities**

71 **7.1 *Current Use***

- 72
  - **None at this time**

73 **7.2 *Planned or Ongoing Trials***

- 74
  - **Europe:** For SESAR validation carried out by 2015.

- 75
  - **USA:** For NextGen validation carried out by 2015

76 **8. Reference Documents**

77 **8.1 *Standards***

78 TBD

79 **8.2 *Procedures***

80 TBD

81 **8.3 *Guidance Material***

82 TBD

83

# 1 Module N° B1-81: Remotely Operated Aerodrome Control

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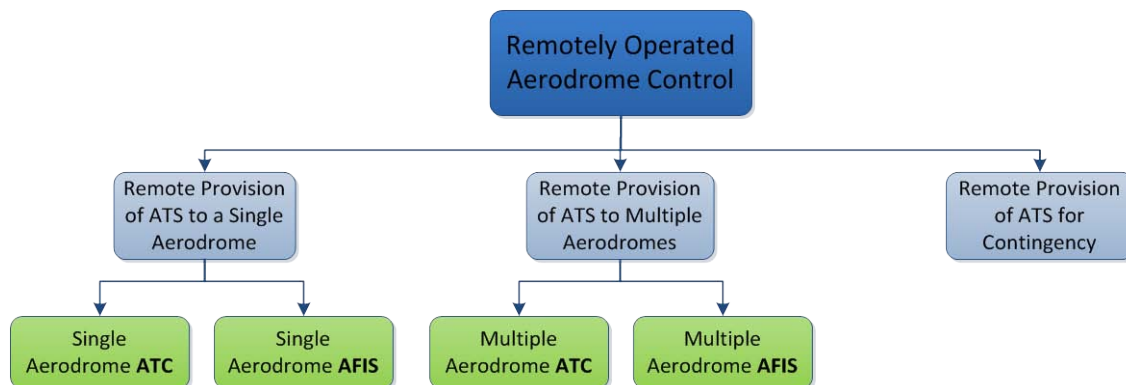
<b>Summary</b>	<p>The performance objective is to provide a safe and cost effective ATS to aerodromes where dedicated, local ATS is no longer sustainable or cost effective, but there is a local economic and social benefit from aviation</p> <p>Remotely Operated Aerodrome Control concerns the provision 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.</p>	
<b>Main Performance Impact</b>	KPA-04 Efficiency; KPA-10 Safety	
<b>Domain / Flight Phases</b>	TMA, Descent, Airport Surface, Climb Out.	
<b>Applicability Considerations</b>	<p>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.</p> <p>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.</p> <p>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.</p>	
<b>Global Concept Component(s)</b>	<p>CM: Conflict Management</p> <p>AO: Airport Operations</p>	
<b>Global Plan Initiatives (GPI)</b>	<p>GPI-13 Aerodrome design and management</p> <p>GPI-15 Match IMC and VMC operating capacity</p> <p>GPI-9 Situational awareness</p>	
<b>Main Dependencies</b>	None	
<b>Global Readiness Checklist</b>		<b>Status (ready or date)</b>
	Standards Readiness	Est. 2018
	Avionics Availability	Est. 2018
	Infrastructure Availability	Est. 2018
	Ground Automation Availability	Est. 2018
	Procedures Available	Est. 2018
	Operations Approvals	Est. 2018

## 3 1. Narrative

### 4 1.1 General

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

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



11  
12

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

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

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

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

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

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

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

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

49



### 50 **1.1.1 Baseline**

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

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

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

### 57 **1.1.2 Change brought by the module**

58 The main improvements will be:

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

## 67 **1.2 Element 1: Remote Provision of ATS for Single Aerodromes**

68 The objective of Remote Provision for a Single Aerodrome is to provide the ATS defined in ICAO Documents  
69 4444, [9426](#) and EUROCONTROL's Manual for AFIS for one aerodrome from a remote location. The full  
70 range of ATS should be offered in such a way that the airspace users are not negatively impacted (and  
71 possibly benefit) compared to local provision of ATS. The overall ATS will remain broadly classified into  
72 either of the two main service subsets of TWR or AFIS.

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

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

## 79 **1.3 Element 2: Remote Provision of ATS for Multiple Aerodromes**

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

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

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

- 92 • Resource Management – balancing of shift size according to the number of aerodromes, traffic  
93 demand, and the number of aerodromes a single ATCO/AFISO can provide service to;
- 94 • Controller Working Positions – the number and configuration of CWP in the RTC. A single CWP  
95 may serve one aerodrome, several aerodromes, or share service provision to the same aerodrome  
96 with other CWP (larger aerodromes only);

- 97 • Operating Methods – it is expected that the ATCO/AFISO will be able to provide ATS to more  
98 aerodromes when there are no current aircraft movements at those aerodromes yet the airspace is  
99 Established and provision of ATS is required. As traffic increases, the maximum number of  
100 aerodromes per single ATCO/AFISO will decrease;
- 101 • Air Traffic Management – The ability to accommodate both IFR and VFR traffic requires  
102 management – demand and capacity balance. Slot coordination and traffic synchronisation across  
103 multiple aerodromes will help extract maximum benefit from Multiple Tower by reducing the  
104 occasions when several aerodromes have simultaneous aircraft movements;
- 105 • Aerodrome clustering – the selection of which aerodromes can be operated in parallel by a single  
106 ATCO/AFISO;
- 107 • Approach Control – whether the approach control is also provided by the multiple aerodrome  
108 ATCO/AFISO, whether it is provided by a dedicated APP controller, or a combination of both;
- 109 • Each factor contains several options and it is the combination of these options for a given set of  
110 aerodromes that determines the make-up of an RTC.

#### 111 **1.4 Element 3: Remote Provision of ATS for Contingency Situations**

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

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

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

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

#### 126 **1.5 Element 4:**

### 127 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	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
<i>Efficiency</i>	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
<i>Cost Effectiveness</i>	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.

<i>Flexibility</i>	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
<i>Safety</i>	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.

<i>CBA</i>	<p>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.</p> <p>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.</p> <p>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.</p> <p>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).</p>
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128

### 129 3. Necessary Procedures (Air & Ground)

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

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

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

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

143 **4. Necessary System Capability**

144 **4.1 Avionics**

145 NIL

146 **4.2 Ground Systems**

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

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

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

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

162 Specification are already available in RTCA and EUROCAE documents.

163 **5. Human Performance**

164 **5.1 Human Factors Considerations**

165 TBD

166 **5.2 Training and Qualification Requirements**

167 TBD

168 **5.3 Others**

169 TBD

170 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

174 **7. Implementation and Demonstration Activities**

175 **7.1 Current Use**

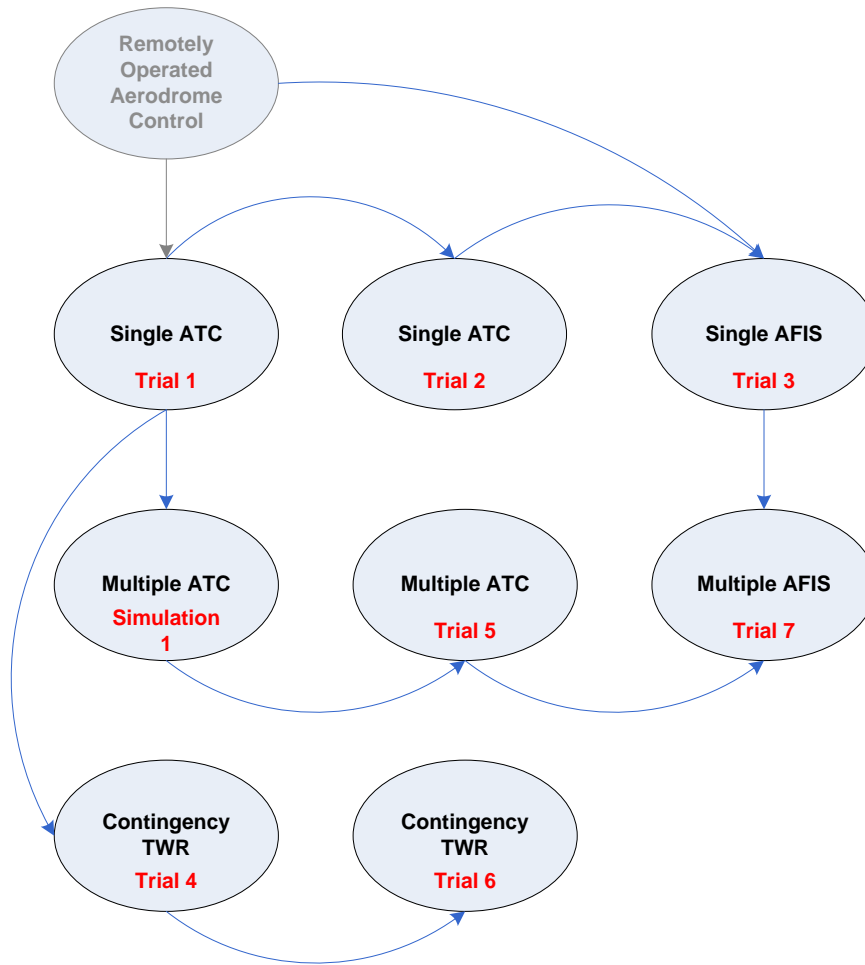
176 There is no current operational use of Remotely Operated Aerodrome Control in normal operations. Some  
177 aerodromes have contingency facilities, but none that include an OTW view.

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

182 **7.2 Planned or Ongoing Trials**

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

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



187  
 188 Shadow Mode trials for the Single Tower service will take place in 2011 and 2012.  
 189 A Real Time Simulation for the Multiple Tower service will be conducted in 2012, followed by Shadow Mode  
 190 trials in 2013 and 2014. Shadow Mode trials for the Contingency Service will take place in 2013 and 2014.  
 191

192 **8. Reference Documents**

193 **8.1 Standards**

194 TBD

195 **8.2 Procedures**

196 TBD

197 **8.3 Guidance Material**

198 TBD

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# 1 Module N° B1-15: Improved Airport operations through

## 2 Departure, Surface and Arrival Management

<b>Summary</b>	Extended arrival metering, Integration of surface management with departure sequencing bring robustness to runways management and increase airport performances and flight efficiency.	
<b>Main Performance Impact</b>	KPA-02 Capacity; KPA-04 Efficiency; <b>KPA-09 Predictability</b> , KPA-06 Flexibility	
<b>Domain/ Flight Phases</b>	Aerodrome and Terminal	
<b>Applicability Considerations</b>	Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.  Complexity in implementation of this module 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 module. PBN routes need to be in place.	
<b>Global Concept Element(s)</b>	TS – Traffic Synchronization AO – Airport operations	
<b>Global Plan Initiative</b>	GPI-6 Air Traffic Flow Management GPI-12 Functional integration of ground systems with airborne systems GPI-14 Runway operations GPI-16 Decision support systems and alerting systems	
<b>Pre-Requisites</b>	B0-15, B0-75	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est 2018</b>
	Avionics Availability	<b>Est. 2018</b>
	Infrastructure Availability	<b>Est. 2018</b>
	Ground Automation Availability	<b>Est. 2018</b>
	Procedures Available	<b>Est. 2018</b>
	Operations Approvals	<b>Est. 2018</b>

### 3 1. Narrative

#### 4 1.1 General

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

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

14 In particular, improved surface surveillance and management will facilitate the optimal use of movement  
15 areas.

16 The synergy of precise surface management and departure sequencing will further hone the predictability and  
17 accuracy of departure times assigned to flights. It will enable departure dynamic spacing and sequencing,  
18 leading to a higher departure rate. Departure and arrival patterns can be adjusted to lessen the impact  
19 separation procedures posed.

20 Flights can be sequenced such that the effect of natural phenomena (i.e. wake turbulence) can be mitigated.  
21 Wake turbulence effects can be minimized by putting a series of heavy aircrafts behind light aircrafts, as wake  
22 turbulence generated by light aircrafts dissipates quickly. The coupling of surface and departure management  
23 enables greater flexibility in runway balancing. Runway can be re-configured to adapt and support the ever  
24 changing arrival and departure scenarios. The runway can be configured such that wake turbulence effects  
25 can be circumvented, e.g. dedicated runways for heavies and light aircrafts that diverge into different  
26 directions.

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

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

37 This module also seeks to increase the utilisation of performance based navigation procedures such as  
38 RNAV/RNP procedures in high density areas. RNAV/RNP procedures can efficiently direct flights into arrival  
39 and departure metering fixes. Procedures such as Standard Terminal Arrival (STAR) and Standard Instrument  
40 Departure (SID) are of tremendous efficacy in managing strained resources at high density areas. This will  
41 further optimize both aerodrome and terminal resource allocation.

### 42 **1.1.1 Baseline**

43 Module B0-15 introduced time based arrival metering, arrival and departure management automation. These  
44 automations work independently, with the ATC personnel serving as the integrator of information generated  
45 by these systems.

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

51 **Departure management automation** provides departure scheduling. Departure scheduling will optimise the  
52 sequence in which the flow is fed to the adjacent ATC authorities. Departure is sequenced based on flights'  
53 arrival flow constraints if necessary (non specialized or runways, departure/arrival interference). Departure  
54 management also provides automated disseminations and communication of departure restriction, clearance,  
55 and other relevant information.

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

### 60 **1.1.2 Change brought by the module**

61 This module will enable **surface management, extended arrival metering, and departure/surface**  
62 **integration**. Departure management automation will eliminate conflicts and provide smoother departure  
63 operations and streamlined synchronization with adjacent ATC authority. Enhanced surface movement  
64 tracking and control will decrease each flight's runway occupancy time on the aerodrome surface, thus  
65 boosting aerodrome throughput. In addition, integrated surface and departure management enable more  
66 flexible runway balancing, further increase aerodrome throughput. This integration will also facilitate more



67 efficient and flexible departure operations and ensure optimized resource allocation both on the aerodrome  
68 surface and in the terminal airspace.

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

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

### 81 **1.2 Element 1: Surface Management**

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

### 89 **1.3 Element 2: Departure and Surface Integration**

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

98  
99 These measures serve to increase aerodrome throughput and departure rates.

### 100 **1.4 Element 3: Extended Arrival Metering**

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

### 107 **1.5 Element 4: Utilization of RNAV/RNP routes**

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

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## 2. Intended Performance Operational Improvement/Metric to determine success

Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Time based metering will optimize usage of terminal airspace and runway capacity. Optimize utilization of terminal and runway resources.
<i>Efficiency</i>	Surface Management decreases runway occupancy time, more robust departure rates, and enables dynamic runway rebalancing and re-configuration. Departure/Surface integration enables dynamic runway rebalancing to better accommodate arrival and departure patterns. Reduction in airborne delay/holding <i>Traffic flow synchronization between en-route and terminal domain.</i> RNAV/RNP procedures will optimize aerodrome/terminal resource utilization.
<i>Predictability</i>	Decrease uncertainties in aerodrome/terminal demand prediction. Increased compliance with assigned departure time and more predictable and orderly flow into metering points Greater compliance to Controlled Time of Arrival (CTA) and more accurate assigned arrival time and greater compliance
<i>Flexibility</i>	Enables dynamic scheduling.
<i>Safety</i>	Greater precision in surface movement tracking
<i>Environmental</i>	Reduction in fuel burn and environment impact (emission and noise)

120

<i>CBA</i>	<p>Surface management streamlines traffic flow on the aerodrome surface and facilitate more efficient use of runways and increase runway capacity. In addition, surface management smoothen 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.</p> <p>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</p> <p>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.</p> <p>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.</p>
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### 121 **3. Necessary Procedures (Air & Ground)**

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

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

### 128 **4. Necessary System Capability**

#### 129 **4.1 Avionics**

130 No additional avionics is required beyond block 0 requirements for the implementation of this module, i.e;  
131 FMS and RNP plus Data-link for transmission of the clearance (D-TAXI, CTA transmission,)

#### 132 **4.2 Ground Systems**

133 Surface management requires more precise surface movement tracking. (B0-75 A-SMGCS )

134 Ground automation support is required with appropriate information exchange between ATC, Airport  
135 operations and airlines operations. (see B0-80 and B1-80)

136 Mechanism to share surface information effectively and in a timely manner is essential to this element and  
137 also fosters greater common situational awareness between all users of the aerodrome surface.

138 Extended transmission of CTA to the upstream ATC authorities (B0-25 B1-25, SWIM B1-31)

### 139 **5. Human Performance**

#### 140 **5.1 Human Factors Considerations**

141 Automation support is needed for Air Traffic Management in airspace with high demands

#### 142 **5.2 Training and Qualification Requirements**

143 Training on the required automation is needed for ATM personnel. ATM personnel responsibilities will not be  
144 affected

#### 145 **5.3 Others**

### 146 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

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

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

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

160 **7. Implementation and Demonstration Activities**

161 **7.1 Current Use**

162 **US:** Surface movement tracking and navigational systems, such as the ASDE-X, are deployed to support  
163 tracking, guidance, routing and planning of surface operations.

164 **Europe:** initial A-SMGCS (Advanced Surface Movement Guidance and Control System) is deployed to  
165 support tracking, guidance, routing and planning of surface operations.

166 Departure and surface management synchronization is currently achieved mostly through human coordination  
167 in both US and Europe.

168 In Airport CDM there is a first of integration of Departure Management and Surface Management in  
169 connection with AFTM measures. At Paris CDG the synchronisation of Departure of the gate and departure at  
170 the runways is in operation since end of 2010.

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

172 RNAV/RNP routes are implemented at the all most metroplexes across the US and Europe

173 **7.2 Planned or Ongoing Trials**

174 SMAN (Surface Manager) will be introduced as the go-to surface management tool in Europe. Similarly,  
175 Tower Flight Data Manager (TFDM) will be introduced in the US to fulfil the same role. SMAN is a function in  
176 the ASMGCS tool to maintain a safe and efficient traffic flow on the surface.

177 Departure and surface management synchronization is a crucial component in the US Time based flow  
178 management (TBFM) and AMAN/DMAN/SMAN efforts in the US and Europe. Departure and surface  
179 management harmonization will be implemented as these capabilities mature.

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

186 Extended AMAN is considered in Initial 4D SESAR project

187 The aims of the US and European efforts are congruous.

188 Extended metering will be implemented along with these capabilities as they mature.

189 **8. Reference Documents**

190 **8.1 Standards**

191 **8.2 Procedures**

192 **8.3 Guidance Material**

- 193 • [European ATM Master Plan](#),
- 194 • [SESAR Definition Phase Deliverable 2 – The Performance Target](#),
- 195 • [SESAR Definition Phase Deliverable 3 – The ATM Target Concept](#),
- 196 • [SESAR Definition Phase 5 – SESAR Master Plan](#)
- 197 • TBFM Business Case Analysis Report
- 198 • NextGen Midterm Concept of Operations v.2.0
- 199 • RTCA Trajectory Concept of Use

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# 1 Module N° B1-25: Increased Interoperability, Efficiency and 2 Capacity through FF-ICE/1 application before Departure 3

<b>Summary</b>	Introduction of FF-ICE step 1, to implement ground-ground exchanges using common flight information reference model (FIXM) and XML standard format used before departure.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, <b>KPA-07 Global Interoperability</b> , KPA-10 Safety,	
<b>Domain / Flight Phases</b>	Planning phase for FF-ICE/1	
<b>Applicability Considerations</b>	Applicable between ATC units and to facilitate exchange between ASP, Airspace user operations and airport operations.	
<b>Global Concept Component(s)</b>	DCB – Demand capacity Balancing CM - Conflict management IM - Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-6 ATFM GPI-7 Dynamic and flexible route management GPI-16 Decision Support Systems	
<b>Main Dependencies</b>	Successor of B0-25 and B0-30 (AIXM) Connection to B1-30 (AIRM) and B1-31 (SWIM)	
<b>Global Readiness Checklist</b>		<b>Status (ready or estimated date)</b>
	Standards Readiness	Est 2016
	Avionics Availability	No requirement
	Ground systems Availability	Est 2018
	Procedures Available	Est 2018
	Operations Approvals	Est 2018

## 4 1. Narrative

### 5 1.1 General

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

#### 9 1.1.1 Baseline

10 The baseline for this module is present process for submission of FPL through ICAO standardized FPL/2012  
11 messages (Amdt 1 to PANS/ATM) and automated standard for information exchange through a set of  
12 messages and limited need for direct speech coordination (B0-25).

#### 13 1.1.2 Change brought by the module

### 14 1.2 Element 1: FF-ICE/1 before departure

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

19 The objective of FF-ICE/1 is to establish the basis for transition towards a full FF-ICE deployment. This basis  
20 consists of:

- 21 • Introduction of a Globally Unique Flight Identifier: GUF1

- 22 • Introduction of common data format i.e. Flight Information eXchange Model (FIXM) in the context of
- 23 the overall transition to XML for aeronautical information.
- 24 • Introduction of basic roles, rules and procedures for submission and maintenance of FF-ICE
- 25 information including provisions for the early sharing of trajectory information.
- 26 The use of the new format will facilitate the evolution of the contents of FPL to introduce new data and solve
- 27 specific regional needs.

28 List of changes included in FF-ICE/1

- 29 1. Support for early provision of flight intention information.
- 30 2. Support for exchange of 4D Trajectory information between the AOC and the ASP
- 31 3. New format for flight and flow information using internet protocol and XML
- 32 4. Globally Unique Flight Identifier (GUFI)
- 33 5. FF-ICE/1 Information Elements (first list of Information elements).
- 34

35 The foreseen Services related to Flight Information Submission and Management in the frame of FF-ICE/1  
36 are:

- 37 • Initial submission
- 38 • Validation
- 39 • GUFI Allocation (after the initial submission)
- 40 • Nominal trajectory Generation (in absence of Airspace users defined trajectory
- 41 • Flight Information Negotiation (to solve conflict between Airspace users flight and existing
- 42 constraints)
- 43 • Flight Information Update (to change or add to current flight information)
- 44 • Acknowledgement/rejection
- 45 • Flight Information Publication
- 46 • Flight Information Subscription
- 47 • Flight Information Cancellation
- 48 • Flight Suspension
- 49 • Flight Information

### 50 1.3 Other remarks

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

### 53 2. Intended Performance Operational Improvement/Metric to determine success

54 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Reduced controller workload and increased data integrity supporting reduced separations translating directly to cross sector or boundary capacity flow increases.
<i>Efficiency</i>	Better knowledge of aircraft capabilities allows trajectories closer to Airspace user preferred trajectories and better planning
<i>Global Interoperability</i>	The use of new mechanism for FPL filling and information sharing will facilitate the Flight data sharing among the actors.
<i>Participation by the ATM community</i>	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...
<i>Safety</i>	More accurate flight information

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<i>CBA</i>	The new services have to be balanced by the cost of software change in the ASP, AOC and airport ground systems
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### 56 **3. Necessary Procedures (Air & Ground)**

- 57 • Required procedures exist. They need local instantiation on the specific flows; the experience from
- 58 other regions can be a useful reference.
- 59 • Means of compliance: EUROCONTROL On-Line Data Interchange (OLDI) standard
- 60 • FF-ICE/1 Manual, SARPS and concept of use to be developed.

### 61 **4. Necessary System Capability**

#### 62 **4.1 Avionics**

63 There are no specific airborne requirements, but use of Electronic Flight Bag onboard associated to high  
 64 speed connection, in particular when aircraft is on the ground, could facilitate the FF-ICE information sharing  
 65 with both AOC and ASP.

#### 66 **4.2 Ground Systems**

67 FF-ICE/1 SARPS, FIXM and Interface need to be used and require further developments in ground systems.  
 68 Airspace users systems will need to be modified to support the provision of FF-ICE to ANSPs.

### 70 **5. Human Performance**

#### 71 **5.1 Human Factors Considerations**

72 TBD

#### 73 **5.2 Training and Qualification Requirements**

74 Training to the new procedures and change in flight data information is required for operators in charge of  
 75 their provision and for the users of these informations.

#### 76 **5.3 Others**

77

### 78 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

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

83 For FF-ICE/1 SARPS should be developed and validated (cf ATMRPP tasks, ref WP470, 479, 480)

### 84 **7. Implementation and Demonstration Activities**

#### 85 **7.1 Current Use**

#### 86 **7.2 Planned or Ongoing Trials**

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

### 88 **8. Reference Documents**

89 Same as B0-25 +

#### 90 **8.1 Standards**

- 91 • Eurocae ED-133 June 09 Flight Object Interoperability Specification
- 92 • FF-ICE/1 based on FIXM to be developed

93 **8.2** *Procedures*

94 **8.3** *Guidance Material*

95 • [FF-ICE concept document](#)

96 • Eurocontrol OLDI V4.2

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# 1 Module N° B1-30: Service Improvement through Integration of 2 all Digital ATM Information

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity; <b>KPA-03 Cost-Effectiveness</b> ; KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All phases of flight	
<b>Applicability Considerations</b>	Applicable at State level, with increased benefits as more States participate	
<b>Global Concept Component(s)</b>	IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-18 Electronic information services	
<b>Pre-Requisites</b>	Successor of: B0-30 Parallel progress with: B1-25, B1-31	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est. 2018</b>
	Avionics Availability	<b>NA</b>
	Ground Systems Availability	<b>Est. 2018</b>
	Procedures Available	✓
	Operations Approvals	<b>Est. 2018</b>

## 4 1. Narrative

### 5 1.1 General

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

#### 12 1.1.1 Baseline

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

#### 15 1.1.2 Change brought by the module

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

22 **2. Intended Performance Operational Improvement/Metric to determine success**

23 Metrics to determine the success of the module are proposed at Appendix C.

<i>Access and Equity</i>	Greater and timelier access to up-to-date information by a wider set of users.
<i>Cost Effectiveness</i>	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.
<i>Global Interoperability</i>	Essential for global interoperability.
<i>Safety</i>	Reduced probability of error or inconsistency in/across data; reduced possibility to introduce additional errors by subsequent manual inputs.
<i>Security</i>	Information security considerations are embedded in the developments.

<i>CBA</i>	Business case to be established in the course of the projects defining the models and their possible implementation.
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25 **3. Necessary Procedures (Air & Ground)**

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

27 **4. Necessary System Capability**

28 **4.1 Avionics**

29 No avionics requirement.

30 **4.2 Ground Systems**

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

33 **5. Human Performance**

34 **5.1 Human Factors Considerations**

35 The use of a common model supported by the industrial IT tools is of a nature reduce errors in manual  
36 transcription of data and in the management of information.

37 **5.2 Training and Qualification Requirements**

38 Training is required for personnel managing the ATM information and for their users if the interfaces and  
39 access conditions change.

40 **5.3 Others**

41 Nil

42 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

44 **7. Implementation and Demonstration Activities**

45 **7.1 Current Use**

46 None at this time.

47 **7.2 *Planned or Ongoing Activities***

- 48   ▪ **Europe:** SESAR is currently defining and validating the ATM Information Reference Model (AIRM) &  
49 Information Service Reference Model (ISRM) including the specific data models Weather Exchange  
50 model (WXXM), Flight Information Exchange Model (FIXM). For more information see [www.aixm.aero](http://www.aixm.aero),  
51 [www.wxxm.aero](http://www.wxxm.aero) and [www.fixm.aero](http://www.fixm.aero).
- 52   ▪ **US:** This is covered through the EA OV-7 and associated service model activities of the NextGen  
53 programme.
- 54   ▪ US-Europe cooperation is in place on the joint development and maintenance of the data models  
55 AIXM/WXXM/FIXM and the overall AIRM framework (OV-7 view in FAA Enterprise Architecture)

56 **8. Reference Documents**

57 **8.1 *Standards***

- 58   ▪ New PANS-AIM document (2016) to address all formatting/template type information of [Annex 15](#) & [Doc](#)  
59 [8126](#)

60 **8.2 *Procedures***

61       TBD

62 **8.3 *Guidance Material***

- 63   ▪ WXXM available in 2012

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# 1 Module N° B1-31: Performance Improvement through the 2 application of System Wide Information Management (SWIM) 3

<b>Summary</b>	Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximise interoperability.	
<b>Main Performance Impact</b>	<b>KPA-03 Cost-Effectiveness</b> , KPA-05 Environment, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All phases of flight	
<b>Applicability Considerations</b>	Applicable at State level, with increased benefits as more States participate	
<b>Global Concept Component(s)</b>	IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-18 Electronic information services	
<b>Pre-Requisites</b>	Successor of: B0-30 Parallel progress with: B1-30	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est. 2016</b>
	Avionics Availability	<b>NA</b>
	Ground Systems Availability	<b>Est. 2018</b>
	Procedures Available	<b>Est. 2016</b>
	Operations Approvals	<b>Est. 2016</b>

## 4 1. Narrative

### 5 1.1 General

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

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

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

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

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

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

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

51 **1.1.1 Baseline**

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

58 **1.1.2 Change brought by the module**

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

64 The module addresses applications of SWIM on the ground. Most of the air ground data exchanges will  
 65 remain based on point-to-point communication.

66

67 **2. Intended Performance Operational Improvement/Metric to determine success**

68 Metrics to determine the success of the module are proposed at Appendix C.

<i>Cost Effectiveness</i>	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
<i>Efficiency</i>	(indirect) Using better information allows operators and service providers to plan and execute better trajectories
<i>Environment</i>	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
<i>Safety</i>	access protocols and data quality will be designed to reduce current limitations in these area
<i>Security</i>	access protocols and data quality will be designed to reduce current limitations in these area

<i>CBA</i>	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
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### 70 **3. Necessary Procedures (Air & Ground)**

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

### 75 **4. Necessary System Capability**

#### 76 **4.1 Avionics**

77 No avionics requirement.

#### 78 **4.2 Ground Systems**

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

### 81 **5. Human Performance**

#### 82 **5.1 Human Factors Considerations**

83 SWIM is a new concept to address information and its use. In essence it is close to the notion of an intranet. It  
 84 therefore needs to be understood as such by all personnel, which will need to be aware of the principles and  
 85 conditions of use. In addition, the architecture (logical and physical) and the management of the information  
 86 data will be different from today and affect those that were in charge of these functions. End-users will be  
 87 affected only if their access to data via interfaces does not remain stable.

#### 88 **5.2 Training and Qualification Requirements**

89 Training will be requirements will be high.

#### 90 **5.3 Others**

91 Nil

### 92 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

94 SWIM governance (set of policies, best practices, roles and responsibilities apportionment) and rules for  
 95 SWIM enabling services (as part of the infrastructure: Service catalogue, Information discovery, SWIM  
 96 security, SWIM supervision, SWIM Recording – not limited to the legacy infrastructure) should be established.

### 97 **7. Implementation and Demonstration Activities**

#### 98 **7.1 Current Use**

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

101   ▪   **US:** tbc.

102   **7.2   *Planned or Ongoing Activities***

103   ▪   **Europe:**

104       ○   SWIM Step1 infrastructure demonstration by the end of 2011

105       ○   Planned Release 2 V&V SWIM-enabled exercises:

106           ▪   “*IOP Validation*”: ATC-ATC Coordination by means of a new mechanism based on the  
107               Flight Object

108           ▪   “*Slot Swapping*”: DMEAN implemented improvement (slot swapping). Prototype of  
109               enhanced slot swapping function to cover extension to all flights from/to a given airport.

110           ▪   “*UDPP extension to 4D BT FTS*”: Extension to full 4D business/mission trajectory. Testing  
111               of different models for priority rules and collaborative prioritization. UDPP extended to en-  
112               route congestion.

113           ▪   “*AIMQuick win (Step1)*”: Validate new ways of publishing complex up-to-date aeronautical  
114               information based on the Digital NOTAM concept with its particular temporality data  
115               representation.

116       ○   SESAR trials in 2013-16 for SWIM protocols and prototype

117   ▪   **US:** tbc.

118   **8.    Reference Documents**

119   **8.1   Standards**

120   ▪   New PANS-AIM document (2016) to address all formatting/template type information of [Annex 15](#) &  
121       [Doc8126](#)

122   **8.2   Procedures**

123       TBD

124   **8.3   Guidance Material**

125   ▪   WXXM available in 2012

126



## Module N° B1-10: Improved Operations through Free Routing

<b>Summary</b>	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, application of reduced route spacing based on more consistent and accurate navigational behaviour, and dynamic sectorisation.	
<b>Main Performance Impact</b>	KPA-02 Capacity, <b>KPA-04 Efficiency</b> , KPA-05 Environment	
<b>Operating Environment/Phases of Flight</b>	En-route, TMA, incl. Oceanic & Remote areas	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	AOM – Airspace Organisation and Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-1 Flexible use of airspace GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>	Successor of: B0-10 Predecessor of: B3-10	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	✓
	Avionics Availability	✓
	Ground System Availability	✓
	Procedures Available	<b>Est. 2018</b>
	Operations Approvals	<b>Est. 2018</b>

### 1. Narrative

#### 1.1 General

##### 1.1.1 Baseline

The baseline is the use of published routes and fixed sectors; 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.

In addition, where/when traffic flows and density justifies the pre-arrangement of traffic over published routes as a means to systemise traffic management by ATC and maximise the resulting capacity, the dispersion of navigational errors, especially during turns of aircraft equipped with traditional RNAV, leads to apply spacing based on that dispersion and prevents the achievement of an efficient route design.

##### 1.1.2 Change brought by the module

The module is the opportunity to exploit further PBN capabilities, beyond the benefits achieved by B0-10, in order to continue eliminating design constraints and operating more flexibly.

20 The module is made of the following elements:

- 21 ▪ Free routing;
- 22 ▪ Reduced route spacing;
- 23 ▪ Dynamic sectorisation.

### 24 **1.2 Element 1: Free Routing**

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

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

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

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

38 The benefits of free routing are primarily in terms of adherence to the user-preferred profile. ATC may need to  
39 be provided with the necessary tools to ensure flight progress monitoring and coordination activities, and  
40 conflict prediction.

### 41 **1.3 Element 2: Reduced Route Spacing**

42 A key tenet of the PBN concept is to combine the accuracy and functionality of navigation in specifications  
43 which can be tailored to the intended operations.

44 A serious problem with the use of classical RVAV in the last decades has not been the achieved accuracy on  
45 straight segments, but the behaviour of aircraft in transiting phases, especially turns, where significant  
46 differences are noted from one aircraft to the next and depending on conditions such as wind. This has  
47 resulted in the inability to exploit the intrinsic accuracy and to design better routes, due to the need to protect  
48 large volumes of airspace.

49 This element addresses not only routes. It also provides improvements to other issues related to lateral  
50 navigation and can be summarised as follows:

- 51 ▪ Closer route spacing, particularly en route;
- 52 ▪ Maintaining same spacing between routes on straight and turning segments without a need to increase  
53 route spacing on the turn;
- 54 ▪ Reduction of the size of the holding area to permit holds to be placed closer together or in more optimum  
55 locations;
- 56 ▪ Aircraft ability to comply with tactical parallel offset instructions as an alternative to radar vectoring;
- 57 ▪ Means of enabling curved approaches, particularly through terrain rich areas.

58 The selection of a suitable PBN specification will eliminate the above shortcomings, and allow to design in  
59 both en-route and TMA routes which require lower spacing between them, directly resulting in higher airspace  
60 capacity, additional design flexibility and generally more efficient routes as well.

### 61 **1.4 Element 3: Dynamic Sectorisation**

62 The improvements in the design of the route network or the possibility to fly outside of a fixed route network  
63 make the pattern and concentration of traffic not always the same. Where sectorisation is designed to create  
64 capacity for ATC, the implementation of the above elements requires that the sectorisation be adjusted more  
65 dynamically than only in strategic ATC phases.

66 This dynamic sectorisation can take several forms, the most complex/dynamic ones with real-time design  
 67 computing are considered beyond Block 1. In this module, dynamic sectorisation can take simple forms such  
 68 as:

69 - a pre-defined volume of airspace being swapped from a sector to an adjacent sector;

70 - catalogues of pre-defined sector configurations based on a defined mosaic of elementary volumes, allowing  
 71 a more general application of the above;

72 - sectors based on an organised (dynamic) track structure.

73 The dynamic sectorisation is applied in real-time by selecting the most suitable configuration among those  
 74 available. Unlike grouping/degrouping of sectors, it does not affect the number of control position in use.  
 75 Dynamic sectorisation should be based on an assessment of the traffic situation expected in the next  
 76 minute/hour.

77 Dynamic sectorisation can also be applied across FIR/ANSP boundaries.

## 78 2. Intended Performance Operational Improvement/Metric to determine success

79 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	<p>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.</p> <p>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.</p> <p>Reduced route spacing means reduced consumption of airspace by the route network and greater possibility to match it with flows.</p>
<i>Efficiency</i>	<p>Trajectories closer to the individual optimum by reducing constraints imposed by permanent design and/or by the variety of aircraft behaviours. 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.</p> <p>Where capacity is not an issue, fewer sectors may be required as the spreading of traffic or better routings should reduce the risk of conflicts.</p> <p>Easier design of high-level Temporary Segregated Airspace (TSAs).</p>
<i>Environment</i>	<p>Fuel burn and emissions will be reduced; however, the area where emissions and contrails will be formed may be larger.</p>
<i>Flexibility</i>	<p>Choice of routing by the airspace user would be maximised. Airspace designers would also benefit from greater flexibility to design routes that fit the natural traffic flows.</p>

<i>CBA</i>	<p>The business case of free routing 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).</p>
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## 81 3. Necessary Procedures (Air & Ground)

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

87 **4. Necessary System Capability**

88 **4.1 Avionics**

89 Aircraft need to be suitably equipped. This is a matter of accuracy and functionality, i.e. a suitable PBN  
90 specification(s).

91 **4.2 Ground Systems**

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

96 Dynamic sectorisation requires the FDPS to be able to work with different sector configurations and sector  
97 grouping/degrouping functionality, which is available in many systems today.

98 **5. Human Performance**

99 **5.1 Human Factors Considerations**

100 The change step is achievable from a human factors perspective. The roles and responsibilities of  
101 controller/pilot are not affected. Free routing, when compared to a structured route system, can reduce the  
102 number of potential interactions between flights but makes their occurrence less predictable and their  
103 configurations more variable. This is why it needs to be supported by automated assistance to  
104 understand/visualise the flight paths and their interactions as soon as traffic is significant. It is easier to  
105 implement it progressively, e.g. starting in low traffic conditions/periods.

106 Reduced route spacing has no direct human performance incidence.

107 **5.2 Training and Qualification Requirements**

108 The required training is available.

109 **5.3 Others**

110 Nil

111 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

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

113 **7. Implementation and Demonstration Activities**

114 **7.1 Current Use**

115 **Oceanic areas:** tbc

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

119 A CBA conducted in 2001 for a Free Route Airspace (FRA) implementation initially planned in Europe in  
120 2006 concluded as follows:

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

124 The total costs of implementing FRA are estimated at € 53M, incurred mostly in 2005 and 2006. The  
125 benefit (reduced flight distances and times due to more direct flights) in the first year of operation, 2007, is  
126 € 27M, and the benefit is expected to increase each year with traffic growth. FRA is likely to become  
127 'financially beneficial' (ie the financial benefits will be greater than the costs) because the costs are mostly  
128 incurred once while the benefits cumulate year on year. The CBA shows that, under the baseline  
129 assumptions, the cumulative benefits will overtake the costs in 2009. Over the 10 year project lifetime,

130 from 2005 to 2014, the project has a Net Present Value (NPV) of € 76M and an Internal Rate of Return  
131 (IRR) of 40%.

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

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

146 The A-RNP specification is being proposed for a European regulation to progressively enter into force in  
147 2018. Advanced RNP is set to become the next ECAC-wide navigation specification used in en-route and  
148 terminal airspace, including the approach, missed approach and departure phases of flights. It serves an  
149 airspace concept, extending well beyond PBN, and having the following characteristics: parallel network  
150 of ATS routes, based; system of feeder or link routes which connect to P-RNAV or Conventional SIDs and  
151 STARs starting at the nominal TMA boundary; organised track system (OTS ) in the north Atlantic based  
152 on MNPS; airspace Classification Class C above FL195; extensive use of the Flexible Use of Airspace  
153 concept; limited use of Free Route Airspace; evolution from State managed upper airspace to Functional  
154 Airspace Blocks.

- 155 ▪ **US:** tbc
- 156 ▪ **Australia:** tbc

## 157 **7.2 Planned or Ongoing Activities**

- 158 ▪ **Terra X:** tbc.

## 159 **8. Reference Documents**

### 160 **8.1 Standards**

- 161 ▪ PANS-ATM (Doc 4444), Procedures for Air Navigation Services — Air Traffic Management Chapter 5

### 162 **8.2 Procedures**

163 TBD

### 164 **8.3 Guidance Material**

- 165 ▪ [Doc 9426](#), Air Traffic Services Planning Manual
- 166 ▪ [Doc 9689](#), Manual on Airspace Planning Methodology for the Determination of Separation Minima
- 167 ▪ [Doc 9613](#), Performance-based Navigation (PBN) Manual
- 168 ▪ [Doc 9554](#), Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to  
169 Civil Aircraft Operations
- 170 ▪ [Doc 9750](#), Global Air Navigation Plan
- 171 ▪ [Doc 9854](#), Global Air Traffic Management Operational Concept
- 172 ▪ ICAO Global Collaborative Decision Making (CDM) Guidelines (under development)
- 173 ▪ [ICAO Circular 330](#) AN/189 Civil/Military Cooperation in Air Traffic Management

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# 1 Module N° B1-35: Enhanced Flow Performance through 2 Network Operational Planning

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	<b>KPA-02 Capacity</b> ; KPA-04 Efficiency; KPA-08 Participation by the ATM Community; KPA-09 Predictability	
<b>Operating Environment/Phases of Flight</b>	Pre-flight phases, some action during actual flight	
<b>Applicability Considerations</b>	Region or sub-region for most applications; specific airports in case of initial UDPP. This module is more particularly needed in areas with the highest traffic density. However, the techniques it contains would also be of benefit to areas with lesser traffic, subject to the business case	
<b>Global Concept Component(s)</b>	DCB Demand-Capacity Balancing TS Traffic Synchronisation AOM Airspace Organisation and Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-1 Flexible use of airspace GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>	Successor of: B0-35, B0-10 (FUA aspects in particular) Predecessor of B2-35	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	<b>Est. 2018</b>
	Avionics Availability	<b>NA</b>
	Ground Systems Availability	<b>Est. 2018</b>
	Procedures Available	<b>Est. 2018</b>
	Operations Approvals	<b>Est. 2018</b>

## 4 1. Narrative

### 5 1.1 General

6 This module introduces enhanced processes to manage flows or groups of flights in order to improve overall  
7 fluidity. It also increases the collaboration among stakeholders in real time so as to better know user  
8 preferences, inform on system capabilities, and further apply CDM in a certain set of problems/circumstances,  
9 in particular to take into account priorities of an airline among flights within its schedule. It also extends the  
10 notion of flexible use of airspace so as to include network efficiency considerations.

#### 11 1.1.1 Baseline

12 The previous module, B0-35, provided a solid foundation for regulating traffic flows, and B0-10 introduced  
13 flexible use of airspace (FUA). The experience shows that further improvements can be introduced: managing  
14 airspace and traffic flows needs to be better integrated into the notion of network operations, ATFM  
15 techniques and algorithms can be improved and in particular could better take into account user preferences.

16 **1.1.2 Change brought by the module**

17 This module introduces enhanced processes to manage flows or groups of flights in order to improve overall  
18 fluidity. This module refines ATFM techniques, integrates the management of airspace and traffic flows in  
19 order to achieve greater efficiency in their management. It also increases the collaboration among  
20 stakeholders in real time so as to better know user preferences, inform on system capabilities, further apply  
21 CDM in a certain set of problems/circumstances in particular to take into account priorities of an airline among  
22 flight within its schedule.

23 **1.2 Element 1: Improved ATFM and AFTM-AOM integration**

24 Studies have shown that there is room for improvement of the ATFM algorithms and techniques. The module  
25 will implement those that will have been validated in the period of reference.

26 A particular development is required to accommodate the use of free routings implemented in B1-10.

27 In addition, with ATFM having introduced the notion of re-routing, either for ATC capacity constraints or to  
28 avoid other phenomena such as severe weather, it appears that a greater integration of ATFM and airspace  
29 management would bring significant benefits to traffic, not only civil traffic, but also for the more dynamic  
30 definition of areas which may be used for military.

31 **1.3 Element 2: Synchronisation**

32 When getting really closer to capacity limits, the small variations in take-off time allowed by ATFM slots may  
33 still generate local bunching of traffic at times, which are extremely sensitive at a small number of choke-  
34 points in the network. It would therefore be useful to be able to anticipate on these situations once the flight is  
35 airborne and the uncertainties on its trajectory are reduced compared to before take-off, by using trajectory  
36 predictions and perform additional smoothing, not only along a flow (miles in trail) but for several converging  
37 flows at a few number of most critical choke points in a given airspace.

38 **1.4 Element 3: Initial UDPP**

39 User Driven Prioritisation Process is designed to allow airspace users to intervene more directly in the  
40 implementation of flow regulations, in particular in cases where an unplanned degradation of capacity  
41 significantly impacts the realisation of their schedule. The module proposes a simple mechanism by which the  
42 affected airlines can collaboratively among themselves and with ATFM come to a solution which takes into  
43 account their commercial/operational priorities which are not known by ATM. Due to the potential complexity  
44 of several intricate prioritisation and allocation processes, this module will implement UDPP only in specific  
45 situations, e.g. when the perturbation affects one airport.

46 **1.5 Element 4: Full FUA**

47 ICAO development of FUA documentation on civil/military cooperation.

48 The full FUA introduces mechanisms, in conjunction with the more dynamic ATS routes (module B1-10) to  
49 make the airspace and its use as flexible as possible and a continuum that can be used in an optimal manner  
50 by the civil and military users.

51 **1.6 Element 5: Complexity Management**

52 The introduction of improved complexity and workload assessment tools is a means to improve the accuracy  
53 and reliability of the identification and mitigation of capacity constraints, both in the tactical ATFM phase as  
54 well as during the flight. This exploits information on planned incoming traffic.

55 **2. Intended Performance Operational Improvement/Metric to determine success**

56 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Better use of the airspace and ATM network, with positive effects on the overall cost-efficiency of ATM. Optimisation of DCB measures by using assessment of workload/complexity as a complement to capacity.
<i>Efficiency</i>	Reduction of flight penalties supported by airspace users.
<i>Environment</i>	Some minor improvement is expected compared to the module's baseline.



<i>Predictability</i>	Airspace users have a greater visibility and say on the likelihood to respect their schedule and can make better choices based on their priorities.
<i>Safety</i>	The module is expected to further reduce the number of situations where capacity or acceptable workload would be exceeded.

<i>CBA</i>	The business case will be a result of the validation work being undertaken.
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57

### 58 **3. Necessary Procedures (Air & Ground)**

59 New procedures to exploit the new techniques: for ATC to communicate in-flight measures to crews; for  
60 informing operators before departure.

61 UDPP rules and application criteria will need be defined.

### 62 **4. Necessary System Capability**

#### 63 **4.1 Avionics**

64 No avionics impact.

#### 65 **4.2 Ground Systems**

66 Ground ATFM/AOM tools, offering access to aircraft operators and ANSPs.

### 67 **5. Human Performance**

#### 68 **5.1 Human Factors Considerations**

69 Roles and responsibilities of controllers and pilots are expected not to be much affected in tactical operations  
70 (except by the more tactical re-routings or sequencing), but will need to understand that the decisions made  
71 on flights are for the common good.

#### 72 **5.2 Training and Qualification Requirements**

73 The new procedures will require training adapted to the collaborative nature of the interactions, in particular  
74 between ATFM and airline operations personnel.

#### 75 **5.3 Others**

76 Nil

### 77 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

78 Standards would avoid misunderstandings from one region to the next.

79 Some elements such as rules of the game and respect of equity may require standards and/or regulation.

### 80 **7. Implementation and Demonstration Activities**

#### 81 **7.1 Current Use**

82 ▪ **Europe:** Some European ACCs already exploit complexity management tools to better predict sector  
83 workloads and take measures such as de-grouping to absorb traffic bunching effects.

84 ▪ **US:** tbc

#### 85 **7.2 Planned or Ongoing Activities**

86 ▪ **Europe:** SESAR will validate the initial UDPP requirements and procedures, as well as the airspace  
87 management and network operations related to the module.

88	<b>8.</b>	<b>Reference Documents</b>
89	<b>8.1</b>	<b><i>Standards</i></b>
90		TBD
91	<b>8.2</b>	<b><i>Procedures</i></b>
92		TBD
93	<b>8.3</b>	<b><i>Guidance Material</i></b>
94		<a href="#">EUROCONTROL AFUA Concept</a>
95		

1 **Module N° B1-105: Better Operational Decisions through**  
 2 **Integrated Weather Information (Planning and Near-term Service)**

<b>Summary</b>	This module develops weather information supporting automated decision process or aids involving: weather information, weather translation, ATM impact conversion and ATM decision support. This module enables 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. The decision horizons considered are from several hours out to support planning, down to several minutes out to support in-flight avoidance of weather.	
<b>Main Performance Impact</b>	KPA-02 Capacity; KPA-04 Efficiency; KPA-09 Predictability, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All flight phases	
<b>Applicability Considerations</b>	Applicable to traffic flow planning, and to all aircraft operations in all domains and flight phases, regardless of level of aircraft equipage.	
<b>Global Concept Component(s)</b>	AOM - Airspace Operations and Management DCB - Demand and Capacity Balancing AO - Aerodrome Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-19 Meteorological Systems GPI-6 Air Traffic Flow Management GPI-16 Decision Support Systems and Alerting Systems	
<b>Pre-Requisites</b>	Module B0-10: Improved En-Route Profiles, Module B0-15: Runway Arrival Sequencing; Module B0-35: Air Traffic Flow Management/Network Operations Procedures (ATFM/NOP) and Collaborative Decision Making (CDM); Parallel development with; 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	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date).</b>
	Standards Readiness	Est 2018
	Avionics Availability	2018
	Infrastructure Availability	Est 2018
	Ground Automation Availability	Est 2018
	Procedures Available	Est 2018
	Operations Approvals	Est 2018

3 **1. Narrative**

4 **1.1 General**

5 This module improves the current baseline case where ATM decision makers manually determine the amount of  
 6 change in capacity associated with an actual or forecast weather phenomenon, manually compare the resultant  
 7 capacity with the actual or projected demand for the airspace or aerodrome, and then manually devise ATM  
 8 solutions when the demand exceeds the weather-constrained capacity value. This module also improves in-

9 flight avoidance of weather by providing more precise information on the location, extent and severity of weather  
10 affecting specific flights.

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

#### 14 **1.1.1 Baseline**

15 Weather is a major cause of flight delay in many airspace systems. Research analyses have suggested that a  
16 significant portion of that delay could be mitigated if weather forecasts were “perfect” and appropriate air traffic  
17 management (ATM) solutions were able to be consistently devised and employed. Rigid airspace structures  
18 often preclude the consistent employment of the best ATM solutions.

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

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

#### 28 **1.1.2 Change brought by the module**

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

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

#### 41 **1.2 Element 1: Weather Information**

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

#### 46 **1.3 Element 2: Weather Translation**

47 Weather Translation refers to automated processes which ingest raw weather information and translate them  
48 into characterized weather constraints and aerodrome threshold events. The output of the Weather Translation  
49 process is a non-meteorological value which represents a potential change in the permeability of airspace or  
50 capacity of the aerodrome.

51 It is unlikely that future automation systems will incorporate Weather Translation methodology without also  
52 including ATM Impact Conversion components. As such, this element is likely to be more of an enabler of the  
53 next element and the entire process as opposed to an interim end state.

54 **1.4 Element 3: ATM Impact Conversion**

55 The ATM Impact Conversion element determines the anticipated weather-constrained capacity of the airspace or  
 56 aerodrome and compares this to the projected demand. If an imbalance exists between the two, this information  
 57 is provided to the system user and/or the ATM Decision Support element to inform development of mitigation  
 58 strategies for dealing with the imbalance.

59 **1.5 Element 4: Weather Integrated Decision Support**

60 The final element is Weather Integrated Decision Support, which is comprised of automated systems and  
 61 processes that create ranked mitigation strategies for consideration and execution by ATM decision makers. The  
 62 solutions are based on requirements and rules established by the ATM community. These improvements also  
 63 augment the communication and display of weather information to service providers and operators to support  
 64 tactical avoidance.

65 **2. Intended Performance or Operational Improvement / Metric for Success**

<i>Capacity</i>	<p>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. <u>Associated Metric:</u> Improved weather information in reference to the number of user-preferred profiles that can be accommodated.</p> <p>Maximum use of available airspace capacity. <u>Associated Metric:</u> With respect to capacity, the number of user-preferred profiles that can be accommodated would be an appropriate metric for Weather Integrated Decision Support.</p>
<i>Efficiency</i>	<p>Improvements in weather information lead to better data concerning the extent, time period and severity of weather impacts on airspace. <u>Associated Metric:</u> An improvement in efficiency associated with improved weather information would be the number of deviations from user-preferred profiles.</p> <p>Advanced decision support tools, fully integrated with weather information, support stakeholders in planning for the most efficient routes possible, given the anticipated weather situation. <u>Associated Metric:</u> 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.</p>
<i>Environment</i>	<p>More precise planning for weather mitigation produces more efficient routes, less fuel burn, and reduction of emissions due to fewer ground hold/delay actions. <u>Associated Metric:</u> Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected.</p>
<i>Flexibility</i>	<p>Users have greater flexibility in selecting trajectories that best meet their needs, in the face of weather situations. <u>Associated Metric:</u> Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected.</p>
<i>Predictability</i>	<p>Weather Translation combined with ATM Impact Conversion leads 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. <u>Associated Metric:</u> 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.</p> <p>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</p>

	<p>fuel burn. <u>Associated Metric:</u> 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.</p> <p>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. <u>Associated Metric:</u> 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.</p>
Safety	<p>Weather information improvements lead to increased situation awareness by pilots, AOCs and ANSPs, enabling avoidance of hazardous weather conditions. <u>Associated Metric:</u> Safety improvement associated with better weather information would be the number of weather-related aircraft incidents and accidents.</p> <p>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. <u>Associated Metric:</u> Decreases in the variability and numbers of responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation.</p>
CBA	<p>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.</p>

66 **3. 3. Necessary Procedures (Air & Ground)**

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

71 **4. 4. Necessary System Capability**

72 **4.1 Avionics**

73 This module does not depend on significant avionics additions. Improved weather information can be  
74 disseminated to the pilot via flight operations centers, controllers, or via air-ground links (e.g. FIS) where  
75 available. The extensive use of aircraft-based capabilities to support tactical weather avoidance is the focus of  
76 module B3-105.

77 **4.2 Ground Systems**

78 Technology development in support of this element will include the creation and implementation of a consistent,  
79 integrated 4-D database of global weather observations and forecasts, including linkage (data exchange and  
80 communications standards) between global weather information systems.

81 Technology development in support will include the introduction of automated weather translation methodologies  
82 based on the operational needs for such information.

83 Technology development in support will include the introduction of automated methodologies that use weather  
84 translation information to assess the impact on ATM operations, for flows and individual flights.

85 Technology development in support of this element will include the introduction of decision support tools, for  
86 both ANSPs and users, which automatically ingest ATM Weather Impact information, and support decision  
87 making via generation of candidate mitigation strategies.

## 88 **5. Human Performance**

### 89 **5.1 Human Factors Considerations**

90 This module will necessitate significant changes in how service providers and users deal with weather situations.  
91 The availability of decision support tools, integrated with enhanced observation and forecast information, will  
92 enable more efficient and effective development of mitigation strategies. But, procedures will need to be  
93 developed, and changes to cultural aspects of how decision making is done today will need to be considered.  
94 Also, the realization of a "common view" of the weather situation between service providers, flight operational  
95 and pilots will require trust in a single, common information base of weather.

### 96 **5.2 Training and Qualification Requirements**

97 Automation support, integrated with weather information is needed for flight operations, pilots and service  
98 providers. Training in the concepts behind the automation capabilities will be necessary to enable the effective  
99 integration of the tools into operations. Also, enhanced procedures for collaboration on ATM decision making  
100 will need to be developed and training provided, again to ensure effective operational use.

## 101 **6. Regulatory/Standardisation needs and Approval Plan (Air & Ground)**

102 This module requires the development of global standards for weather information exchange, with emphasis on  
103 the exchange of 4-D (X, Y, Z and T [time]) gridded weather information, and regulatory agreement on what  
104 constitutes required weather information in the age of digital exchange, versus text and graphics. Standardised  
105 Weather Translation parameters and ATM Impact Conversion parameters will also require development.

## 106 **7. Implementation and Demonstration Activities**

### 107 **7.1 Current Use**

108 A considerable amount of research and analysis is currently underway. The development of the United States'  
109 4D Weather Data Cube is underway. Decisions concerning internal infrastructure, data exchange standards and  
110 communications are nearing completion, and initial demonstrations of the system have taken place.

### 111 **7.2 Planned or Ongoing Activities**

112 No global demonstration trials are currently planned for this element. There is a need to develop such a plan as  
113 part of the collaboration on this module.

## 114 **8. Reference Documents**

### 115 **8.1 Standards**

116 World Meteorological Organization standards for weather information content and format. Others TBD; to be  
117 developed as part of this research

### 118 **8.2 Procedures**

119 To be developed

### 120 **8.3 Guidance material**

121 To be developed.

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# 1 Module N° B1-85: Increased Capacity and Flexibility through 2 Interval Management

3

<b>Summary</b>	Interval Management provides 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 and reducing the environmental impact.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-03 Cost-Effectiveness, <b>KPA-04 Efficiency</b> , KPA-05 Environment and KPA-06 Flexibility.	
<b>Operating Environment/Phases of Flight</b>	Cruise, Arrival, Approach, Departure.	
<b>Applicability Considerations</b>	En-route and terminal areas.	
<b>Global Concept Component(s)</b>	DCB – Demand and Capacity Balancing; TS –Traffic Synchronisation; CM – Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-7 Dynamic and Flexible ATS Route Management; GPI-9 Situational Awareness; GPI-17 Data Link Applications.	
<b>Pre-Requisites</b>	B0-85	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	Est. 2014
	Avionics Availability	Est. 2015
	Ground System Availability	Est. 2018
	Procedures Available	Est. 2015
	Operations Approvals	Est. 2015

## 4 1. Narrative

### 5 1.1 General

6 IM is defined as the overall system that enables the improved means for managing traffic flows and aircraft  
7 spacing, it may include the use of ground tools that assist the controller in evaluating the traffic picture and  
8 determining appropriate clearances to merge and space aircraft efficiently and safely and the use of airborne  
9 tools that allow the flight crew to conform with the IM Clearance. IM operations in the first phase will cover the  
10 arrival phase of flight (from the end of cruise to final approach) of airspace under surveillance, where Direct  
11 Controller Pilot Communications (such as voice or CPDLC) exist. As the applications evolve they will be applied  
12 to other phases of flight.

13 IM includes both the ground capabilities needed for the controller to support an IM Clearance and the airborne  
14 capabilities needed for the flight crew to follow the IM Clearance.

#### 15 1.1.1 Baseline

16 Current Ground-Based ATM.

17 **1.1.2 Change brought by the module**

18 Interval Management is a suite of functional capabilities that can be combined to produce operational  
19 applications to achieve or maintain an interval or spacing from a target aircraft. ATC will be provided with a new  
20 set of (voice or datalink) instructions directing, for example, that the flight crew establish and maintain a given  
21 time from a reference aircraft. These new instructions will reduce the use of ATC vectoring and speed control,  
22 which is expected to reduce the overall number of transmissions. These reductions are expected to reduce ATC  
23 workload per aircraft.

24 The flight crew will perform these new tasks using new avionics functions e.g. airborne surveillance, display of  
25 traffic information, and spacing functions with advisories. A few examples of IM in various phases of flight  
26 include: Cruise - delivering metering or miles-in-trail prior to top-of-descent; Arrival – interval management during  
27 optimum profile descents to merge (if applicable); Approach – achieve and maintain appropriate interval to  
28 stabilized approach point; and Departure – maintain interval no-closer-than to previous departure. These  
29 examples provide more efficient flight trajectories, better scheduling performance, reduced fuel burn and  
30 decreased environmental impacts.

31 Benefits of the interval management include;  
32

33 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Cost-Effectiveness</i>	Consistent, low variance spacing between paired aircraft (e.g., at the entry to an arrival procedure and on final approach) resulting in reduced fuel burn.
<i>Efficiency</i>	Early speed advisories removing requirement for later path-lengthening Continued Optimized Profile Descents (OPDs) in medium density environments <ul style="list-style-type: none"><li>○ expected to allow OPDs when demand &lt;=70%</li><li>○</li></ul> Resulting in reduced holding times and flight times.
<i>Environment</i>	All efficiency benefits have an impact of the environment. Resulting in reduced emissions.
<i>Safety</i>	Reduced ATC instructions and workload <ul style="list-style-type: none"><li>○ Without unacceptable increase in flight crew workload</li></ul>

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<i>CBA</i>	<b>TBD</b>
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36 **3. Necessary Procedures (Air & Ground)**

37 Procedures for Interval Management have yet to be developed.

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## 39 **4. Necessary System Capability**

### 40 **4.1 Avionics**

41 Necessary technology includes ADS-B OUT and ADS-B IN capability and a cockpit based Cockpit Display of  
42 Traffic information (CDTI) to have situational awareness for performing interval management operations. CPDLC  
43 in accordance with message set developed by SC-214 and WG-78 may be required. ADS-B OUT is required for  
44 surrounding aircraft.

### 45 **4.2 Ground Systems**

46 Ground automation to support the Interval Management application may be required. Where implemented this  
47 will most likely be customised based on the set of interval management procedures allowed in a given terminal  
48 area.

## 49 **5. Human Performance**

### 50 **5.1 Human Factors Considerations**

51 TBD

### 52 **5.2 Training and Qualification Requirements**

53 TBD

### 54 **5.3 Others**

55 TBD

## 56 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

57 TBD

## 58 **7. Implementation and Demonstration Activities**

### 59 **7.1 Current Use**

60 None at this time.

### 61 **7.2 Planned or Ongoing Activities**

62 None at this time.

63

## 64 **8. Reference Documents**

### 65 **8.1 Standards**

66 RTCA Document DO-328 and EUROCAE ED-195, Safety, Performance and Interoperability Requirements  
67 Document for Airborne Spacing – Flight Deck Interval Management (ASPA-FIM)

### 68 **8.2 Procedures**

### 69 **8.3 Guidance Material**

70 EUROCONTROL Documents – Flight Crew Guidance on Enhanced Traffic Situational Awareness during Flight  
71 Operations; Flight Crew Guidance on Enhanced Situational Awareness on the Airport Surface; Flight Crew  
72 Guidance on Enhanced Visual Separation on Approach;

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1 **Module N° B1-05: Improved Flexibility and Efficiency in Descent**  
 2 **Profiles (OPDs)**  
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<b>Summary</b>	This module provides the baseline for use Required Navigation Performance (RNP) with Barometric Vertical Navigation (VNAV). Baro-VNAV requires that the vertical system accuracy is 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.	
<b>Main Performance Impact</b>	KPA-02 Capacity, <b>KPA-04 Efficiency</b> , KPA-06 Predictability, KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	Descent, Arrival, Flight in Terminal Area	
<b>Applicability Considerations</b>		
<b>Global Concept Component(s)</b>	Airspace Organization and Management (AOM) Demand and Capacity Balancing (DCB) Airspace User Operations (AUO) Aerodrome operations (AO) Traffic synchronization (TS) Conflict management (CM)	
<b>Global Plan Initiatives (GPI)</b>	GPI-2 Reduced vertical separation minima GPI-5 RNAV and RNP (Performance-Based Navigation) GPI-9 Situational Awareness	
<b>Pre-Requisites</b>	NIL	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	2018
	Avionics Availability	√
	Ground System Availability	2018
	Procedures Available	√
	Operations Approvals	2018

4 **1. Narrative**

5 **1.1 General**

6 RNP with Vertical Containment is an altimetry-based capability which enables an equipped aircraft to precisely  
 7 descend on a vertical path, as computed by the Flight Management Computer (FMC), within a tolerance set in  
 8 feet, while providing the flight crew with navigation performance information through avionics monitoring and  
 9 alerting. The system defaults to an initial tolerance set by the individual operator, but a crew may select a new  
 10 tolerance (e.g., 75 feet in the terminal area.) It is similar to lateral containment of RNP, but in the vertical plane.

11

12 **1.1.1 Baseline**

13 The baseline for this block is Improved Flight Descent Profile enabled by Block B0-5. This block is a component  
14 of Trajectory-Based Operations (TBO).

15 **1.1.2 Change brought by the module**

16 Vertical RNP contributes to Terminal airspace design and efficiency due to an aircraft's ability to maintain a  
17 vertical path during descent thus enabling vertical corridors for ingressing and egressing traffic. Other benefits  
18 include reduced aircraft level-offs, enhanced vertical precision in the terminal airspace, de-confliction of arrival  
19 and departure procedures and adjacent airport traffic flows, and the ability of an aircraft to fly an approach  
20 procedure not reliant upon ground based equipment for vertical navigation. This ultimately leads to higher  
21 utilization of airports and runways lacking vertical approach guidance.

22

23 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	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.
<i>Efficiency</i>	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.
<i>Predictability</i>	Vertical RNP allows for enhanced predictability of flight paths which leads to better planning of flights and flows.
<i>Safety</i>	Precise altitude tracking along a vertical descent path leads to improvements in overall system safety.

24

<i>CBA</i>	<p>Safety Enhancement: Flying more precise vertical profiles</p> <p>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</p> <p>Economic: Vertical RNP allows for reduced aircraft level-offs, resulting in fuel and time savings.</p>
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25 **3. Necessary Procedures (Air & Ground)**

26 Flight crews require training in the proper use of the Vertical RNP functions of the FMC. Standard procedures  
27 guide the flight crews on which altitude tolerances may be selected for a particular phase of flight.

28 **4. Necessary System Capability**

29 **4.1 Avionics**

30 The technology for Vertical RNP is contained within the Flight Management Computer.

31 **4.2 Ground Systems**

32 N/A

33 **5. Human Performance**

34 **5.1 Human Factors Considerations**

35 TBD

36 **5.2 Training and Qualification Requirements**

37 TBD

38 **5.3 Others**

39 TBD

40 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

41 Vertical RNP availability is better than 99.9%/hour for a single FMC installation. From an equipment certification  
42 standpoint, the loss of function is probable. Redundant equipment installation supports improbable loss of  
43 function, where required.

44 **7. Implementation and Demonstration Activities**

45 **7.1 Current Use**

46 RNP with Vertical Containment is currently being used on Boeing aircraft during the descent phase of flight.

47 **7.2 Planned or Ongoing Activities**

48 No demonstration trials are currently planned for this module. There is a need to develop a trial plan as part of  
49 the collaboration on this module.

50 **8. Reference Documents**

51 **8.1 Standards**

52 ED-75B 'MASPS required navigation performance for area navigation.

53 RTCA DO-236B, Minimum Aviation System Performance Standards: Required Navigation Performance for Area  
54 Navigation

55 Boeing Document D6-39067-3, RNP Capability of FMC Equipped 737, Generation 3

56 Boeing Document D243W018-13 Rev D, 777 RNP Navigation Capabilities, Generation 1

57 **8.2 Procedures**

58 **8.3 Guidance Material**

59 ICAO Document [9750](#), Global Air Navigation Plan

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1 **Module N° B1-40: Improved Traffic Synchronisation and Initial**  
 2 **Trajectory-Based Operation**

3

<b>Summary</b>	Improve the synchronisation of traffic flows at en-route merging points and to optimize the approach sequence through the use of 4DTRAD capability and airport applications, e.g.; D-TAXI, via the air ground exchange of aircraft derived data related to a single controlled time of arrival (CTA).	
<b>Main Performance Impact</b>	KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment; <b>KPA-09 Predictability</b> KPA-10 Safety	
<b>Operating Environment/Phases of Flight</b>	All flight phases	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	IM – Information Management TS – Traffic Synchronisation CM – Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-9 Situational awareness GPI-17 Implementation of data link applications GPI-18 Electronic information services	
<b>Pre-Requisites</b>	None	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>2013</b>
	Avionics Availability	<b>Est. 2016</b>
	Ground Systems Availability	<b>Est. 2016</b>
	Procedures Available	<b>Est. 2018</b>
	Operations Approvals	<b>Est. 2018</b>

4 **1. Narrative**5 **1.1 General**

6 This module is a step towards the goal to introduce 4D trajectory based operations that uses the capabilities of  
 7 aircraft Flight Management Systems to optimise aircraft flight trajectories in four dimensions. Trajectory Based  
 8 Operations will manage uncertainty by improving predictability for all ATM Stakeholders across all boundaries or  
 9 ATM sector structures. In this context it will facilitate Traffic Synchronisation and strategic Conflict Management  
 10 supported by Separation Provision that minimises tactical “radar type” intervention (e.g. open loop vectoring). It  
 11 also introduces a number of Airport applications that increase safety and reduce controller-pilot workload.

12

13 **1.1.1 Baseline**

14 Traffic synchronisation is based on the flight data processing information fed by flight plan data with current  
15 positions updated by radar information and on mental extrapolation by controllers. This is not accurate and  
16 represents a workload for assessing the situation and monitoring its evolution. Actions are difficult to anticipate in  
17 upstream sectors which may not be aware of the problem to be solved.

18 The transmission of information at and around airports, including for complex routings is done through voice  
19 radio, implying a high workload for pilots and controllers, frequent misunderstandings and repetitions.

20 **1.1.2 Change brought by the module**

21 This module implements additional air-ground data link applications to: download trajectory information and  
22 improve the synchronisation of traffic flows at merging points, in particular in view of optimising an approach  
23 sequence, with negotiation of a required time of arrival using the FMS functionality. Existing ground-ground  
24 coordination capabilities will be improved to allow complex route clearances to be exchanged across multiple  
25 airspace boundaries.

26 The module will also implement data transmission for airport/TMA related information and clearances.

27 **1.2 Element 1: Initial 4D Operations (4DTRAD)**

28 Supporting this is 4DTRAD, a recognised approach to initial Trajectory Based Operations which offers an  
29 advanced view of the future ATM environment including seamless integration of operational goals through an  
30 increased situational awareness and by the sharing of air ground data in a strategic and tactical collaborative  
31 decision making environment.

32 4DTRAD requires the availability of sophisticated air ground data exchange that includes use of new ADS-C and  
33 data link functionality beyond current capabilities and performance requirements. Furthermore, ground-ground  
34 data exchange to exchange complex clearances needs to be secure, widely available.

35 As a step transition to Trajectory Based Operations, the introduction of a common time reference with the use of  
36 aircraft FMS required time of arrival (RTA) and speed control with less demanding performance and technology  
37 requirements to that of 4DTRAD promises early predictability and efficiency benefits to airspace users and  
38 service providers.

39 Using the aircraft RTA for planning arrival flows from En-route (or Oceanic) into Terminal airspace is feasible  
40 using current aircraft capability with lower performance requirements than for example 4DTRAD. This would  
41 only focus on building traffic flows and sequences leaving more precise metering and separation provision to be  
42 achieved through current operations or with new RNAV performance based navigation procedures.

43 Synchronising the RTA and Controlled Time of Arrival (CTA) with appropriate PBN levels offers the opportunity  
44 to further develop stable and predictable traffic flows into a Terminal area, letting the pilot optimise the flight  
45 profile (e.g. top of descent and descent profile).

46 Furthermore, predictable pre-planned traffic flows facilitate consistent application of Continuous Descent  
47 Operations and Tailored Arrival procedures whilst Terminal holding can be avoided through pre-planned path  
48 stretching undertaken by the aircraft using the RTA or speed control as well as integrating both long and short  
49 haul flights into arrival sequences.

50 The deployment of RNP/RNAV procedures and use of techniques such as "Point Merge" and others provide the  
51 opportunity to manage aircraft without recourse to radar vectoring intervention, leading to a closed loop FMS  
52 operation and an informed ground system supporting efficient aircraft profiles and predictable ATM operations.

53 To realise such benefits, communication between en-route and terminal control units is needed to coordinate the  
54 CTA constraint which may be achieved through existing mechanisms such as on-line data exchange with  
55 delivery to the aircraft via R/T or coordination with the airline operations centres to deliver to long haul aircraft by  
56 company data link.

57 A wider approach to the block will consider the combination with arrival management techniques using currently  
58 available ground based tools providing a more demanding performance facilitating refined metering of traffic into  
59 Terminal airspace and existing CPDLC capability to deliver the CTA.

60 A first step which relies on existing systems and capabilities or requiring only minor modifications will make use  
61 of current FMS capability to define and output an RTA or speed control. Existing data link capabilities such as  
62 CPDLC, AOC, or even voice could be used to agree this RTA or speed control with the ground CTA. Most  
63 ground systems are incorporating trajectory prediction functionality and existing AMAN calculate the equivalent  
64 of a CTA. Ground-ground communications infrastructure will enable the exchange of flight plan and can be  
65 updated to exchange CTA.

66 Beyond this first step more significant changes are anticipated to enable 4DTRAD and trajectory based  
67 operations with advanced, and standardised FMS functionality able to provide more accurate and complete  
68 trajectory information which could be down linked with new ADS-C or CPDLC protocols. Depending on the  
69 definition of this trajectory information for download new data link technology may be required in the long term.  
70 The ground-ground communication infrastructure, in the context of SWIM will enable this trajectory information to  
71 be made available to the various en-route, terminal and airport systems which can use the common trajectory  
72 reference. System modifications to make full use of this trajectory information must also be planned.

73 Initial 4D operations can be broken down in to two steps; the first is the synchronisation between air and ground  
74 of the flight plan or Reference Business Trajectory. The second step is imposing a time constraint and allowing  
75 the aircraft to fly its profile in the most optimal way to meet that constraint.

#### 76 ***Trajectory Synchronisation and Monitoring***

77 The ATM system relies on all actors having the same view; it is therefore essential that the trajectory in the Flight  
78 Management System (FMS) is synchronised with that held on the ground in the Flight Data Processing Systems  
79 (FDPS) and the wider Network systems.

80 The crew and the ATC agree on the trajectory to be flown and during the entire execution, they continuously  
81 check if it is, and will be, followed by the aircraft. In case of non-conformance warning are raised and a new  
82 interaction between the crew and the responsible ATC occurs.

83 The early air/ground agreement on the trajectory to be flown and its execution allows the FMS to optimize the  
84 trajectory providing efficiency benefits to the User in terms of aircraft flight profile optimisation and ensuring  
85 maximum environmental benefits, both through reduced fuel burn and optimum routings en-route, in the  
86 Terminal Area and in the vicinity of the airport avoiding noise sensitive areas.

87 Improved consistency between air & ground trajectory ensures that controllers have highly reliable information  
88 on aircraft behaviour. This more accurate trajectory prediction enables better performance from the decision  
89 support tools providing a better anticipation of congestion by allowing early detection of traffic bunching providing  
90 better adaptation to the real traffic situation and reduced inefficient radar based tactical intervention.

91 The increased levels of predictability mean that potential conflicts within a medium-term time horizon will be  
92 identified and resolved early while the increased accuracy of ground computed trajectory, especially for short  
93 term prediction, reduces the risk of unexpected events.

#### 94 ***Required Time of Arrival***

95 The avionics function, Required Time of Arrival (RTA), can be exploited by both en-route and TMA controllers for  
96 demand/capacity balancing, metering of flows and sequencing for arrival management.

97 By preparing the metering of aircraft at an earlier stage of their flight the impact of the constraint is minimised.  
98 This allows ATC to make optimum use of capacity at the right time, minimising risks through complexity  
99 reduction to ensure that human capabilities are not exceeded. This also supports optimised aircraft profile  
100 management by the pilot.

101 Reduction of inefficient ATC tactical interventions through early planning of traffic en-route and in to the arrival  
102 management phase avoids severe and costly sequencing measures. This process enhances aircraft profile  
103 optimisation, flight predictability and allows improvements in the stability and reliability of the sequence built by  
104 ATC.

105 It should lead to reduced need for aircraft to hold, inefficiently burning fuel with the associated chemical and  
106 noise pollution. Aircraft will be able to plan better and adhere more accurate to arrival schedules leading to better  
107 planning for the airlines due to increased flight predictability.

108 **1.3 Element 2: Data Link Operational Terminal Information Service (D-OTIS)**

109 Before flight departure, the flight crew may request meteorological and operational flight information and  
110 NOTAMs of the departure and destination aerodrome using a single data link service - Data link-Operational  
111 Terminal Information Service (D-OTIS).

112 At any time during the flight, the pilot may receive automatic updates of the meteo data, operational information  
113 and NOTAMS of the destination or alternate aerodromes. D-OTIS may be tailored for the specific flight crew  
114 needs and so the pilot can readily form a picture from meteo and operational perspectives.

115 **1.4 Element 3: Departure Clearance (DCL)**

116 The implementation of DCL eliminates potential misunderstandings due to VHF voice, hence enabling the ATC  
117 to provide a safer and more efficient service to their users. DCL also enables to reduce controllers' workload.  
118 DCL supports the airport system automation and information sharing with other ground systems.

119 For busy airports, the use of DCL data link results in a significant decrease in ATC tower frequency congestion.  
120 CPDLC systems that are integrated with FMS allow direct input of more complex clearances into the FMS.

121 **1.5 Element 4: Data link TAXI (DTAXI)**

122 This provides automated assistance and additional means of communication to controllers and pilots when  
123 performing routine communication exchanges during ground movement operations, Start-up, Pushback, Routine  
124 taxi messages and Special airport operations.

125 **2. Intended Performance Operational Improvement/Metric to determine success**

126 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Positively affected because of the reduction of workload associated to the establishment of the sequence close to the convergence point and related tactical interventions.  Positively affected because of the reduction of workload associated to the delivery of departure and taxi clearances.
<i>Efficiency</i>	Increased by using the aircraft RTA capability for traffic synchronisation planning through en-route and into Terminal Airspace. "Closed loop" operations on RNAV procedures ensure common air and ground system awareness of traffic evolution and facilitate its optimisation.  Flight efficiency is increased through proactive planning of top of descent, descent profile and en-route delay actions, and enhanced terminal airspace route efficiency.
<i>Environment</i>	More economic and environmentally friendly trajectories, in particular absorption of some delays.
<i>Predictability</i>	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.
<i>Safety</i>	Safety at/around airports by a reduction of the misinterpretations and errors in the interpretation of the complex departure and taxi clearances.

127

128

<i>CBA</i>	Establishment of the business case is underway.  The Benefits of the proposed Airport services were already demonstrated in the EUROCONTROL CASCADE Programme.
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129 **3. Necessary Procedures (Air & Ground)**

130 TBD

131 **4. Necessary System Capability**

132 **4.1 Avionics**

133 Initial operations based on existing aircraft FMS capability, air-ground data link. The necessary technology is  
134 defined in the EUROCAE WG78/RTCA SC 214 standards and comprises converged CPDLC and ADS-C  
135 implementations.

136 **4.2 Ground Systems**

137 For ground systems, the necessary technology includes the ground-ground data interchange and the ability to  
138 negotiate a time constraint over a given metering fix as well as to process the aircraft trajectory. It also includes  
139 the ability to facilitate the provision of start-up, push-back and taxi clearances via data link. Enhanced  
140 surveillance through multi-sensor data fusion is required.

141 **5. Human Performance**

142 **5.1 Human Factors Considerations**

143 Data communications reduce the workload and the risk to misinterpret information in clearances, in particular  
144 when typing them in FMS. They allow reducing the congestion of the voice channel with overall understanding  
145 benefits and more flexible management of air-ground exchanges.

146 Automation support is needed for both the pilot and the controller. Overall their respective responsibilities will not  
147 be affected.

148 **5.2 Training and Qualification Requirements**

149 Automation support is needed for both the pilot and the controller which therefore will have to be trained to the  
150 new environment and to identify the aircraft/facilities which can accommodate the data link services in mixed  
151 mode environments.

152 **5.3 Others**

153

154 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

155 Related to airspace and procedures design based on existing guidance and ICAO material.

156 Publication of the EUROCAE WG78/RTCA SC 214 standards.

157 Air and ground certification and approvals basis.

158 **7. Implementation and Demonstration Activities**

159 **7.1 Current Use**

160 

- Capability used ad hoc for tailored arrivals with RTA as well as arrival planning for Oceanic arrivals plus wide  
161 scale trials of point merge techniques now focused on deployment in European Terminal airspace and  
162 Approach areas with available OSED SPR material.

163 

- Australia: Planned or Ongoing Trials

- 164   ▪ **Europe:** CASCADE D-TAXI and D-OTIS Trials (2007)
- 165   ▪ **Europe:** For Initial 4D and Airport Services, SESAR Release 1 and 2 (2011 & 2012).

## 166   **8.       Reference Documents**

### 167   **8.1     Standards**

- 168   ▪ EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305,  
169     ED110B/DO280
- 170   ▪ EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.
- 171   ▪ Point Merge: Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous  
172     Descent. Operational Services and Environment Definition – EUROCONTROL, July 2010

### 173   **8.2     Procedures**

### 174   **8.3     Guidance Material**

- 175   ▪ Manual of Air Traffic Services Data Link Applications ([DOC](http://www.icao.int/Meetings/anconf12/Documents/9694_cons_en%5B1%5D.pdf)  
176     [9694http://www.icao.int/Meetings/anconf12/Documents/9694\\_cons\\_en%5B1%5D.pdf](http://www.icao.int/Meetings/anconf12/Documents/9694_cons_en%5B1%5D.pdf))
- 177   ▪ New OPLINK Ops Guidance under development
- 178   ▪ [4DTRAD: Initial 4D – 4D Trajectory Data Link \(4DTRAD\) Concept of Operations – EUROCONTROL,](#)  
179     December 2008
- 180   ▪

1 **Module N° B1-90 Initial Integration of Remotely-Piloted**  
 2 **Aircraft (RPA) Systems into non-segregated airspace**  
 3

<b>Summary</b>	Implementation of basic procedures for operating RPAs in non-segregated airspace including detect and avoid.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity, KPA-10 Safety	
<b>Domain/Flight Phases</b>	En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing)	
<b>Applicability Considerations</b>	Applies to all RPAS operating in controlled airspace and at aerodromes. Requires good synchronization of airborne and ground deployment to generate significant benefits, in particular to those able to meet minimum certification and equipment requirements.	
<b>Global Concept Component(s)</b>	AOM - Airspace Organization and Management CM - Conflict Management AUO - Airspace User Operations	
<b>Global Plan Initiatives (GPI)</b>	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	
<b>Main Dependencies</b>		
<b>Global Readiness Checklists</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	Est. 2018
	Avionics Availability	Est. 2018
	Ground Systems Availability	Est. 2018
	Procedures Available	Est. 2018
	Operations Approvals	Est. 2018

4 **1. Narrative**

5 **1.1 General**

6 This module will discuss the baseline from which the improvements discussed will be based. The aim is to move from  
 7 accommodation of RPA, to integration into traffic within controlled airspace and at controlled aerodromes, and finally to full  
 8 transparent operation within the airspace. Block 1 is the first step in this process. The Block 1 improvements are:

- 9 • Streamline process to access non-segregated controlled airspace
- 10 • Define airworthiness certification for RPA
- 11 • Define operator certification
- 12 • Define remote pilot licensing requirements
- 13 • Define detect and avoid technology performance requirements
- 14

15 The United States, specifically the FAA, is in the review process for defining “small UAS” procedures: Once small UAS  
 16 procedures are approved, small UAS operations in the U.S., outside of military operating areas may be permitted, first in  
 17 unpopulated, then sparsely populated areas. Small UAS policy will be based on the successive expansions of use and the  
 18 rules and procedures that are established. These small UAS procedures will continue to be developed to allow small UAS to  
 19 operate in more types of airspace. VLOS will be used to provide detect and avoid mitigation for these UAS. This is a U.S.-  
 20 focused approach that currently may not apply for other States.

21 Some States are looking at localized ground-based detect and avoid (GBDAA) technology to support the detect and avoid  
 22 requirements.

23 Below is a list of definitions that are used in the development of this block.

- 24 • **Command and control (C2) link.** The data link between the remotely-piloted aircraft and the remote pilot station
- 25 for the purposes of managing the flight.
- 26 • **Controlled airspace.** An airspace of defined dimensions within which air traffic control service is provided in
- 27 accordance with the airspace classification.
- 28 • **Segregated airspace.** Airspace of specified dimensions allocated for exclusive use to a specific user(s).
- 29 • **Detect and avoid.** The capability to see, sense or detect conflicting traffic or other hazards and take the
- 30 appropriate action.
- 31 • **Remote pilot.** A person charged by the operator with duties essential to the operation of a remotely-piloted aircraft
- 32 and who manipulates the flight controls, as appropriate, during flight time.
- 33 • **Remote pilot station.** The component of the remotely-piloted aircraft system containing the equipment used to pilot
- 34 the remotely-piloted aircraft.
- 35 • **Remotely-piloted aircraft (RPA).** An unmanned aircraft which is piloted from a remote pilot station.
- 36 • **Remotely-piloted aircraft system (RPAS).** A remotely-piloted aircraft, its associated remote pilot station(s), the
- 37 required command and control links, and any other components as specified in the approved type design.
- 38 • **RPA observer.** A trained and competent person designated by the operator who, by visual observation of the
- 39 remotely-piloted aircraft, assists the remote pilot in the safe conduct of the flight.
- 40 • **Visual line-of-sight (VLOS) operation.** An operation in which the remote pilot or RPA observer maintains direct
- 41 visual contact with the remotely-piloted aircraft.

### 42 1.1.1. Baseline

43 The baseline is applicable to RPA IFR operations in non-segregated controlled airspace, including over the high seas, and at  
 44 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	RPA 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	RPA 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			



<b>Populated Areas</b>	Restrictions to be determined by the State
<b>ATC Services</b>	Consistent with Annex 11
<b>Flight Plan</b>	RPA operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed.
<b>Meteorological Conditions</b>	Restrictions to be determined by the State
<b>Transponder</b>	RPA shall have and use an operating mode C/S transponder
<b>Safety</b>	Identify the hazards and mitigate the safety risks; adhere to the authorization
<b>NOTAMs</b>	NOTAM requirements, if any, to be determined by the State

### 45 1.1.2. Change brought by the module

46 **Streamline process to access non-segregated controlled airspace.** State authorities will need to consider if current  
 47 national/regional processes are adequate for enabling the level of airspace access necessary to accomplish all missions  
 48 proposed or envisioned for RPA flights. While international RPAS standards and certification requirements are being  
 49 developed, national and/or regional authorization processes will be used to access airspace. Methods for improving and  
 50 streamlining these processes will be worked on during this time frame. Approval to use existing technologies, such as  
 51 ground-based detect and avoid systems, may support access to airspace through enhanced collision avoidance capability.  
 52 This will allow authorities to streamline the process to grant authorization for airspace access.

53 **Defining airworthiness certification for RPAS:** Standards committees (such as RTCA SC-203, ASTM F 38, EUROCAE  
 54 WG 73, and others) will continue their work in the Block 1 timeframe, developing minimum aviation system performance  
 55 standards (MASPS). Certification takes into account system configuration, usage, environment, and the hardware and  
 56 software of the entire system (e.g. aircraft, remote pilot stations, C2 links). It also considers design characteristics, production  
 57 processes, reliability, and in-service maintenance procedures that adequately mitigate risk of injury/damage to people,  
 58 property or other aircraft. EASA's Rulemaking Directorate has issued policy statement E. Y013-01 for Airworthiness  
 59 Certification of RPAS that outlines procedures for type certification of civil RPA once standards have been established.  
 60 Technical standards might be used to certify specific components of the RPAS. The certificate of Airworthiness will be issued  
 61 to the aircraft while considering the entire system. The C2 links will have to meet identified performance criteria. Certification  
 62 standards and procedures will need to be worked out during this time frame.

#### 63 **Define operator certification:**

64 (This is being worked on by UASSG)TBD

#### 65 **Define remote pilot licensing requirements:**

66 (This is being worked on by UASSG, EASA and some States)TBD

67 **Define detect and avoid** technology performance requirements. These performance-based requirements will be developed  
 68 and certified to support the RPAS operational improvements as discussed above. The technology will be developed in  
 69 conjunction with other risk mitigation efforts to gain incremental access to the airspace. Initial capabilities may include  
 70 ground-based detect and avoid systems consisting of any combination of policy, procedures, and technology derived from  
 71 ground-based sensors intended to facilitate safe airspace access over land or water. Surveillance (radar, ADS-B) initiatives  
 72 will help gather, test, and verify data, along with the appropriate modeling and simulation activities, to establish requirements  
 73 and build an overall safety case for detect and avoid. The detect and avoid technology will be used by the remote pilot to  
 74 meet collision and hazard avoidance responsibility and provide situational awareness.

### 75 1.1.1 Other Remarks

76 This module describes the baseline and consists of only one element, accommodation of RPA operating in controlled  
 77 airspace. All of the improvements are related to this activity of accommodating the RPA in the controlled airspace.

78

79

80

81

82 **2. Intended Performance Operational Improvement/Metric to determine success**

83

<i>Capacity</i>	Could be negatively impacted due to larger separations being applied for safety reasons between RPA and traditional traffic
<i>Efficiency</i>	Access to airspace by a new category of users.
<i>Environment</i>	The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States.
<i>Predictability</i>	Increased predictability of RPA through global interoperability of communications and situational awareness.
<i>Safety</i>	Increased situational awareness; controlled use of aircraft

<i>CBA</i>	The business case is directly related to the economic value of the aviation applications supported by RPAS.
------------	---

84 **3. Necessary Procedures (Air & Ground)**

85 It is anticipated that as the improvements take shape in this block, air traffic services and procedures will have to change to  
86 accommodate these new airspace users. RPAS procedures such as C2 link failure will need to be standardized. These  
87 procedures may include a specific transponder code or ADS-B emergency mode to indicate a C2 link failure.

88 **4. Necessary System Capability (Air & Ground)**

89 **4.1 Avionics**

90 Communications includes traditional voice/data communications as well as all data related to command and control of the  
91 RPA. Current air-to-ground communications networks presume the pilot is on board the aircraft. The implications of the  
92 remote pilot being external to the aircraft will require a review and revision to preferred communications networks as well as  
93 bandwidth to support the amount of data required to operate and manage the RPA (STANAG 4586).

94 **4.2 Ground Systems**

95 Ground-based Detect and Avoid (GBDAA) is the technology in this time frame envisioned to afford the greatest return on  
96 investment to allow better access to non-segregated airspace. This technology will improve the “detect and avoid” situational  
97 awareness for the remote pilot within the specific coverage areas defined by the systems and has the potential to be the  
98 near/midterm solution to the detect and avoid problem plaguing the RPAS community. This approach is currently utilized on a  
99 limited basis and may become a global approach in this time frame.

100 **5. Human Performance**

101 **5.1 Human Factor Considerations**

102 The controller-pilot relationship is changing and will need to be investigated. Specific training for controllers, remote pilots  
103 and pilots will be required, in particular with respect to the new detect and avoid situations.

104 **5.2 Training and Qualifications Requirements**

105 **5.3 Others**

106 **6. Regulatory/standardization needs and Approval Plan (Air & Ground)**

- 107 • Certificate of airworthiness
- 108 • Operator certificate
- 109 • Remote pilot licence
- 110 • Frequency spectrum
- 111 • Communications (including C2 link failure)
- 112 • Detect and avoid

## 113 7. Implementation and Demonstration Activities

### 114 7.1 Current Use

115 None at this time.

### 116 7.2 Planned or On Going Trials

- 117 • In the US and Europe, several civil applications, initially VLOS and more integration of civil IFR/VFR operations in
- 118 this time frame are expected based on full certification and special authorization
- 119 • Requirements for frequency spectrum for RPAS will be established in this time frame
- 120 • SESAR addresses UAS within WP 9, 11 and 15
- 121 • The European Defence Agency has launched the MIDCAS project. It is addressing detect and avoid from both
- 122 military and civil perspectives. The budget is 50 million euros and it is expected to produce a working prototype for
- 123 detect and avoid application by the end of 2013.
- 124 • Mercator, an ultra-light UAS that is solar/battery powered for long duration flights at around FL450 is being tested in
- 125 Belgian airspace to demonstrate a UAS flight in a busy ATM environment.

#### 126 7.2.1 Europe

- 127 • EUROCONTROL is in the process of integrating an RPAS in Class C and D airspace under IFR and VFR. Detect
- 128 and avoid is mitigated through GBDAA and scanning through the on-board camera system. This will enable further
- 129 integration.
- 130 • The MIDCAS consortium is developing a detect and avoid test bed that should be available for testing beginning in
- 131 2012
- 132 • In regard to VLOS, the Netherlands will certify an RPAS this year (civil certified)
- 133 • Euro Hawk is flying in controlled airspace as “operational air traffic”
- 134 • EUROCAE (EC) has finalized their work on a guidance document for VLOS
- 135 • A strategy document outlining EC policy on UAS is in preparation through an EC UAS panel, addressing industry
- 136 and market issues, UAS insertion and spectrum, safety, societal dimensions and R&D
- 137 • Legal framework for the development of AMC (???) is in place. EASA will only deal with UAS with a mass greater
- 138 than 150 kg.

#### 139 7.2.2 United States

140 The baseline is currently being used in the U.S. The Army has an authorization for ground-based sense and avoid (GBSAA)

141 operations of their Medium/Large RPA, the Sky Warrior (Predator variant) at El Mirage, CA. The Marines/Navy are in the

142 process of getting authorization for GBSAA operations at Cherry Point, SC. The USAF is looking at a corridor for

143 Predator/Reaper aircraft climbing out of Cannon AFB, NM. This GBSAA concept will include a 12 NM corridor between the

144 military Class D airspace and nearby restricted airspace. By 2013, the USAF will have developed a Dynamic Protection Zone

145 (DPZ) concept that will shrink these large exclusion zones down to non-cooperative aircraft self-separation criteria of less

146 than 10 NM much like is used for cooperative aircraft flying under IFR today.

## 147 8. Reference Documents

### 148 8.1 Standards

- 149 • [ICAO Circ 328](#) – *Unmanned Aircraft Systems (UAS)*
- 150 • [Annex 2](#) — *Rules of the Air* proposal for amendment
- 151 • U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- 152 • NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*

### 153 8.2 Procedures

154 TBD

155	<b>8.3</b>	<b><i>Guidance Material</i></b>
156		EUROCAE Document (under development)
157		
158		

# **BLOCK 2**

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# 1 Module N° B2-70: Advanced Wake Turbulence Separation 2 (Time-based) 3

<b>Summary</b>	Wake Turbulence Separation – Time-based. This ICAO ATM System Block Upgrade Module implements dynamic time-based spacing for wake-separation for high-density and high-throughput terminal areas. The time-based separation will be dynamically assessed for each aircraft pairing and provided to ANSP tools and the flight deck for cooperative separation.	
<b>Main Performance Impact</b>	<b>KPA-02 Capacity;</b>	
<b>Domain / Flight Phases</b>	Aerodrome	
<b>Applicability Considerations</b>	Most Complex - 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.	
<b>Global Concept Component(s)</b>	CM – Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-13 Aerodrome Design GPI 14 Runway Operations	
<b>Main Dependencies</b>	Pre-requisite: B0 and B1-70	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	Est. 2023
	Avionics Availability	N/A
	Ground Systems Availability	Est. 2023
	Procedures Available	Est. 2023
	Operations Approvals	Est. 2023

## 4 1. Narrative

### 5 1.1 General

6 Refinement of the Air Navigation Service Provider (ANSP) aircraft-to-aircraft wake mitigation processes,  
7 procedures and standards to time-based assignment will allow increased runway capacity with the same or  
8 increased level of safety. Block 2 upgrade will be accomplished without any required changes to aircraft  
9 equipage or changes to aircraft performance requirements although full benefit from the upgrade will require, as  
10 in block 1, aircraft broadcasting their aircraft based real-time weather observations during their airport approach  
11 and departure operations to continually update the model of local conditions.. The upgrade is dependent on the  
12 block 1 establishment of wake turbulence characterization based on the wake generation and wake upset  
13 tolerance of individual aircraft types.

#### 14 1.1.1 Baseline

15 ANSP applied wake mitigation procedures and associated standards were developed over time, with the last  
16 comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved 6 category wake turbulence  
17 separation standards. Block 1 represented technology being applied to make available further runway capacity

18 savings by enhancing the efficiency of wake turbulence separation standards and the ease by which they can be  
 19 applied by the ANSP. In particular the expansion of the 6 category wake separation standards to a  
 20 Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more  
 21 separate pairings), is expected to yield an average increased airport capacity of 4% above that which was  
 22 obtained by the Block 0 upgrade to the ICAO 6 category wake separation standards. In addition Block 1  
 23 expanded the use of specialized ANSP wake mitigation separation procedures to more airports by using airport  
 24 wind information (predicted and monitored) to adjust the needed wake mitigation separations between aircraft on  
 25 approach.

26 **1.1.2 Change brought by the module**

27 Module B2–70 represents a shift to time-based application of the Block 1 expanded distance based wake  
 28 separation standards and ANSP wake mitigation procedures upgrade. Block 1 represented technology being  
 29 applied to make available further runway capacity savings by enhancing the efficiency of wake turbulence  
 30 separation standards by expanding the 6 category wake separation standards to a Leader/Follower - Pair Wise  
 31 Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings). Automation  
 32 supported the ANSP by providing the minimum distance to be applied by the ANSP between pairs of aircraft.  
 33 That expanded matrix represented a less conservative, but albeit still conservative, conversion of essentially  
 34 time based wake characteristics into a standard set of distances.  
 35

36 Block 1’s goal was to reduce the number of operations in which an excessive wake spacing buffer reduced  
 37 runway throughput. Block 2 uses the underlying criteria represented in the expanding re-categorization, the  
 38 current winds, assigned speeds, and real time environmental conditions to dynamically assess the proper  
 39 spacing between the aircraft to achieve wake separation. It couples that information with expect runway  
 40 occupancy to establish a time spacing that provides a safe separation. These time-based separations are  
 41 provided with support tools to the ANSP on their displays, and to the flight deck in the instances of cooperative  
 42 separation which assumes already available flight deck tools for interval management. Further development of  
 43 the Time-based separation will use Weather dependent separation (WDS) which develops the basic weather  
 44 dependent concepts further and integrated with Time-Based Separation for approach. This concept utilises both  
 45 wake decay and transport concepts (such as P-TBS and CROPS) into a single coherent concept, backed by  
 46 advanced tools support and provides further landing rate improvements and resilience.  
 47

48 **2. Intended Performance Operational Improvement/Metric to determine success**

49 Metrics to determine the success of the module are proposed at Appendix C

50

<i>Capacity</i>	
<i>Efficiency</i>	
<i>Environment</i>	
<i>Predictability</i>	
<i>Safety</i>	

<i>CBA</i>	
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52 **3. Necessary Procedures (Air & Ground)**

53 ***Implement Leader/Follower - Pair Wise Time-based Separation Standards***

54 The change to the ICAO wake separation standards implemented in the Block 2 timeframe will change from a  
 55 distance based separation that was expanded through the previous blocks from 3 to 60 or more to a tailored  
 56 time-based minima.



- 57  
58 Implementing Element 2 will not require any changes to air crew flight procedures.
- 59 **4. Necessary System Capability**
- 60 **4.1 Avionics**
- 61 N/A
- 62 **4.2 Ground System**
- 63 This new ANSP procedure will need automation support in providing the required time-based aircraft-to-aircraft  
64 wake separations to its air traffic controllers.
- 65 **5. Human Performance**
- 66 **5.1 Human Factors Considerations**
- 67 TBD
- 68 **5.2 Training and Qualification Requirements**
- 69 TBD
- 70 **5.3 Others**
- 71 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**
- 72 **5.1 Implement Leader/Follower - Pair Wise Time-based Separation Standards**
- 73 The product of this activity is a new procedure with supporting automaton requirements to establish time-based  
74 separation standards for high density and high throughput terminal areas. This will require an expansion of ICAO  
75 wake separation standards and supporting documentation. Once approved, ICAO's revised wake separation  
76 standards will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards.
- 77 **7. Implementation and Demonstration Activities**
- 78 **7.1 Current Use**
- 79 None at this time
- 80 **7.2 Planned or Ongoing Trials**
- 81 Currently being developed by SESAR WP 6.8.1
- 82
- 83 **8. Reference Documents**
- 84 **8.1 Standards**
- 85 **8.2 Procedures**
- 86 **8.3 Guidance Materials**
- 87 ICAO [Doc 9854](#) Global ATM Operational Concept, and ICAO [Doc 9750](#) Global Air Navigation Plan  
88 This module also incorporates R199Doc 9882
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# 1 Module N° B2-75: Optimised Surface Routing and Safety

## 2 Benefits (A-SMGCS Level 3-4, ATSA-SURF IA and SVS)

<b>Summary</b>	This module describes taxi routing and guidance evolving to trajectory based with ground / cockpit monitoring and data link delivery of clearances and information. Cockpit synthetic visualisation systems are also included that can improve efficiency and reduce the environmental impact of surface operations, including during periods of low visibility. The improvements are achieved through collaboration and data sharing between air navigation service providers (ANSP), aerodrome operators, and airspace users. The efficiencies are accomplished through the management of pushback times, the creation and execution of surface trajectories (including time), and integration with arrival and departure flow management operations. Queuing for departure may be reduced to the minimum necessary to optimize runway use, thus reducing taxi times. Operations are more robust so that low visibility conditions (weather obscuration, night) have minor effect on surface movement.	
<b>Main Performance Impact</b>	KPA-04 Efficiency, KPA-10 Safety	
<b>Domain / Flight Phases</b>	Aerodrome	
<b>Applicability Considerations</b>	Most applicable to large aerodromes with high demand, as the upgrades address issues surrounding queuing and management and complex aerodrome operations	
<b>Global Concept Component(s)</b>	AO - Aerodrome Operations CM - Conflict Management DCB - Demand Capacity Balancing TS - Traffic Synchronisation	
<b>Global Plan Initiatives (GPI)</b>	GPI-14 Runway Operations GPI-16 Decision Support Systems and Alerting Systems GPI-17 Data Link Applications	
<b>Main Dependencies</b>	B1-75, Enhanced Surface Situational Awareness Technical or operational relationship to: B2-80 (Remote Tower)	
<b>Global Readiness Checklist</b>		<b>Status</b> (indicate ready with a tick or input date)
	Standards Readiness	Est. 2018-2023
	Avionics Availability	Est. 2018-2023
	Infrastructure Availability	Est. 2018-2023
	Ground Automation Availability	Est. 2018-2023
	Procedures Available	Est. 2018-2023
	Operations Approvals	Est. 2018-2023

### 3 1. Narrative

#### 4 1.1 General

5 This module is focused on improving the baseline case (completion of B1-75, Enhanced Surface Situational  
6 Awareness), by the introduction of new capabilities that enhance the coordination among ANSP, Airspace  
7 Users, and the Aerodrome Operator, and permit automated management of surface operations:

- 8 • Initial Surface Traffic Management (A-SMGCS Level 3)

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- Enhanced Surface Traffic Management (A-SMGCS Level 4)

This module assumes that a cooperative aircraft surveillance capability is in operational use at aerodromes, and that air navigation service provider (ANSP) and flight crews have access to surveillance and safety logic. This provides a common situational awareness between the ANSP and Flight Crew.

### 1.1.1 Baseline

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 air traffic management (ATM) system in pushback is included, it has been limited to manual coordination of Air Traffic Flow Management (ATFM), not the aerodrome operation itself. As a result, taxiway congestion and departure queues form which extend taxi times, increase direct operating costs (excess fuel burn), impact environment (emissions), and impede the efficient implementation of ATFM plans.

These capabilities will include changes to ANSP, airspace user and airport operations, and flight deck operations.

### 1.1.2 Change brought by the module

This module implements additional surface traffic management (A-SMGCS Level 3) capabilities which 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.

This module also extends to enhance the surface traffic management to an A-SMGCS Level 4 capability which 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.

All of these capabilities combine to lessen the impact of reduced visibility conditions on aerodrome operations, as visual scanning is augmented by the presence of situational awareness, safety logic, and guidance and monitoring of aircraft taxi paths and trajectories. These capabilities also support the use of Virtual or Remote towers as described in the B2-80 module.

## 1.2 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
- Detection of Conflicting ATC clearance for ANSP – automation considers the existing surface operation and active clearances, and detects if conflicts arise in ATC clearances as the surface situation changes.
- Data Link Delivery of Taxi Clearance – the taxi clearance is provided electronically to aircraft
- Conformance Monitoring of ATC Clearance for ANSP – automation monitors the movement of aircraft on the surface and provides an alert if aircraft deviate from their assigned ATC clearance
- 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

55 choose their own priorities for assigning specific flights to these taxi opportunities. This capability will  
56 have basic ability to incorporate any Air Traffic Flow Management Constraints to specific flights.

57 • Data Sharing – information about taxi times, queues, and delays is shared with other ANSP flight  
58 domains, and with external users (airspace users and airport operators).

59 • Improved Guidance by use of Aerodrome Ground Lighting – ground lighting systems on the aerodrome  
60 are enhanced to provide visual cues to aircraft operating on the surface.

61 These activities are intended to directly improve efficiency by maximizing runway use while minimizing taxi  
62 times, within the context of any higher level Air Traffic Flow Management strategy and available airport  
63 resources (e.g. gates, apron areas, stands, taxiways, etc.). This will result in reduced fuel burn, with associated  
64 lowering of environmental impacts.

65 Further, data sharing will improve the information available to Air Traffic Flow Management, leading to better  
66 coordination and decision making among ANSP and airspace users. A secondary impact of this element will be  
67 improved safety, as conformance to taxi clearance is monitored. Aircraft will receive taxi clearances  
68 electronically, to further reduce potential confusion about taxi routes. These capabilities also lessen the impact of  
69 reduced visibility conditions on the aerodrome operation.

### 70 **1.3 Element 2: Enhanced Surface Traffic Management (A-SMGCS Level 4)**

71 This element of the block enhances capabilities from Element 1:

72 • Taxi Trajectories – automation builds a predicted trajectory for each aircraft including times along the  
73 taxi path. When this capability matures, taxi trajectories will be used to assist with deconflicting runway  
74 crossings. Conformance monitoring is enhanced to monitor against trajectory times in addition to paths,  
75 with prediction and resolution of taxi trajectory conflicts.

76 • Taxi Trajectory Guidance for Pilots – digital taxi clearances are parsed by the aircraft avionics to allow  
77 depiction of the taxi route on surface moving maps. Avionics may be further enhanced to provide visual  
78 and/or aural guidance cues for turns in the taxi route, as well as taxi speed guidance to meet surface  
79 trajectory times. This can be displayed on the instrument panel or on a Heads-Up Display.

80 • Synthetic Vision Systems – area navigation capability on the aircraft and detailed databases of  
81 aerodromes will allow for a computer-synthesized depiction of the forward visual view to be displayed in  
82 the cockpit. Integration with Enhanced Vision System will add integrity to this depiction. This capability  
83 reduces the impact that low visibility conditions have on the safety and efficiency of the surface  
84 operation. The depiction can be displayed on the instrument panel or on a Heads-Up Display.

85 • Flight-Specific Departure Schedule Management – ANSP and airspace users will collaboratively develop  
86 a flight-specific surface schedule. Automation assists in identifying appropriate departure times that  
87 consider any Air Traffic Flow Management actions. Other operational factors such as wake turbulence  
88 separation requirements will be considered by automation in sequencing aircraft for departures.  
89 Pushback and taxi operations will be managed to this schedule.

90 • Integration with Arrival and Departure Management – taxi schedules are built to account for arriving  
91 aircraft, and so that aircraft departures meet the objectives for system-wide Air Traffic Flow Management  
92 activities. Flight will be permitted to pushback with the intent to meet targeted departure times.

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## 2 Intended Performance Operational Improvement / Metric to determine success

<i>Access and Equity</i>	This activity contributes to airport access during periods of reduced visibility, by augmenting visual scanning in the tower and in the cockpit by a common surveillance picture, safety logic, and taxi routing, conformance, and guidance. The impact of visual obscuration and night operations on aerodrome operations is lessened.
<i>Efficiency</i>	<p>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.</p> <ul style="list-style-type: none"> <li>a. Reduced Taxi Out Times <ul style="list-style-type: none"> <li>i. Reduced fuel burn and other direct operating cost</li> <li>ii. Associated reduced impact to environment</li> </ul> </li> <li>b. Reduced Start/Stop of during Taxi <ul style="list-style-type: none"> <li>iii. Reduced fuel burn and other direct operating cost</li> <li>iv. Associated reduced impact to environment</li> </ul> </li> </ul>
<i>Flexibility</i>	<ul style="list-style-type: none"> <li>a. Improved ability to re-sequence departing aircraft to meet changing conditions</li> <li>b. Coordination with Air Traffic Flow Management <ul style="list-style-type: none"> <li>i. Improved ability to predict congestion (actual demand vs. capacity)</li> </ul> </li> <li>a. Improved application of Air Traffic Flow Management by trajectory</li> <li>b. Improved Information to Air Traffic Flow Management <ul style="list-style-type: none"> <li>i. Improved ability to predict congestion (actual demand vs. capacity)</li> <li>ii. Improved application of Air Traffic Flow Management Actions</li> </ul> </li> <li>c. Improved flexibility on the aerodrome surface by improving the ability to re-sequence departing aircraft to meet changing conditions</li> </ul>
<i>Safety</i>	<p>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 of path intersections such as runway crossings. Aerodrome operations are less affected by low visibility conditions.</p> <ul style="list-style-type: none"> <li>a. Reduced Taxi Non-Conformance</li> <li>b. Reduced Taxi Clearance Communications Errors</li> </ul>
<i>CBA</i>	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.

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### 102 **3 Necessary Procedures (Air & Ground)**

103 Significant ANSP procedure changes for managing aerodrome surface operations will be required, including the  
 104 creation of collaboration procedures and norms with airspace users and/or aerodrome operators for aggregate  
 105 surface scheduling. In particular, managing surface operations by ANSP control of pushback times is potentially  
 106 a significant change in aerodrome management policies at many locations. Specific procedures for each  
 107 element and sub-element are required to effectively achieve the benefits of this module, and ensure safety,  
 108 including procedures for ANSP use of Data Link Taxi Clearances and procedures for coordination with Air Traffic  
 109 Flow Management.

110 Airspace users and/or aerodrome operators need to make significant changes to their procedures for managing  
 111 surface operations, especially for the collaborative building of aggregate surface taxi schedules and the  
 112 accommodation of ANSP control of pushback times.

113 Flight deck procedures for use and integration of Data Link Taxi Clearances are required.

### 114 **4 Necessary System Capability**

#### 115 **4.1 Avionics**

116 The following aircraft technology is required:

- 117 1. Data Link Communications
- 118 2. Synthetic Vision System
- 119 3. Taxi Trajectory Guidance capability

#### 120 **4.2 Ground Systems**

121 The following ANSP technology is required:

- 122 1. Initial and enhanced A-SMGCS / Surface Traffic Management Automation
- 123 2. Data sharing with Air Traffic Flow Management
- 124 3. Data Link Communications.

125 This element also requires an airspace user/aerodrome operator technology deployment in the form of an  
 126 Enhanced A-SMGCS / Collaboration capability with ANSP Surface Traffic Management capability.

127

### 128 **5 Human Performance**

#### 129 **5.1 Human Factors Considerations**

130 Since ground operations procedural changes for managing aerodrome surface operations will be required,  
 131 including the creation of collaboration procedures and norms with airspace users and/or aerodrome operators for  
 132 aggregate surface scheduling, human factors must be considered and demonstrated during the planning  
 133 process. Human factors must also be considered in the context of workload and failure modes to ensure safety,  
 134 including procedures for ANSP use of Data Link Taxi Clearances.

135 Human factors in the form of workload analysis must also be considered for airspace users and/or aerodrome  
 136 operators when they make significant changes to their procedures for managing surface operations, especially  
 137 for the collaborative building of aggregate surface taxi schedules and the accommodation of ANSP control of  
 138 pushback times.

139 Additional studies must be completed as to the effects of changes in flight deck procedures for use and  
 140 integration of Data Link Taxi Clearances.

#### 141 **5.2 Training and Qualification Requirements**

142 Automation and procedural changes for aircrews, controllers, ramp operators, etc. will invoke necessary training  
143 for the new environment and to identify operational and automation issues before implementation. Scenarios will  
144 also have to be developed and trained that incorporate likely hood of occurrences of off nominal situations so the  
145 full capability of this module can be implemented.

## 146 **6 Regulatory/Standardisation needs and Approval Plan (Air & Ground)**

147 Standards for (a) Initial and Enhanced A-SMGCS / Surface Traffic Management Automation, (b) communication  
148 standards with Air Traffic Flow Management and Airspace User and/or Aerodrome Operators (aggregate  
149 collaboration on schedule, (integration of arrival, surface, and departure schedules), (c) Data Link  
150 Communications (d) Flight Deck Taxi Trajectory Guidance, and (e) Flight Deck Synthetic Vision Systems (RTCA  
151 SC-213/Eurocae WG-79).

## 152 **7 Implementation and Demonstration Activities**

### 153 **7.1 Current Use**

154 ANSPs and commercial companies have developed initial capabilities in this area. These capabilities allow for  
155 data exchange of surface surveillance data between ANSPs, airspace users, and airport operators.  
156 Enhancements to operations are largely centered on improvements that shared surface situational awareness  
157 provides.

### 158 **7.2 Planned or Ongoing Trials**

#### 159 **7.2.1 Initial Surface Traffic Management (A-SMGCS Level 3)**

160 Various ANSPs, research and government organizations and industry are working on prototype capabilities of  
161 Surface Traffic Management. These activities include Surface Traffic Management / Airport Collaborative  
162 Decision Making capabilities and concepts under evaluation at airports around the world (e.g. Memphis, Dallas-  
163 Fort Worth, Orlando, Brussels, Paris/Charles de Gaulle, Amsterdam, London/Heathrow, Munich, Zurich, and  
164 Frankfurt). Laboratory simulation experiments on more advanced capabilities such as Taxi Conformance  
165 Monitoring (MITRE) have been performed. European development is being accomplished via SESAR Work  
166 Program 6, Eurocontrol, and others. Deployment in the United States of initial capabilities is slated for the 2018  
167 timeframe.

#### 168 **7.2.2 Enhanced Surface Traffic Management (A-SMGCS Level 4)**

169 Collaborative Departure Scheduling is under research in the US and Europe, but has not yet undergone  
170 operational trials. Laboratory simulation experiments on more advanced capabilities such as Taxi Route  
171 Guidance (NASA) have been performed. Other areas such as management of aerodrome surface operations by  
172 trajectory are still under concept formulation.

173

## 174 **8. Reference Documents**

### 175 **8.1 Standards**

176 EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305,  
177 ED110B/DO280

178 EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.

### 179 **8.2 Procedures**

180 **tbd**

### 181 **8.3 Guidance Material**

- 182 ▪ ICAO [Doc 9830](#) Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual
- 183 ▪ FAA Advisory Circulars:



- 184 ▪ [AC120-28D Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout](#)
- 185 ▪ [AC120-57A Surface Movement Guidance and Control System](#)
- 186 ▪ Manual of Air Traffic Services Data Link Applications ([DOC 9694](#))

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190 (REFERENCES)

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195 concept also requires clearance and conformance to clearance for those vehicles.

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223 Hopff, P., "D-TAXI Trials at Brussels Airport", Eurocontrol CASCADE Workshop, Toulouse April 2006.

224 NASA CTO-5, ATMSDI Surface Management System, Final Life-Cycle Benefits Assessment – June 2004.-  
225 Improved runway allocation provided single year benefits of \$172.8 M / year if implemented at 52 airports – 92  
226 m/year at 18 airports; Improved data for sector demand prediction (over ETMS) – 38.2\$M /yr

227 Dan Howell, "Effect of Surface Surveillance Data Sharing on FedEx Operations at Memphis International  
228 Airport", Air Traffic Control Quarterly, Vol. 13, No. 3, 2005 - 0.7 min reduction in taxi time for North Flow, 0.3 in  
229 South Flow; ROM – 0.5 min/flt – say 10-20K flts/day = 1.8-3.6 m min/yr ~100m\$/yr

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238

1 **Module N° B2-15: Linked AMAN/DMAN**

<b>Summary</b>	Synchronised AMAN/DMAN will promote more agile and efficient en-route and terminal operations	
<b>Main Performance Impact</b>	KPA-02 Capacity; <b>KPA-04 Efficiency</b> ; KPA-09 Predictability KPA-06 Flexibility	
<b>Domain/ Flight Phases</b>	Aerodrome and Terminal	
<b>Applicability Considerations</b>	Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.  The implementation of this module is Least Complex.  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 RNAP/RNP routes need to be in place.	
<b>Global Concept Element(s)</b>	TS – Traffic Synchronization	
<b>Global Plan Initiative</b>	<b>GPI-6</b> Air Traffic Flow Management	
<b>Main Dependencies</b>	B1-15	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est. 2025</b>
	Avionics Availability	<b>Est. 2025</b>
	Ground Systems Availability	<b>Est. 2025</b>
	Procedures Available	<b>Est. 2025</b>
	Operations Approvals	<b>Est. 2025</b>

2 **1. Narrative**

3 **1.1 General**

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

7 In Block 2 (2023), departure and arrival sequencing will be synchronised. Arrival and departure exact strains on  
8 the same aerodrome resources. Thus, the coupling of arrival and departure manager will harmonize and de-  
9 conflict the respective flows and enable more efficient runway utilization. ATM authorities can now coordinate  
10 arrival and departure activities and devise an arrival/departure sequence that avoids conflicts between the two.  
11 The synchronization of arrival and departure management allows ANSPs to configure arrival and departure  
12 procedures to maximize utilization of aerodrome and terminal airspace.

13 This synchronisation will foster greater runway throughput and airspace capacity. In addition, the integration  
14 enables dynamic sequencing for both arrival and departure. The ANSP can, based on runway configuration and  
15 demand, adjust departure and arrival flow by manipulation of meter fixes and such that airspace capacity is used

16 efficiently. This joint sequencing will aid with ANSP's demand and capacity balancing prerogatives and enable  
17 more efficient terminal and aerodrome airspace configuration.

18 Synchronisation of arrival and departure sequences relies upon operational consistency and information  
19 homogeneity. Flight information, such as speed, position, restrictions, and other relevant information, must be  
20 uniform and share across all ATC authorities. Information homogeneity and common procedures are essential in  
21 achieving the operational consistency between ATC authorities that is the stepping stone for departure and  
22 arrival synchronisation.

### 23 **1.1.1 Baseline**

24 Block 1 brought about the synchronisation of surface and departure management. Specifically, surface  
25 management and departure sequencing will be linked to further streamline departure operations. Surface and  
26 departure activities will be coordinated. Precise surface movement reduces runway occupancy time and improve  
27 conformance to assigned departure time. RNAV/RNP procedures usage in high density terminal domain is more  
28 prevalent. Greater usage of RNAV/RNP procedures optimises throughput and provides fuel-efficient routes for  
29 airspace users. Metering will also be extended into adjacent FIR airspace, ensure greater monitoring on  
30 conformance to Control Time of Arrivals. Extended metering will also assist in transitioning flights from en-route  
31 to terminal airspace.

### 32 **1.1.2 Change brought by the module**

33 In Block 2, arrival and departure sequencing will be synchronised. The primary benefits of such synchronisation  
34 are optimised allocation of airspace/aerodrome resources, resulting in greater runway and airspace throughput.  
35 Arrival and departure flow can be sequence to circumvent the negative impacts of natural phenomena,  
36 separation restrictions, and conflicts. This gives ATM greater latitude in coping with excess demand. Runway  
37 and airspace configuration can be dynamically adjusted to accommodate any change in the arrival/departure  
38 flow patterns. Integrated arrival and departure management ensure that aircrafts are optimally spaced to achieve  
39 the maximum throughput.

40 The synchronised information flow as the result of harmonisation between departure and arrival also foster  
41 greater common situation awareness for all stakeholders. Information transferred between all ATC authorities  
42 involved will be reconciled to provide a common operational picture. This reduces the complexity

## 43 **1.2 Element 1: Arrival and Departure Synchronization**

44  
45 Arrival and departure synchronization establishes a predictable and efficient stream of flights in the terminal and  
46 aerodrome airspace. The synchronization will optimize both terminal procedures and runway configuration to  
47 accommodate the maximum volume of aircrafts. Dynamic sequencing of arrival and departure flow will aid in the  
48 optimization of terminal procedures by avoiding or lessening the impact of relevant restrictions. The coupled  
49 arrival and departure sequence can be adjusted to accommodate the demand and terminal domain resource  
50 constraints.  
51

## 52 **2. Intended Performance Operational Improvement/Metric to determine success**

53 Metrics to determine success of the module are proposed at Appendix C.

54

<i>Capacity</i>	Decrease in Miles-in-Trail (MIT) restrictions implies greater capacity in the terminal and aerodrome domain
<i>Efficiency</i>	Optimize utilization of terminal and runway resources. a. Optimize and coordinate arrival and departure traffic flows in the terminal and aerodrome domain
<i>Predictability</i>	Decrease uncertainties in aerodrome/terminal demand prediction

<i>Flexibility</i>	Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns
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55

<i>CBA</i>	Linked AMAN/DMAN will reduce ground delay. In the US, the Integrated Arrival and Departure Capability (IDAC) provide over .99 million minutes in benefits over the evaluation period, or \$47.20 million (risk adjusted constant year) <sup>3</sup> in benefits to airspace users and passengers. Implementation of linked AMAN/DMAN will also increase compliance to ATM decision such as assigned arrival and departure time. Coordination of arrival and departure flow, along with modifications to airspace and aerodrome configuration will m enhance throughput and airspace capacity. Reconfiguration of airspace to accommodate different arrival/departure patterns entails more agile terminal operations.
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57 **3. Necessary Procedures (Air & Ground)**

58 The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides  
 59 guidance on implementing integrated arrival and departure consistent with the vision of a performance-oriented  
 60 ATM System. The TBFM and AMAN/DMAN efforts, along with other initiatives, provide the systems and  
 61 operational procedures necessary. Airspace integration and re-design maybe required.

62

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

65 **4. Necessary System Capability**

66 **4.1 Avionics**

67 No additional avionics beyond Block 0 is required for the implementation of this module.

68 **4.2 Ground Systems**

69 Mechanism to share relevant information effectively and in a timely manner is essential to this element and also  
 70 fosters greater common situational awareness between all users of the aerodrome and its surrounding airspace.

71

72 **5. Human Performance**

73 **5.1 Human Factors Considerations**

74 ATM personnel responsibilities will not be affected

75 **5.2 Training and Qualification Requirements**

76 Automation support is needed for Air Traffic Management in airspace with high demands. Thus, training is  
 77 needed for ATM personnel.

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<sup>3</sup> Exhibit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

81 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

82 Linked AMAN/DMAN will entail policies on arrival and departure information sharing, roles and responsibilities of  
83 all users of the aerodrome surface and terminal airspace, and mutual understanding/acceptance of operational  
84 procedures. A framework, similar to A-CDM in Europe and surface CDM in the US, should be established to serve  
85 as a forum for all stakeholders to discuss relevant issues and concerns.

86 **7. Implementation and Demonstration Activities**

87 **7.1 *Planned or Ongoing Trials***

88 Linked AMAN/DMAN will be introduced as the next step following the integration of surface and departure  
89 management. The integration of arrival and departure management realizes the synchronization of arrival,  
90 departure, and surface operations.

91

92 **8. Reference Documents**

93 **8.1 *Standards***

94 **8.2 *Procedures***

95 **8.3 *Guidance Material***

96 [European ATM Master Plan](#),

97 [SESAR Definition Phase Deliverable 2 – The Performance Target](#),

98 [SESAR Definition Phase Deliverable 3 – The ATM Target Concept](#),

99 [SESEAR Definition Phase 5 – SESAR Master Plan](#)

100 TBFM Business Case Analysis Report

101 NextGen Midterm Concept of Operations v.2.0

102 RTCA Trajectory Concept of Use

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1 **Module N° B2-25 Improved Coordination through multi-centre**  
 2 **Ground-Ground Integration: (FF-ICE/1 and Flight Object, SWIM)**  
 3

<b>Summary</b>	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 ATSU's.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, <b>KPA-07 Global Interoperability</b> , KPA-08 Participation by the ATM community KPA-10 Safety,	
<b>Operating Environment/Phases of Flight</b>	All flight phases and all types of ground stakeholders	
<b>Applicability Considerations</b>	Applicable to all ground stakeholders (ATS, Airports, Airspace Users) in an homogeneous areas, potentially global.	
<b>Global Concept Component(s)</b>	AUO –Airspace User Operations AO – Airport Operations DCB – Demand capacity Balancing CM - Conflict management IM - Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-7 Dynamic and flexible route management GPI-12 Functional integration of ground systems with airborne systems GPI-16 Decision Support Systems	
<b>Pre-Requisites</b>	Successor of B1-25, B1-31	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	Est; 2018
	Avionics Availability	No requirement
	Ground Systems Availability	Est; 2020
	Procedures Available	Est. 2020
	Operations Approvals	Est; 2020

4 **1. Narrative**

5 **1.1 General**

6 **1.1.1 Baseline**

7 The baseline for this module is coordination transfers and negotiation as described in B0-25 and B1-25 and the  
 8 first step of FF-ICE/1 for ground application, during the planning phase before departure.

9 **1.1.2 Change brought by the module**

10 Sharing of all the Flight and Flow information during Planning and Execution Flight Phase

11 **1.2 Element:**

12 FF-ICE/1 will be extended for a complete use of FF-ICE after departure supporting Trajectory based Operations.  
13 The technical specification for FF-ICE will be implemented in the ground systems (ASP, AOC, Airport) using  
14 Flight Object implementation and IOP standard.

15 The module makes available a protocol to support exchange and distribution of information for multicentre  
16 operations.

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

22 The first implementations of SWIM (B1-31, B2-31) will facilitate flight information sharing.

23 **1.3 Other remarks**

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

26 **2. Intended Performance Operational Improvement/Metric to determine success**

27 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Reduced controller workload and increased data integrity and improved seamlessness at borders of ATSUs
<i>Efficiency</i>	Through more direct route and use of RTA to upstream centers..
<i>Flexibility</i>	Better adaptation to user request change through facilitated information exchange
<i>Global Interoperability</i>	Easier facility of system connexion and wide exchange of the information among the actors
<i>Participation by the ATM community</i>	FF-ICE will facilitate the participation of all interested parties
<i>Safety</i>	More accurate and updated information
<i>Human performance</i>	Positive impact of more accurate information.

<i>CBA</i>	Balance between cost of ground system change and improved capacity/flight efficiency to be determined.
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29 **3. Necessary Procedures (Air & Ground)**

30 Need for new procedures for new set of applications towards Trajectory Based operation

31 **4. Necessary System Capability**

32 **4.1 Avionics**

33 Data communication will be used for exchange of trajectory information with the ground-system.

34 Only non-secured equipment like Electronic Flight Bag will have access to the ground SWIM environment.



35 **4.2 Ground Systems**

36 ATM ground systems need to support IOP and SWIM concept.

37 Data communication infrastructure is required to support high speed ground-ground communication between  
38 ground systems and be connected to air-ground data-links.

39 **5. Human Performance**

40 **5.1 Human Factors Considerations**

41 Positive impact of more accurate information.

42 **5.2 Training and Qualification Requirements**

43 **5.3 Others**

44 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

- 45 • Eurocae ED133 is available for Flight data Processing. For the time being it addresses only civil ATSU's  
46 FDP interoperability needs but it is foreseen that other Flight Information users needs will also be  
47 accomodated by this standard.
- 48 • Further standards are needed to support CDM applications and Flight information sharing and access to  
49 all ground stakeholders.

50 **7. Implementation and Demonstration Activities**

51 **7.1 Current Use**

52 **7.2 Planned or Ongoing Activities**

53 In SESAR Project 10.2.5, Flight Object Interoperability (IOP) System Requirement & Validation using Eurocae  
54 ED133 first demonstration and validation activities are planned during 2012-2014 period and first developments  
55 in industrial systems are available from 2015.

56 It is anticipated that the initial implementation date in Europe between two ATSUs from two system providers  
57 and two ANSPs will occur between 2018 and 2020.

58 SESAR R&D projects on SWIM are in WP14 SWIM technical architecture and WP8 Information management.

59 **8. Reference Documents**

60 **8.1 Standards**

- 61 • [Eurocae ED133 Flight Object Interoperability Standard](#)  
62 • FF-ICE FIXM SARPs to be developed

63 **8.2 Procedures**

64 **8.3 Guidance Material**

65 [FF-ICE concept document](#)

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# 1 Module N° B2-31: Enabling Airborne Participation in collaborative 2 ATM through SWIM

3

<b>Summary</b>	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.	
<b>Timescale</b>	From 2023	
<b>Main Performance Impact</b>	KPA-01 Access & Equity, KPA-04 Efficiency, KPA-05 Environment, KPA-08 Participation by the ATM Community, KPA-09 Predictability, KPA-10 Safety	
<b>Domain / Flight Phases</b>	All phases of flight	
<b>Applicability Considerations</b>	long-term evolution potentially applicable to all environments	
<b>Global Concept Component(s)</b>	IM – Information Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-17 Implementation of data link applications GPI-18 Electronic information services	
<b>Main Dependencies</b>	Successor of: B1-30, B1-31, B1-105,	
<b>Global Readiness Checklist</b>		<b>Status (ready or date)</b>
	Standards Readiness	<b>2023</b>
	Avionics Availability	<b>2023</b>
	Infrastructure Availability	<b>2023</b>
	Ground Automation Availability	<b>2023</b>
	Procedures Available	<b>2023</b>
	Operations Approvals	<b>2023</b>

## 4 1. Narrative

### 5 1.1 General

6 The Global concept envisages that the aircraft is an integral part of the collaborative, information-rich ATM  
7 environment. This ultimately makes it a regular node of the SWIM processes and infrastructure, able to  
8 participate in the 4D trajectory management and collaborative processes. Enabling the aircraft to participate in  
9 SWIM is the availability of a low cost data link capability for strategic information exchange.

#### 10 1.1.1 Baseline

11 Modules B1-30 and B1-31 have created the ground SWIM infrastructure and the information reference model,  
12 and implemented processes and applications for ground users. Through datalinks such as WiMax , a high  
13 capacity data link exists for aircraft at the gate (end of pre-flight phase). Aviation, motivated first by non-ATM  
14 needs, has access to commercial satellite communication.

15 **1.1.2 Change brought by the module**

16 This module allows the aircraft to be fully connected as an information node in SWIM, enabling full participation  
17 in collaborative ATM processes with access to voluminous dynamic data including meteorology, initially for non-  
18 safety critical exchanges supported by commercial data links. The applications of this module are integrated into  
19 the processes and the information infrastructure which had evolved over the previous blocks.

20 The module can then evolve smoothly to the use of other technologies as they become available for the air-  
21 ground link when the aircraft is airborne. To enable the Collaborative ATM, and meteorological information  
22 exchange capabilities in this module, network access on the aircraft is required on the ground and in the air.  
23 However, since these capabilities are not safety-critical, the security and reliability requirements are lower than  
24 those of critical systems such as the VDL network, a commercial system utilizing cell-based or satellite based  
25 internet services could be used.

26 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Access and Equity</i>	Access by the aircraft to the ATM information environment
<i>Efficiency</i>	Better exploitation of meteorological and other operational (e.g. airport situation) information to optimise the trajectory
<i>Environment</i>	Better exploitation of meteorological information to optimise the trajectory
<i>Participation by the ATM community</i>	The aircraft becomes an integral part of continuous collaboration and of the overall information pool.
<i>Predictability</i>	Anticipation of situations affecting the flight through the access to relevant information
<i>Safety</i>	Anticipation of potentially hazardous or safety bearing situations affecting the flight through the access to relevant information

<i>CBA</i>	The business case will be established in the relevant validation programmes.
<i>Human Performance</i>	A critical element is the integration of the new information processes in the tasks of the pilot; they may also affect the respective duties of the aircraft crew and the airline dispatchers.  The use of the applications during demanding flight conditions will need careful investigation.  Training will be required.

27

28 **3. Necessary Procedures (Air & Ground)**

29 Procedures are to be defined. They will define the conditions of access to information and the use to supported  
30 applications depending on the characteristics of these and of the communication channels available, in particular  
31 safety, security and latency.

32 **4. Necessary System Capability**

33 **4.1 Avionics**

34 The enabling technologies are under development. The most important one is the availability of a suitable  
35 combination of air-ground data links to support safety- or non-safety-critical applications.

36 **4.2 Ground Systems**

37 The enabling technologies are under development.

## 38 5. Human Performance

### 39 5.1 Human Factors Considerations

40 A critical element is the integration of the new information processes in the tasks of the pilot; they may also affect  
41 the respective duties of the aircraft crew and the airline dispatchers.

42 The use of the applications during demanding flight conditions will need careful investigation.

### 43 5.2 Training and Qualification Requirements

44 Training will be required for the reasons given in Section 5.1.

### 45 5.3 Others

46

## 47 6. Regulatory/standardisation needs and Approval Plan (Air & Ground)

48 Specifications are to be defined.

## 49 7. Implementation and Demonstration Activities

### 50 7.1 Current Use

- 51 ▪ None

### 52 7.2 Planned or Ongoing Trials

- 53 ▪ **Europe: D-AIM trials in 2009/10.** The Digital Aeronautical Information Management (D-AIM) project, a joint  
54 EUROCONTROL and LFV activity (with Jeppesen for the last year). It culminated in a series of a dozen  
55 of successful flight trials at Stockholm-Arlanda airport and around Stockholm TMA focusing on transmission  
56 of real-time originated NOTAMs & SIGMETs over data link, graphically depicted to the pilot on the Electronic  
57 Flight Bag (EFB) with moving map functionality. An integral element of the D-AIM project was the encoding  
58 of Airport Mapping data, shared to ground and air users over generic information services. The project was  
59 based on an open architecture based on global industry standards, with a description of the current and  
60 possible future architectures in combination with precise use-cases defining the work to be performed in the  
61 real world. LFV is progressing towards making some of the developed services operational. More  
62 information can be found on [www.d-aim.aero](http://www.d-aim.aero) .
- 63 ▪ **US: FAA AAtS trials:** simulations, demonstrations and trials in the 2011-14 period, for both domestic and  
64 oceanic/remote areas global interoperability trials; the concept of use, architecture and technical  
65 requirements will be developed and tested. More information can be found on [www.swim.gov](http://www.swim.gov) .

66

## 67 8. Reference Documents

### 68 8.1 Standards

### 69 8.2 Procedures

### 70 8.3 Guidance Material

- 71 • FF-ICE Manual (under development)
- 72 • ICAO Global Concept

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1 **Module N° B2-35: Increased user involvement in the dynamic**  
 2 **utilisation of the network**

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	<b>KPA-02 Capacity</b> ; KPA-09 Predictability	
<b>Operating Environment/Phases of Flight</b>	Pre-flight phases	
<b>Applicability Considerations</b>	Region or sub-region	
<b>Global Concept Component(s)</b>	DCB-Demand-Capacity Balancing TS-Traffic Synchronisation AOM-Airspace Organisation and Management AUO-Airspace Users Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>	Successor of B1-35 Requires B1-30 and probably B2-25	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	<b>Est. 2023</b>
	Avionics Availability	<b>Est. 2023</b>
	Ground Systems Availability	<b>Est. 2023</b>
	Procedures Available	<b>Est. 2023</b>
	Operations Approvals	<b>Est. 2023</b>

4 **1. Narrative**

5 **1.1 General**

6 **1.1.1 Baseline**

7 The previous module, B1-35, has introduced an initial version UDPP, focused on the issues at an airport.

8 **1.1.2 Change brought by the module**

9 This module further develops the CDM applications by which ATM will be able to offer/delegate to the users the  
 10 optimisation of solutions to flow problems, in order to let the user community take care of competition and their  
 11 own priorities in situation when the network or its nodes (airports, sector) does no longer provide actual capacity  
 12 commensurate with the satisfaction of the schedules. This module also builds on SWIM for more complex  
 13 situations.



14 **2. Intended Performance Operational Improvement/Metric to determine success**

15 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Improved use of the available capacity in situations where it is constrained.
<i>Predictability</i>	The module offers airlines the possibility to have their priorities taken into account and optimise their operations in degraded situations.

<i>CBA</i>	To be established when the research on the module has progressed more significantly
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16

17 **3. Necessary Procedures (Air & Ground)**

18 Procedures to specify the conditions (in particular rules of participation, rights and duties, equity principles, etc)  
19 and notice for UDPP to be applicable. The process will need to be done in a way that does not conflict with or  
20 degrades the optimisation of the network done by ATFM.

21 **4. Necessary System Capability**

22 **4.1 Avionics**

23 None in addition to that required for participation in SWIM where applicable.

24 **4.2 Ground Systems**

25 Will be supported by SWIM environment technology and ground-ground integration, including with Airline  
26 operation systems.

27 Automated functions allowing negotiation among users and connection with ATFM systems.

28 **5. Human Performance**

29 **5.1 Human Factors Considerations**

30 No significant issue identified. Nevertheless, the module will introduce additional factors in the decision making  
31 related to flight preparation and planning which will need to be understood by airline personnel.

32 **5.2 Training and Qualification Requirements**

33 The new procedures will require training adapted to the collaborative nature of the interactions, in particular  
34 between ATFM and airline operations personnel.

35 **5.3 Others**

36 Nil

37 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

38 Equity requirements will likely imply that the mechanisms underlying the process are transparent and verifiable.  
39 The procedures mentioned above will need be regulated.

40 **7. Implementation and Demonstration Activities**

41 **7.1 Current Use**

42 None at this time.

43 **7.2 *Planned or Ongoing Activities***

- 44   ▪ **Europe:** SESAR work programme has just started to formulate the concept of UDPP, and will need to  
45    elaborate this module further before describing the trials for it.

46 **8. Reference Documents**

47 **8.1 *Standards***

48       TBD

49 **8.2 *Procedures***

50       TBD

51 **8.3 *Guidance Material***

52       TBD

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# Module N° B2-85 Airborne Separation (ASEP)

<b>Summary</b>	<p>To create operational benefits through temporary delegation of responsibility to the flight deck for separation provision between suitably equipped designated aircraft, thus reducing the need for conflict resolution clearances while reducing ATC workload and enabling more efficient flight profiles.</p> <p>The flight crew ensures separation from suitably equipped 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.</p>	
<b>Main Performance Impact</b>	KPA-02 Capacity, <b>KPA-03 Cost Effectiveness</b> KPA-04 Efficiency, KPA-05 Environment	
<b>Domain / Flight Phases</b>	En-route phase, oceanic, and approach, departure and arrival	
<b>Applicability Considerations</b>	The safety case need to be carefully assessed and the impact on capacity is still to be assessed in case of delegation of separation for a particular conflict implying new regulation on airborne equipment and equipage roles and responsibilities (new procedure and training). First applications of ASEP are envisaged in Oceanic airspace and in approach for closely-spaced parallel runways.	
<b>Global Concept Component(s)</b>	CM- Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-16 Decision support systems and alerting systems	
<b>Pre-Requisites</b>	In-Trail-Procedure (ITP) B0-85 and Interval Management (IM) B1-85,	
<b>Global Readiness Checklist</b>		<b>Status (ready or date)</b>
	Standards Readiness	Est. 2023
	Avionics Availability	Est. 2023
	Ground Systems Availability	Est. 2023
	Procedures Available	Est. 2023
	Operations Approvals	Est. 2023

## 1. Narrative

### 1.1 General

Airborne separation is described in the Global ATM Operational concept (ICAO [Doc 9854](#))

“

#### Cooperative separation

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.”

12 **1.1.1 Baseline**

13 The baseline is provided by the first ASAS application described in the modules B0-86 and B1-85. These ASAS-  
 14 ASEP operations will be the next step.

15 **1.1.2 Change brought by the module**

16 This module will introduce new modes of separation relying on aircraft capabilities including airborne surveillance  
 17 supported by ADS-B and giving responsibility for separation to the pilot by delegation from the controller. This  
 18 relies on the definition of new Airborne Separation Minima.

19 **1.2 Element: ASEP**

20 **Airborne separation:** The flight crew ensures separation from designated aircraft as communicated in new  
 21 clearances, which relieve the controller from the responsibility for separation between these aircraft. However,  
 22 the controller retains responsibility for separation from aircraft that are not part of these clearances and from  
 23 aircraft involved in ASEP and surrounding aircraft.

24 **Typical Airborne Separation applications include:**

- 25 • In-descent separation: the flight crews maintain a time-based horizontal separation behind designated  
 26 aircraft.
- 27 • Level flight separation: the flight crews maintain a time or distance-based longitudinal separation behind  
 28 designated aircraft.
- 29 • Lateral crossing and passing: the flight crews adjust the lateral flight path to ensure that horizontal  
 30 separation with designated aircraft is larger than the applicable airborne separation minimum.
- 31 • Vertical crossing: the flight crews adjust the vertical flight path to ensure that vertical separation with  
 32 designated aircraft is larger than the applicable airborne separation minimum.
- 33 • Paired Approaches in which the flight crews maintain separation on final approach to parallel runways
- 34 • In oceanic airspace many procedures are considered as improvement of In Trail Procedure (ITP) using  
 35 new airborne separation minima
  - 36 ○ ASEP-ITF In Trail Follow
  - 37 ○ ASEP-ITP In Trail Procedure
  - 38 ○ ASEP-ITM In Trail Merge

39 **2. Intended Performance Operational Improvement/Metric to determine success**

40 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Increase by allowing reduced separation minima and potential reduction of ATCO workload
<i>Efficiency</i>	More optimum flight trajectories
<i>Environment</i>	Less fuel consumption due to more optimum flight trajectories
<i>Flexibility</i>	More flexibility to take in account change in constraint, weather situation
<i>Predictability</i>	Conflict resolution is optimised and potentially more standardized thanks to the airborne equipment performance standards.
<i>Safety</i>	To be demonstrated

<i>CBA</i>	To be determined by balancing cost of equipment and training and reduced penalties
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42 **3. Necessary Procedures (Air & Ground)**

43 ASAS-ASEP procedures need to be defined for PANS-ATM and PANS-OPS with clarifications of roles and  
 44 responsibilities

45 **4. Necessary System capability (Air & Ground)**

46 **4.1 Avionics**

47 For ASEP and airborne separation delegation: Air-Ground data-link and ADS-B Out and ADS-In airborne system  
48 associated to Airborne Separation Assistance Systems (ASAS). The ASAS is composed of 2 main functions i.e.,  
49 airborne surveillance and conflict resolution.

50 **4.2 Ground systems**

51 On the ground there is a need for specific tools to assess the aircraft capabilities and to support delegation  
52 function. This requires a full sharing of the trajectory information between all the actors. It may be necessary to  
53 tune STCA in a specific mode for this procedure (restricted to collision avoidance only).

54 **5. Human Performance**

55 **5.1 Human Factors Considerations**

56 Change of role of controllers and pilots need to be carefully assessed and understood by both parties.

57 Specific training and qualification are required

58 **5.2 Training and Qualification Requirements**

59 The pilot needs to be trained and qualified to assume the new role and responsibility and correct usage of the  
60 new procedures and avionics.

61 Automation support is needed both for the pilot and the controller which therefore will have to be trained to the  
62 new environment and to identify the aircraft/facilities which can use the services.

63 **5.3 Others**

64 Liability issues are to be considered.

65 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

66 Change in PANS-OPS and PANS-ATM are required. Determination of applicable separation minima is  
67 necessary.

68 **7. Implementation and Demonstration Activities**

69 **7.1 Current Use**

70 None at this time.

71 **7.2 Planned or Ongoing Trials**

72 **European projects**

73 **ASSTAR (2005-2007) initiated the work on ASEP and SSEP applications in Europe which has been**  
74 **pursued by SESAR projects as follows:**

75 **SESAR Project 04.07.04.b ASAS-ASEP Oceanic Applications**

76 "The Airborne Separation In Trail Follow (ASEP-ITF) and In Trail Merge (ASEP-ITM) applications have been  
77 designed for use in oceanic and other non-radar airspace.

78 ASEP-ITF transfers responsibility for separation between the ITF Aircraft and a Reference Aircraft from the  
79 controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high  
80 accuracy and integrity requirements on the avionics (both the ITF and Reference Aircraft positioning, airborne  
81 surveillance and ASEP-ITF ASAS logic). ASEP-ITF is intended as a means of improving vertical flexibility,  
82 allowing aircraft to make a level change where current procedural separation standards will not allow it, by

83 enabling level changes to the flight level of a Reference Aircraft which is operating at a different flight level, but  
84 on the same identical track.

85 ASEP-ITM transfers responsibility for separation between the ITM Aircraft and a Reference Aircraft from the  
86 controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high  
87 accuracy and integrity requirements on the avionics (both the ITM and Reference Aircraft positioning, airborne  
88 surveillance and ASEP-ITM ASAS logic). ASEP-ITM is intended as a means of improving lateral flexibility,  
89 allowing aircraft to change their routing where current procedural separation standards will not allow it, by  
90 enabling a lateral manoeuvre to follow, and then maintain, a minimum interval behind a Reference Aircraft which  
91 is operating at a same direction flight level.

92 Both applications will require the crew to use airborne surveillance information provided on the flight deck to  
93 identify the potential opportunity to use the applications and to maintain a reduced separation from the  
94 Reference aircraft during the manoeuvres.”

95 **SESAR Project 04.07.06 En Route Trajectory and Separation Management – ASAS Separation**  
96 **(Cooperative Separation)**

97 The main objective of this project is to assess the introduction of ASAS separation application in the SESAR  
98 context (taking into account all platforms, including military and UAS).  
99 The project will be focused on the possibility to delegate in specific and defined conditions the responsibility for  
100 traffic separation tasks to the flight deck of suitable equipped aircraft.

101 **8. Reference Documents**

102 **8.1 Standards**

103 To be developed

104 **8.2 Procedures**

105 To be developed

106 **8.3 Guidance material**

- 107 • ICAO [Doc 9854](#) – Global ATM Operational Concept
- 108 • [ICAO ANConf/11-IP5 draft ASAS Circular \(2003\)](#)
- 109 • FAA/EUROCONTROL ACTION PLAN 23 – D3 -The Operational Role of Airborne Surveillance in  
110 Separating Traffic (November 2008)
- 111 • FAA/EUROCONTROL ACTION PLAN 23 – D4 –ASAS application elements and avionics supporting  
112 functions (2010)

113

# 1 Module N° B2-101: New Collision Avoidance System

2

<b>Summary</b>	This module describes the need for a new Airborne Collision Avoidance System (ACAS) adapted to trajectory-based operations with improved surveillance function supported by ADS-B and adaptive collision avoidance logic aiming at reducing nuisance alerts and minimizing deviations. In addition, the module describes the necessary improvements for the new ACAS.	
<b>Main Performance Impact</b>	KPA-02 Capacity; <b>KPA-10 Safety</b> ;	
<b>Operating Environment/Phases of Flight</b>	All airspaces.	
<b>Applicability Considerations</b>		
<b>Global Concept Component(s)</b>	CM - Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI- 2 Reduced vertical separation minima, GPI- 9 Situational awareness, GPI-16 Decision support system and alerting systems	
<b>Pre-Requisites</b>		
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date).
	Standards Readiness	Est. 2023
	Avionics Availability	Est. 2023
	Infrastructure Availability	N/A
	Ground Automation Availability	√
	Procedures Available	√
	Operations Approvals	√

## 3 1. Narrative

### 4 1.1 General

5 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.

18



### 19 **1.1.1 Baseline**

20 Implementation of an improved airborne collision avoidance system must minimize “nuisance alerts” while  
21 maintaining existing levels of safety. Additionally, this new system must be able to more quickly adapt to  
22 changes in airspace procedures and the environment.

### 23 **1.1.2 Change brought by the module**

24 Implementation of a new airborne collision avoidance system will enable more efficient operations and future  
25 airspace procedures while complying with safety regulations. The new airborne collision avoidance systems will  
26 accurately discriminating between necessary alerts and “nuisance alerts” across the expected horizontal and  
27 vertical separation projected in future airspace procedures. Improved differentiation leads to reduction in ATC  
28 personnel workload, as ATC personnel spent exert less time to respond to “nuisance alerts”.

29 These procedures facilitate the optimized utilization of constrained airspace, while maintain safety standards.  
30 The revision of horizontal and vertical separation enables grid-locked areas to accommodate more aircrafts in all  
31 flight domains. Augmented ACAS will facilitate Closely Spaced Parallel Operations, increasing terminal and  
32 aerodrome throughput. The new ACAS will also increase capacity of the en-route domain via the implementation  
33 of 3 nautical mile separation standards.

34 The implementation of this module depends on the on-going effort to develop a successor to the current TCAS  
35 technology. This successor should be capable of accommodating reduced separation standards and other new  
36 airspace procedures.

### 37 **1.1.3 Other remarks**

38 The U.S. Federal Aviation Administration (FAA) has funded research and development of a new approach to  
39 airborne collision avoidance for the past 3 years. This new approach takes advantage of recent advances in  
40 dynamic programming and other computer science techniques to generate alerts using an off-line optimization of  
41 resolution advisories. This approach uses extensive actual aircraft data to generate a highly accurate dynamic  
42 model of aircraft behaviour and sensor performance. Based on a predetermined cost function and using  
43 advance computational techniques, this approach generates an optimized table of optimal actions based on  
44 information regarding intruder state information. This approach significantly reduces logic development time and  
45 effort by focusing developmental activities on developing the optimization process and not on iterative changes  
46 to pseudo-code.

### 47 **1.2 Element: Improve differentiation between legitimate and “nuisance” alerts**

48 To facilitate future airspace procedures, such as Closely Spaced Parallel Operations (CSPO) and 3 nautical mile  
49 separation, the current Resolution Advisory (RA) rate accuracy is inadequate for such procedures. New airborne  
50 collision avoidance system will leverage recent advancements in computer science to achieve the desired RA  
51 rate accuracy. In addition, alerting criteria and procedures will be revisited for the new airborne collision  
52 avoidance system.

53

## 54 **2. Intended Performance Operational Improvement/Metric to determine success**

55 Key performance metrics include Probability of a Near Mid-Air Collision (p(NMAC)), RA alert rate and operational  
56 acceptability. Computation of these metrics is conducted assuming both the future system as well as in  
57 conjunction with existing ACAS and operational environment.

58 P(NMAC) – Since ACAS is a safety-critical system, the key performance metric is the probability of a near mid-  
59 air collision. This probability is computed using Monte Carlo simulation and has historically been used in the  
60 development and evaluation of ACAS II. This probability may be expressed by itself, or may use risk ratio to  
61 express the change in risk associated with implementation of system changes when compared to the existing  
62 system.

63 Resolution Advisory (RA) rate – The future collision avoidance system must minimize nuisance alerts to enable  
64 reduced separation; RA rate is another key performance metric. The RA rate is assessed using Monte Carlo  
65 simulation. These simulations are conducted using encounter models and airspace procedures representative

66 of the current and/or future environment. The observed RA rate may be compared either against the existing  
67 system or against an objective standard.

68 State can use the following metrics to gauge the performance of this module.

69

<i>Capacity</i>	Reduced use of the 1030/1090 MHz spectrum
<i>Safety</i>	<ul style="list-style-type: none"><li>a. Improve Resolution Advisory (RA) rate accuracy to support future airspace procedures, such as new separation standards.<ul style="list-style-type: none"><li>i. Resolution Advisory rate</li><li>ii. Nuisance alerts rate</li></ul></li><li>b. Reduction in the probability of near mid-air collision<ul style="list-style-type: none"><li>i. Probability of Near Mid-Air Collision – P(NMAC)</li></ul></li></ul>

70

CBA	
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71 **3. Necessary Procedures (Air & Ground)**

72 Necessary operational procedures for future ACAS are contained in PANS-OPS (ICAO Doc. 8168) and PANS-  
73 ATM (Doc 4444). Future ACAS capabilities should support the implementation of these procedures.

74 **4. Necessary System Capability**

75 **4.1 Avionics**

76 Improved algorithm and computational technique is needed to increase the accuracy of the RA rates and better  
77 differentiate “nuisance” and legitimate alerts. The necessary technical issues and requirements can be found in  
78 ICAO Annex 6, Part I, and ACAS Manual (ICAO [Doc 9863](#)).

79 **4.2 Ground Systems**

80 NIL

81 **5. Human Performance**

82 **5.1 Human Factors Considerations**

83 TBD

84 **5.2 Training and Qualification Requirements**

85 TBD

86 **5.3 Others**

87 TBD

88 **6. Regulatory/standardisation needs and Approval Plan (Air and Ground)**

89 ICAO Annex 6, Part I, Part II, and Annex 10, Vol. 4 specified the international standards for ACAS equipage and  
90 procedures.

91

92 **7. Implementation and Demonstration Activities**

93 **7.1 Current Use**

94 TCAS is currently required for all aircrafts in the NAS. Level of equipage is dependent on the Max. Take Off  
95 Weight (MTOW) of the aircraft.

96 ICAO ANNEX 6 requires ACAS II for certain categories of aircraft. Currently TCAS II Version 7 is the minimum  
97 equipment specification which complies with the ACAS II standard. Some airspaces will require TCAS II Version  
98 7.1 equipment form 2015.

99 **7.2 Planned or Ongoing Activities**

100 TBD

101

102 **8. Reference Documents**

103 **8.1 Standards**

104 RTCA DO-298 *Safety Analysis of Proposed Change to TCAS RA Reversal Logic.*

105 **8.2 Procedures**

106 **8.3 Guidance Material**

107 M. J. Kochenderfer and J. P. Chryssanthacopoulos, "*Robust airborne collision avoidance through dynamic*  
108 *programming*," Massachusetts Institute of Technology, Lincoln Laboratory, Project Report ATC-371, 2010.

109

# 1 Module N° B2-05: Optimised Arrivals in Dense Airspace

2

<b>Summary</b>	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	
<b>Main Performance Impact</b>	<b>KPA-04 Efficiency</b> ; KPA-05 Environment.	
<b>Operating Environment/Phases of Flight</b>	En-route, Terminal Area (Landings), Descent	
<b>Applicability Considerations</b>	Global, High Density Airspace (based on US FAA Procedures)	
<b>Global Concept Component(s)</b>	Airspace Organization and Management (AOM) Airspace User Operations (AUO) Traffic synchronization (TS)	
<b>Global Plan Initiatives (GPI)</b>	GPI-5 RNAV and RNP (Performance-based navigation) GPI-9 Situational Awareness GPI-11 RNP and RNAV SIDs and STARs	
<b>Pre-Requisites</b>	B0-05, B1-05	
<b>Global Readiness Checklist</b>		<b>Status</b> (ready now or estimated date)
	Standards Readiness	√
	Avionics Availability	2023
	Ground Systems Availability	2023
	Procedures Available	2023
	Operations Approvals	2023

## 3 1. Narrative

### 4 1.1 General

5 Optimised Arrivals in Dense Airspace integrates capabilities that will provide improved use continuously  
6 descending arrivals in highest congested airspace. Key aspects of Optimised Profiles in Dense Airspace are:

- 7 • Arrival procedures which allow the aircraft to fly a “best economy descent” from en-route airspace to final  
8 approach.
- 9 • Limited or no throttle is applied throughout the descent, with momentary level-offs being used to slow an  
10 aircraft as required by airspace restrictions.
- 11 • Flow management automation that allows air traffic control to manage aircraft flying Optimised arrivals with  
12 crossing, departing, and other arriving traffic.
- 13 • Cockpit automation that allows aircraft to freely choose top-of-descent and descent profile based on  
14 aircraft state and weather conditions.
- 15 • En-route and terminal controllers rely on automation to identify conflicts and eventually propose  
16 resolutions.
- 17 • Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of  
18 navigational aids, enabling the flexibility of point-to-point aircraft operations.

- 19 • Required Navigation Performance (RNP) operations introduce the requirement for onboard performance  
20 monitoring and altering. A critical characteristic of RNP operations is the ability of the aircraft navigation  
21 system to monitor its achieved navigation performance for a specific operation, and inform the air crew if  
22 the operational requirement is being met.
- 23 • The basis for the operation is an accurate three-dimensional trajectory that is shared among aviation  
24 system users. This provides accurate latitude, longitude, and altitude information to airspace users.
- 25 • Consistent and up-to-date information describing flights and air traffic flows are available system-wide,  
26 supporting both user and service provider operations.

### 27 **1.1.1 Baseline**

28 The baseline for this block is Improved Flight Descent Profile and Complexity Management enabled by blocks  
29 B0-5 and B3-10. Optimised Arrivals are a component of Trajectory-Based Operations (TBO) initiatives. Decision  
30 support capabilities are available that are integrated to assist aircraft crew and air traffic separation providers in  
31 making better decisions and optimizing the arrival profile. Consistent 3D trajectory information is available to  
32 users to inform ATM decision making.

### 33 **1.1.2 Change brought by the module**

34 This block provides extensions to the baseline, with emphasis on economic descents in airspace with dense  
35 traffic levels. Benefits of these Trajectory Based Operations include fuel savings and noise and emission  
36 reduction by keeping aircraft at a higher altitude and at lower thrust levels than traditional step-down  
37 approaches. Simplifying routes using Optimised Arrivals may also reduce radio transmissions between aircraft  
38 crew and controllers.

39 Benefits of these operations in dense airspace include achieving target traffic and throughput levels while also  
40 enabling fuel savings and noise reduction. A traditional assumption is that the use of Optimised Arrivals will  
41 reduce throughput in dense airspace, or may not be achievable at all due to complexities created in sequencing  
42 Optimised arrivals with non-Optimised arrivals, departures, and crossing traffic.

43 The aircraft's ability to accurately fly an Optimised Arrival, coupled with the state and intent information sent from  
44 the aircraft to ATC automation, will increase accuracy of trajectory modelling and problem prediction.

### 45 **1.1.3 Other**

46 This module continues the evolution in RNAV and RNP procedure design in dense airspace, and the evolution of  
47 automation used to aid in decision support for both air crews and Air Traffic Control.

48

## 49 **1.1 *Element 1: Accurate Trajectory Modelling***

50 This element is focused on obtaining the most accurate trajectory model for use by all automation systems. This  
51 includes accurate position information, clearance information, and the use of automated resolutions that reduce  
52 controller workload.

## 53 **1.2 *Element 2: Advanced Aircraft Capabilities***

54 This element will focus on cockpit capabilities that enable optimal trajectory selection and the ability to fly point-  
55 to-point RNAV and RNP procedures. This element will also examine cockpit automation that enables the aircraft  
56 to self-separate and avoid potential conflicts. This element will focus on globally-harmonized standards  
57 development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

## 58 **1.3 *Element 3: Traffic Flow Management and Time-Based Metering***

59 This element will harmonize the Traffic Flow Management automation which continuously predicts the demand  
60 and capacity of all system resources, and will identify when the congestion risk for any resource (airport or  
61 airspace) is predicted to exceed an acceptable risk. Traffic Management will take action in the form of just in  
62 time reroutes and metering times to congested resources. The problem resolution element will create a solution  
63 that meets all system constraints.

64

65 **2. Intended Performance Operational Improvement/Metric to determine success**

66 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	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.
<i>Efficiency</i>	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.
<i>Flexibility</i>	Users will be able to select arrival trajectory that best accommodates aircraft according to traffic conditions, weather conditions, and aircraft state.
<i>Safety</i>	Economical descents used without sacrificing safety due to enhanced airspace management and automation to aid in aircraft separation.

67

<i>CBA</i>	The major qualitative business case elements of this module are as follows: <ul style="list-style-type: none"><li>• Capacity: Additional flights can be accommodated in terminal airspace because of reduced controller workload and better trajectory modelling/planning.</li><li>• Efficiency: Users will fly more fuel and noise efficient arrival descent profiles.</li><li>• Safety: Economic descents flown without sacrificing safety.</li><li>• Flexibility: Users will have greater flexibility in selecting the flight trajectory that best meets their needs.</li></ul>
------------	--

68

69 **3. Necessary Procedures (Air & Ground)**

70 For strategic actions, the necessary procedures basically exist for Air Navigation Service Providers (ANSPs) and  
71 users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect  
72 the use of increased decision support automation capabilities, including automation-to-automation negotiation.  
73 The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and  
74 will necessitate procedure development, including the roles of ANSPs. International standards for information  
75 exchange between systems to support these operations need to be developed. This includes development of  
76 global standards for the exchange of trajectory information between ground and air.

77 **4. Necessary System Capability**

78 **4.1 Avionics**

79 The continued development of automation for both the cockpit and ANSPs is needed to aid in trajectory  
80 modelling and required separation decision making. Aircraft-based capabilities, such as ADS-B/CDTI exist, but  
81 applications are still being developed to support the objectives of this module.

82 **4.2 Ground Systems**

83 The continued development of automation for both the cockpit and ANSPs is needed to aid in trajectory  
84 modelling and required separation decision making. In addition, development of technology that provides  
85 mitigation strategies for conflicts or potential conflicts will also aid in enabling Optimised profiles in dense  
86 airspace.

87 **5. Human Performance**

88 **5.1 Human Factors Considerations**

89 TBD

90	<b>5.2</b>	<b><i>Training and Qualification Requirements</i></b>
91		TBD
92	<b>5.3</b>	<b><i>Others</i></b>
93		TBD
94	<b>6.</b>	<b>Regulatory/standardisation needs and Approval Plan (Air &amp; Ground)</b>
95		This module requires:
96		• Development of global standards for trajectory information exchange.
97		• Standardisation of procedure design guidance
98		• Standardisation of ATC/Pilot phraseology, such as the use of a “Descend Via” clearance when utilizing
99		an Optimised Arrival
100	<b>7.</b>	<b>Implementation and Demonstration Activities</b>
101	<b>7.1</b>	<b><i>Current Use</i></b>
102		Optimised Arrivals are currently being used at the following U.S. airports in dense airspaces:
103		• Los Angeles International Airport (LAX)
104		• Phoenix Sky Harbor International Airport (PHX)
105		• Atlanta Hartsfield International Airport (ATL)
106		• Las Vegas International Airport (LAS)
107	<b>7.2</b>	<b><i>Planned or Ongoing Trials</i></b>
108		No global demonstration trials are currently planned for this module. There is a need to develop a trial plan as
109		part of the collaboration on this module.
110		
111	<b>8.</b>	<b>Reference Documents</b>
112	<b>8.1</b>	<b><i>Standards</i></b>
113	<b>8.2</b>	<b><i>Procedures</i></b>
114	<b>8.3</b>	<b><i>Guidance Material</i></b>
115		ICAO Doc 9331, Continuous Descent Operations (CDO) Manual
116		
117		

1 **Module N° B2-90: Remotely Piloted Aircraft (RPA) Integration in**  
 2 **Traffic**

3

<b>Summary</b>	Implements refined operational procedures that cover lost link (including a unique squawk code for lost link) as well as enhanced detect and avoid technology; 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 increases in the reliability, availability and security of C2 links, to include SATCOM links for beyond line-of-sight.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity, KPA-10 Safety	
<b>Domain/Flight Phases</b>	En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing)	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Components</b>	AOM - Airspace Organization and Management CM - Conflict Management AUO - Airspace User Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-9, Situational awareness GPI-12, Functional integration of ground systems with airborne systems GPI-17, Data link applications	
<b>Main Dependencies</b>	Preceded by B1-90	
<b>Global Readiness Checklist</b>		<b>Status</b> (indicate ready with a tick or input date)
	Standards Readiness	Est. 2023
	Avionics Availability	Est. 2023
	Ground Systems Availability	Est. 2023
	Procedures Available	Est. 2023
	Operations Approvals	Est. 2023

4 **1. Narrative**

5 **1.3 General**

6 Based on Block 1, basic RPA procedures, Block 2 includes the procedures and technology that are possible in the block 2  
 7 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
<b>Authorization</b>	Strict compliance with the provisions of the authorization is required			Operations not permitted, unless by waiver or authorization
<b>C2 Link Failure Procedures</b>	Will follow standardized procedures. A special purpose transponder code will be established.		Will follow standardized procedures.	
<b>Communications</b>	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.	



<b>Separation Standards</b>	New separation standards may be required	Separation criteria will be analysed and special separation criteria might be developed.
<b>ATC Instructions</b>	RPAS will comply with ATC instructions as required	
<b>RPA Observers</b>	As required for the operation	
<b>Medical</b>	Remote pilots shall have an appropriate medical certificate	
<b>Presence of Other Aircraft</b>	RPAS shall not increase safety risk to the air navigation system	
<b>Visual Separation</b>	Visual separation may be permitted.	TBD
<b>Responsibility of Remote Pilot</b>	Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization	
<b>Populated Areas</b>	Restrictions to be determined by the State.	
<b>ATC Services</b>	Consistent with Annex 11,	
<b>Flight Plan</b>	RPAS operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed.	
<b>Meteorological Conditions</b>	Restrictions to be determined by the State	
<b>Transponder</b>	Shall have and use an operating mode C/S transponder	
<b>Safety</b>	Identify the hazards and mitigate the safety risks; adhere to the authorization	
<b>NOTAMs</b>	NOTAM requirements, if any, to be determined by the State	
<b>Certification</b>	TBD	

8

9 **1.3.1 Baseline**

10 **1.3.2 Changes brought by the module**

11 The projected changes during this time frame include:

- 12 • **Access to most airspace for select airframes without specific airspace constraints:** As aircraft certification  
 13 (based on an established safety case for a particular RPA system – airframe, link, and RPS) is developed and  
 14 procedures are defined, airspace constraints will gradually be lifted and specific RPAs will be permitted to fly in  
 15 more situations. In the Block 2 timeframe, this will start with a very small number of RPAs, but will be permitted to  
 16 grow as the RPA proves it can meet standards, and certification and procedures are developed. This access will be  
 17 based on the improvements to the RPA, the developed technology, (GBDAA, ADS-B, and Specific C2 link failure  
 18 squawk) and improved ATM procedures.
- 19 • **RPAS certification procedures** Using Minimal Aircraft System Performance Specification (MASPS) developed by  
 20 standards committees or adopted by ICAO, material solutions will be developed for integration into RPAS. As these  
 21 solutions are integrated into selected RPAS, the RPAS will go through the process of being certified airworthy.  
 22 Airworthiness and certification are based on a well-established airworthiness design standards. Therefore the  
 23 following RPA related issues will have to be addressed:
  - 24 ○ Procedures Standards and Recommended Practices for all RPA classes
  - 25 ○ Procedures and standards for Ground Control Stations (RPS),
  - 26 ○ Provisions for C2 links
  - 27 ○ Possible rule changes to set forth a type standard for various RPA
  - 28 ○ Modification of type design (or restricted category) standards to account for unique RPA features (e.g.,  
 29 removal of windscreens, crashworthiness standards, control handoff from one RPS to another, etc.)
- 30 • **RPA procedures defined:** Procedures will be developed to permit selected RPA (proven airworthy) to fly in non-  
 31 segregated airspace with manned aircraft. Training for pilots and ATC personal must be developed to  
 32 accommodate these RPAS.
  - 33 ○ **New special purpose transponder code for lost link:** A new transponder code will be developed so that  
 34 the ATC automation can differentiate RPA lost C2 links from loss of two-way radio communications in any

- 35 aircraft. Because transponder codes cannot be received over the high seas, RPA will broadcast position to  
 36 nearby aircraft via ADS-B. If ADS-C is mandated for high seas RPA, lost link position may be tracked by  
 37 ATC if that electronic link remains intact.
- 38 ○ **Standardized lost link procedures**
  - 39 ○ **Revised separation criteria and/or handling procedures (i.e. moving airspace)**
  - 40 • **ADS-B on most RPA classes:** IT is envisioned that ADS-B will be included on most new RPA's being built during  
 41 this time period and a retrofit program should be established.
  - 42 • **Detect and Avoid technologies** will be improved and certified to support RPAs and operational improvements.  
 43 Ground Based Detect and Avoid (GBDAA) will be certified and approved for more pieces of airspace. Other  
 44 approaches to consider include an onboard (airborne) detect and avoid solution (ABDAA). ABDAA efforts are  
 45 currently focused on developing the capability to perform both self-separation and collision avoidance onboard the  
 46 aircraft that ensure an appropriate level of safety even in the event of lost command and control links. The initial  
 47 capability will provide an ability to collect and analyze valuable data for developing a robust airborne DAA system.
  - 48 • **Protected spectrum and security**<sup>4</sup> this necessitates the use of designated frequency bands, i.e. those reserved for  
 49 aeronautical safety and regularity of flight under Aeronautical Mobile (route) Service (AM(R)S), Aeronautical Mobile  
 50 Satellite (route) Service (AMS(R)S), Aeronautical Radio Navigation Service (ARNS) and Aeronautical Radio  
 51 Navigation Satellite Service (ARNSS) allocations as defined in the ITU Radio Regulations. It is essential that any  
 52 communications between the GCS and RPA for C2 meet the performance requirement applicable for that airspace  
 53 and/or operation, as determined by the appropriate authority. SATCOM links may require a backup.

54 **1.4 Elements**

55 There is only one element for this module, RPA integration into traffic, (evolution of basis procedures). All of the improvement  
 56 listed above relate to the integration of RPAS's into traffic.

57 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	Could be impacted due to new separation standards, if applicable Metric: sector capacity
<i>Efficiency</i>	Access to airspace by a new category of users. Metric: volume of RPA traffic
<i>Environment</i>	Increased by standardizing the integration of RPA's with manned aircraft. Procedures for integration will become implemented and become routine. Metric: volume of RPA traffic
<i>Predictability</i>	The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States. Metric: volume of interstate RPA traffic
<i>Safety</i>	Increased situational awareness; controlled use of aircraft Metric: incident occurrences

58

<i>CBA</i>	The business case is directly related to the economic value of the aviation applications supported by RPAS.
------------	--

59

60 **3. Necessary Procedures (Air & Ground)**

61 Improved air traffic management (ATM) procedures will need to be in place to allow the access of RPA's into the non-  
 62 segregated airspace. Specifically:

- 63 • ATM provisions need to be amended to accommodate the RPA taking into account the unique operational  
 64 characteristics of each RPA type as well as their automation and non-traditional IFR/VFR capabilities,
- 65 • Air navigation service providers will need to review emergency and contingency procedures to take account of  
 66 unique RPA failure modes such as a lost link, to include standardized lost link procedures, and the new special

<sup>4</sup> ICAO Cir 328 An/190 Unmanned Aircraft Systems (UAS)

- 67 purpose transponder code for lost link. Also consider procedures that may be necessary if the RPA is using an  
 68 alternate control link that results in excessive delay in responding to RPA pilot inputs,  
 69 • Terminal area will need to improve their procedures to allow for the increased volume of RPA activity,  
 70 • Ground operations will need to be modified to accommodate the increased activity of RPA's as well.

71 Improved RPA certification procedures will need to be developed, as well as standardizing the lost link procedures. As  
 72 ABDAA algorithms are developed, associated RPA operations procedures will need to be developed.

## 73 **4. Necessary System Capability (Air & Ground)**

### 74 **4.1 Avionics**

- 75 • ADS-B on most RPA as well as all manned aircraft
- 76 • Preliminary development and testing of (ABDAA)

### 77 **4.2 Ground Systems**

- 78 • GBDAA where applicable
- 79 • ATC automation will need to be able to respond to this new lost link code
- 80 • Automatic position reporting to ATC capability for lost link over high seas

## 81 **5. Human Performance**

### 82 **5.1 Human Factor Considerations**

83 The controller-pilot relationship is changing and will need to be investigated. Specific training for controllers, remote pilots  
 84 and pilots will be required, in particular with respect to the new detect and avoid situations.

### 85 **5.2 Training and Qualifications Requirements**

86 TBD

### 87 **5.3 Others**

88 TBD

## 89 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

90 Standards are needed for the regulatory approval of the following.

- 91 • Lost link procedures and standards
- 92 • Specific special purpose transponder code for lost link
- 93 • Updated ATM procedures to allow for the integration of RPA's into en-route and terminal airspace
- 94 • Update airworthiness standards and procedures

## 95 **7. Implementation and Demonstration Activities**

### 96 **7.1 Current Use**

97 None at this time. -

### 98 **7.2 Planned or On Going Trials**

#### 99 **Europe**

- 100 • So far all strategies are aimed at full integration within the timeframe of Block 2. SESAR will address this. ADS-B
- 101 and Satcom are on the agenda
- 102 • Integrated RPA/manned Airports operations
- 103 • Separation and airspace safety panel (SASP) will make determination on separation standards that will be
- 104 applicable

105    **8**    ***Reference Documents***

- 106    •    ICAO Circ 328 – *Unmanned Aircraft Systems (UAS)*
- 107    •    [Annex 2](#) — *Rules of the Air* proposal for amendment
- 108    •    U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- 109    •    NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*
- 110    •    EUROCAE Document (under development)

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## **BLOCK 3**

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# 1 Module N° B3-15: Integration AMAN/DMAN/SMAN

<b>Summary</b>	This module includes a brief description of integrated arrival, en-route, surface, and departure management.	
<b>Main Performance Impact</b>	KPA-02 Capacity; <b>KPA-04 Efficiency</b> ; KPA-09 Predictability KPA-06 Flexibility	
<b>Domain/ Flight Phases</b>	Aerodrome and Terminal	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Element(s)</b>	TS – Traffic Synchronization	
<b>Global Plan Initiative</b>	<b>GPI-6</b> Air Traffic Flow Management	
<b>Main Dependencies</b>	B2-15	
<b>Global Readiness Checklist</b>	Standards Readiness	<b>Status</b> (ready now or estimated date)
	Avionics Availability	<b>Est. 2025+</b>
	Ground Systems Availability	<b>Est. 2025+</b>
	Procedures Available	<b>Est. 2025+</b>
	Operations Approval	<b>Est. 2025+</b>

## 2 1. Narrative

### 3 1.1 General

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

7 Synchronization of all flight phases represents the full integration of all control loops. An optimized time profile for  
8 flights can be derived, and use as a mean to manage demand and capacity and optimally space aircrafts.  
9 Optimized time profile describes the time component of the 4D trajectory. 4-D trajectory management enables  
10 airspace users and ATC authorities to negotiate conflict-free trajectories that best suits various stakeholders'  
11 operational objectives. Moreover, all stakeholders will share a coherent and consistent view of the trajectories  
12 from gate to gate. Strategic flow adjustments can be made to the trajectory based on demand and capacity  
13 balancing, along with tactical changes, can be managed timely and effectively. The synchronization and the use  
14 of 4-D trajectories will promote superior predictability and reduce uncertainty between the planned and executed  
15 trajectory.

16  
17 Traffic synchronization also implies that information is synchronized across flight phases. Coordination is needed  
18 between ATC authorities for information synchronization. This coordination requires information homogeneity –  
19 the information that is shared must be of the desired quality and is consistent in content and format. Information



20 such as position, speed, Controlled Time of Arrival (CTAs), Scheduled Time of Arrival (STAs), aircraft weight,  
 21 and relevant ATM decisions must satisfy the quality requirements of each ATC authorities. In addition to  
 22 uniformed quality and format, a common information exchange scheme will be implemented to ensure the  
 23 unhindered information flows between adjacent ATC authorities.

### 24 **1.1.1 Baseline**

25 Block 2 brought about the synchronisation of arrival and departure management. Arrival and departure  
 26 sequencing will be linked to further augment airspace capacity and efficient terminal and aerodrome airspace  
 27 design. This is realized by integrating the terminal with en-route airspace in high density areas and adjusting the  
 28 arrival/departure sequence to ensure that they are both free from conflicts. In addition, this harmonization will  
 29 also serve to reduce idle time at the gates and ground delays.

30 Arrival and departure synchronization advocate the expansion of terminal separation standards of 3 nautical  
 31 miles to adjacent en-route airspace. Less stringent MIT restrictions implies more flights can be accommodated in  
 32 a congested airspace. Furthermore, the expansion allows ATC authorities to optimize the sequencing of  
 33 incoming traffic and increase throughput in high demand aerodromes.

34 Electronic coordination of departure operation between ATC authorities, such as coordination of departure flow  
 35 with relevant ATC authorities, will promote more agile and efficient operations. Automated distribution of relevant  
 36 information has the added benefit of reduced workloads at the respective ATC authorities.

### 37 **1.1.2 Change brought by the module**

38 In block 3, traffic synchronization will be realized.. The integration of surface, arrival, and departure management  
 39 lead to optimized flow management and efficient utilization of airspace..

40 Traffic synchronization will bring about 4-D control of flights. A full time profile facilitates the execution of 4D  
 41 trajectory control. A flight will be given to time profile to adhere to. Time profile enables ATM to optimize airspace  
 42 throughput. The time profile also serves to provide greater predictability and mitigate uncertainty in demand and  
 43 capacity predictions. Greater predictability enables better planning and enhances operational efficiency. In  
 44 addition to predictability, synchronization and 4D trajectory management facilitate greater flexibility. Airspace  
 45 users and ATC authorities can negotiate trajectories to avert conflicts and other hindering factors. These  
 46 trajectories will be conflict free, and will both meet the business objectives (e.g. fuel efficient routes) of the  
 47 airspace users and conform to ATM decisions. Traffic synchronization allows for the strategic and tactical  
 48 management of traffic flows.

49 In addition to predictability, the implementation of time traffic synchronization will advance information  
 50 homogeneity, leading to greater common situational awareness and rapid collaborative ATM decision making  
 51 across multitude of ATC facilities. Information homogeneity across all flight phases presents both the airspace  
 52 users and ATM with consistent, accurate, timely, and relevant information. Furthermore, information  
 53 homogeneity reduces the complexity of ATM operations. As the need for reconciliation of discrepancy in various  
 54 aspects of ATM operations is lessen.

## 55 **1.2 Element 1: Full Traffic Synchronization**

56  
 57 The synchronization of en-route, arrival, departure, and surface represents the establishment and maintenance  
 58 of a safe, efficient, and orderly flow of air traffic. Conflict management, demand and capacity, and  
 59 synchronization will be fully integrated. Traffic synchronization will encompasses all physical phases of a flight. It  
 60 will serve as a tool to manage traffic flows both tactically and strategically. Traffic synchronization will utilize a  
 61 combination automation, procedures, and airspace modification to optimize throughputs in all domains – surface,  
 62 departure, arrival, and en-route.

63  
 64  
 65  
 66

67 **2. Intended Performance Operational Improvement/Metric to determine success**

68  
69 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Mitigate impacts of various restrictions and conflicts and allow a greater throughput
<i>Efficiency</i>	Optimize and coordinate arrival, departure, and surface traffic flows in the terminal and aerodrome domain.
<i>Predictability</i>	Optimized Time Profile and greater ATM decision compliance Gate-to-Gate 4D trajectory will mitigate uncertainties in demand prediction across all domains and enables better planning through all airspace.
<i>Flexibility</i>	Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns

70

<i>CBA</i>	Traffic synchronization brings about optimized flow free of conflict and choke points. The use of time profile enables both strategic and tactical flow management and improves predictability. In addition, traffic synchronization can be used as a tool to reconcile demand and capacity by reduction of traffic density.
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71  
72 **3. Necessary Procedures (Air & Ground)**

73 The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Document 9883) provides  
74 guidance on traffic synchronization consistent with the vision of a performance-oriented ATM System. The TBFM  
75 and AMAN/DMAN efforts, along with other initiatives, can provide the operational procedures necessary for full  
76 traffic synchronization.

77 **4. Necessary System Capability**

78 **4.1 Avionics**

79 Full Traffic Synchronization will require the aircraft to be capable of exchanging information regarding the 4D  
80 Trajectory Profile, and be able to adhere to an agreed 4D Trajectory.

81 **4.2 Ground Systems**

82 Traffic synchronization may require sequencing and optimization automation systems upgrades. These  
83 upgrades should support time based management, integrated sequencing, and augmented surveillance  
84 capabilities.

85 **5. Human Performance**

86 **5.1 Human Factors Considerations**

87 Analysis should be completed to determine if any changes to the Computer Human Interface are needed to  
88 enable ATM Personnel to best manage the 4D Trajectory Profiles.

89 **5.2 Training and Qualification Requirements**

90 Automation support is needed for Air Traffic Management in airspace with high demands. Thus, training is  
91 needed for ATM personnel. ATM personnel responsibilities will not be affected

92 **5.3 Others**

93

94 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

95 Full traffic synchronization will entail policies on information sharing, roles and responsibilities of all actors in 4-D  
96 trajectory management, and mutual understanding/acceptance of new operational procedures. A framework,  
97 similar to should be establish to serve as a forum for all stakeholders to discuss relevant issues and concerns.

98 **7. Implementation and Demonstration Activities**

99 **7.1 Current Use**

100 TBD

101 **7.2 Planned or Ongoing Trials**

102 TBD

103 **8. Reference Documents**

104 **8.1 Standards**

105 **8.2 Procedures**

106 **8.3 Guidance Material**

107 [European ATM Master Plan](#),

108 [SESAR Definition Phase Deliverable 2 – The Performance Target](#),

109 [SESAR Definition Phase Deliverable 3 – The ATM Target Concept](#),

110 [SESAR Definition Phase 5 – SESAR Master Plan](#)

111 TBFM Business Case Analysis Report

112 NextGen Midterm Concept of Operations v.2.0

113 RTCA Trajectory Concept of Use

1 **Module N° B3-25 Improved Operational Performance through the**  
 2 **introduction of Full FF-ICE**

3

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, <b>KPA-07 Global Interoperability</b> , KPA-08 Participation by the ATM community, KPA-10 Safety,	
<b>Operating Environment/Phases of Flight</b>	All phases of flight from initial planning to post-flight	
<b>Applicability Considerations</b>	Air and ground	
<b>Global Concept Component(s)</b>	IM-information management	
<b>Global Plan Initiatives (GPI)</b>	GPI-7 Dynamic and flexible route management GPI-12 Functional integration of ground systems with airborne systems GPI-16 Decision Support Systems	
<b>Pre-Requisites</b>	B1-30, B2-25, B2-31	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	Est 2023
	Avionics Availability	Est 2025
	Ground Systems Availability	Est 2025
	Procedures Available	Est 2025
	Operations Approvals	Est 2025

## 4 1. Narrative

5 **Refer to ICAO Draft Brochure: FLIGHT & FLOW INFORMATION FOR A COLLABORATIVE ENVIRONMENT**  
6 **(FF-ICE) A Concept to Support Future ATM systems**

### 7 The Role of FF-ICE

8  
9 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.

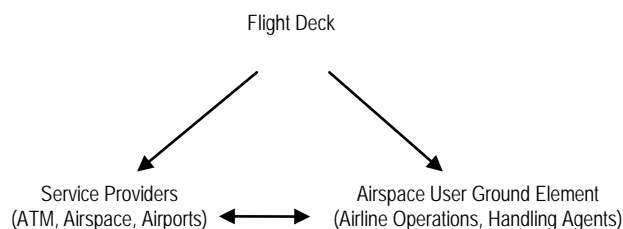
12  
13 FF-ICE will have global applicability and will support all members of the ATM community to achieve strategic, pre-tactical and tactical performance management.

14 FF-ICE emphasises the need for information sharing to enable significant benefits.

16  
17 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.

18  
19 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.

22  
23 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.



28  
29 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:

- 34 • Entail systematic sharing of aircraft trajectory data between actors in the ATM process
- 35 • Ensure that all actors have a common view of a flight and have access to the most accurate data available
- 36 • Allow operations respecting the airspace users' individual business cases

### 37 The Need for Change

38  
39 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:

- 44 • Reduced reliance on voice radio communications for air/ground links
- 45 • Increased collaborative planning amongst ATM actors
- 46 • Providing facilities for real time information exchange
- 47 • Maximising benefits of advanced equipment and encouraging deployment of improved air and/or ground systems

49 **1.1 General**

50 **1.1.1 Baseline**

51 FF-ICE step 1 is implemented and initial SWIM applications are available on the ground. Flight-Object has been  
52 deployed as basis of the new FDP systems.

53 **1.1.2 Change brought by the module**

54 New way to exchange trajectory data to provide better ATM services to airspace users.

55 Flight-object will be implemented in the ground systems and will support the flight information and trajectory  
56 sharing through SWIM during all phases of flight between air and ground. All messages between air and ground  
57 systems will use XML format to facilitate development and evolution.

58 **1.2 Element:**

59 The main challenge is to implement FF-ICE in airborne systems and use SWIM for airborne access to ATM  
60 information.

61 **2. Intended Performance Operational Improvement/Metric to determine success**

62 Metrics to determine the success of the module are proposed at Appendix C.

<i>Cost Effectiveness</i>	Standard information will reduce cost of system development
<i>Efficiency</i>	Better knowledge of trajectory information will allow more optimum flight profile.
<i>Environment</i>	Y
<i>Global Interoperability</i>	Global interoperability is facilitated by easier connection of all stakeholders
<i>Participation by the ATM community</i>	Participation of all stakeholders is facilitated through real-time data sharing
<i>Predictability</i>	The sharing of information between aircraft and ground systems will enhance the predictability
<i>Safety</i>	System wide data sharing will allow early detection of inconsistencies and updated information which will improve situation awareness..

<i>CBA</i>	To be demonstrated by the balance of cost of system change with other performance improvement.
------------	--

63 **3. Necessary Procedures (Air & Ground)**

64 Publish and subscribe mechanisms will allow real-time sharing of the Flight Information for concerned and  
65 authorized actors.

66 The use of these data will be mainly for decision making tools and further automation.

67 **4. Necessary System Capability**

68 **4.1 Avionics**

69 Connection of the Flight Deck systems to the ground systems through a high speed data communication system.

70 Necessary distributed applications to manage the new services

71 **4.2 Ground Systems**

72 There is a need for full secure and high throughput ground-ground and air-ground communications networks  
73 supporting SWIM access for exchange of Flight and Flow information from planning phase to post-Flight phase  
74 Necessarily distributed applications to manage the new services

75 **5. Human Performance**

76 **5.1 Human Factors Considerations**

77 This technological evolution does not affect directly the pilots or controllers and could be transparent. (System to  
78 system exchange, more accurate and updated data)

79 **5.2 Training and Qualification Requirements**

80 Training of pilot, controller to use the new services associated to decision support tools through new procedures.

81 **5.3 Others**

82 Not Applicable ?

83 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

84 **7. Implementation and Demonstration Activities**

85 **7.1 Current Use**

86 **7.2 Planned or Ongoing Activities**

87 Full-FF-ICE could be considered as the ultimate goal of the Trajectory Based Operations and it is part of  
88 NextGen and SESAR R&D plan.

89 List of SESAR Projects: WP14 and WP8.

90 **8. Reference Documents**

91 **8.1 Standards**

92 **8.2 Procedures**

93 **8.3 Guidance Material**

94 6. [FF-ICE concept document](#)

95 7. Trajectory Based Operations documents

96

# Module N° B3-10: Traffic Complexity Management

<b>Summary</b>	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.	
<b>Main Performance Impact</b>	<b>KPA-02 Capacity;</b> KPA-04 Efficiency; KPA-06 Flexibility; KPA-09 Predictability	
<b>Operating Environment/Phases of Flight</b>	Pre-flight and in-flight	
<b>Applicability Considerations</b>	Regional or sub-regional. Benefits are only significant over a certain geographical size and assume that it is possible to know and control/optimize relevant parameters. Benefits mainly useful in the higher density airspace	
<b>Global Concept Component(s)</b>	AOM – Airspace Organisation and Management TS – Traffic Synchronisation DCB – Demand & Capacity Balancing	
<b>Global Plan Initiatives (GPI)</b>	GPI-6 Air traffic flow management GPI-8 Collaborative airspace design and management	
<b>Pre-Requisites</b>	Successor of: B1-10, B2-35 Parallel progress with: B3-5, B3-15, B3-25, B3-85	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	<b>Est. 2028</b>
	Avionics Availability	<b>Est. 2028</b>
	Ground Systems Availability	<b>Est. 2028</b>
	Procedures Available	<b>Est. 2028</b>
	Operations Approvals	<b>Est. 2028</b>

## 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.



17 **1.1.1 Baseline**

18 Prior to this module, most of the ingredients of the Global ATM Concept will have been progressively put in  
19 place, but not yet completely pending the dissemination of a certain number of capabilities and enablers, and  
20 also not fully integrated. There remains room to achieve performance gains by addressing the issues that the  
21 lack of optimised integration will raise.

22 **1.1.2 Change brought by the module**

23 The module provides for the optimisation of the traffic flows and air navigation resources usage. It addresses the  
24 complexity within ATM due to the combination of higher traffic densities, more accurate information on  
25 trajectories and their surrounding environment, closely interacting processes and systems, and the quest for  
26 greater levels of performance.

27 **2. Intended Performance Operational Improvement/Metric to determine success**

28 Metrics to determine the success of the module are proposed at Appendix C.

<i>Capacity</i>	Increase and optimised usage of system capacity.
<i>Efficiency</i>	Optimisation of the overall network efficiency.
<i>Flexibility</i>	Accommodation of change requests.
<i>Predictability</i>	Minimise the impact of uncertainties and unplanned events on the smooth running of the ATM system.

<i>CBA</i>	To be established as part of the research related to the module.
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30 **3. Necessary Procedures (Air & Ground)**

31 To be defined.

32 **4. Necessary System Capability**

33 The module will exploit technology then available, in particular SWIM and TBO which will provide the accurate  
34 information on the flights and their environment. It will also likely rely on automation tools.

35 **4.1 Avionics**

36 None in addition to that required for participation in SWIM and/or TBO operations.

37 **4.2 Ground Systems**

38 Intensive use of automated functions and sophisticated algorithms to exploit information.

39 **5. Human Performance**

40 **5.1 Human Factors Considerations**

41 The high degree of integration of the traffic information and the optimisation of the processes will likely require  
42 high levels of automation and the development of specific interfaces for the human operators.

43 **5.2 Training and Qualification Requirements**

44 Training requirements will be high, not only prior to entry into service but also as a regular maintenance of the  
45 skills.

46 **5.3 Others**

47 Nil

48 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

49 To be defined.

50 **7. Implementation and Demonstration Activities**

51 **7.1 Current Use**

52 None at this time.

53 **7.2 Planned or Ongoing Activities**

54 ▪ **Europe:** the SESAR programme has established a research network on “complexity” together with research  
55 projects addressing some of the relevant issues.

56 ▪ **US:** research is being conducted at NASA and Universities.

57 No live trials in the foreseeable future.

58 **8. Reference Documents**

59 **8.1 Standards**

60 TBD

61 **8.2 Procedures**

62 TBD

63 **8.3 Guidance Material**

64 TBD

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1 **Module N° B3-105: Better Operational Decisions through**  
 2 **Integrated Weather Information (Near-term and Immediate**  
 3 **Service)**

<b>Summary</b>	This module focuses on weather information that supports both air and ground automated decision support aids for implementing weather mitigation strategies. It develops 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 0-20 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.	
<b>Main Performance Impact</b>	KPA-02 Capacity; KPA-04 Efficiency; KPA-09 Predictability, KPA-10 Safety	
<b>Operating Environment/Phase of Flight</b>	All	
<b>Applicability Considerations</b>	Applicable to air traffic flow planning, en-route operations, terminal operations (arrival/departure), and surface. Aircraft equipage is assumed in the areas of ADS-B In/CDTI, aircraft-based weather observations and weather information display capabilities, such as EFBs.	
<b>Global Concept Component(s)</b>	AOM- Airport Operations and Management DCB -Demand and Capacity Balancing AO -Aerodrome Operations TM-Traffic Synchronization CM -Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-9: Situational Awareness GPI-15: Match IMC and VMC Operating Capacity GPI-19: Meteorological Systems	
<b>Pre-Requisites</b>	Successor to B1-105	
<b>Global Readiness Checklist</b>		<b>Status (ready now or estimated date)</b>
	Standards Readiness	Est 2023
	Avionics Availability	Est 2023
	Infrastructure Availability	<b>Est 2023</b>
	Ground Automation Availability	Est 2023
	Procedures Available	Est 2023
Operations Approvals	Est 2023	

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## 6 1. Narrative

### 7 1.1 General

8 This module is focused on developing advanced concepts and necessary technologies to enhance global ATM  
9 decision making in the face of adverse weather. The major components include a consistent, integrated set of  
10 meteorological information available to all users and ANSPs, advanced decision support tools that utilize the  
11 information to assess the potential operational impacts of the weather situation and decision support tools that  
12 develop candidate mitigation strategies for dealing with the impacts.

13 The capabilities discussed in this module will primarily benefit in-flight operations and weather avoidance in the  
14 en-route, terminal and aerodrome domains. But, this module will also extend initial pre-flight and flow planning  
15 capabilities realized in module B1-105. These negotiation capabilities will be globally interoperable to allow for  
16 seamless planning of trajectories for international flights.

#### 17 1.1.1 Baseline

18 The baseline for this module is the initial, enhanced weather decision making capabilities enabled by module B1-  
19 105. Decision support capabilities are available, and integrated with weather information, to assist ANSPs and  
20 users to make better decisions in the strategic timeframe (40 minutes and out). A consistent, integrated weather  
21 information base is available to all ANSPs and users, to inform ATM decision making.

#### 22 1.1.2 Change brought by the module

23 This module provides extensions to this baseline, with emphasis on the tactical (0-420 minute) timeframe, and  
24 greater use of aircraft-based capabilities for weather awareness and avoidance. A major focus is on the  
25 provision of enhanced automation capabilities (building on B1-105) for developing characterizations of potential  
26 weather impacted airspace, and for using those characterizations to determine impact on ATM operations and  
27 individual flights.

### 28 1.2 Element 1: Enhanced Weather Information

29 This element is focused on the development of enhanced weather information for integration into ATM decision  
30 making. The scope of weather information to be considered includes observations and forecasts of the full range  
31 of aviation-relevant phenomena, including convection, turbulence, volcanic ash, low-level wind shear, ceiling and  
32 visibility, wake turbulence, etc. This also includes an emphasis on increasing the availability of characterizations  
33 of potentially weather constrained airspace which may be directly integrated into ANSP and user decision  
34 making. This element also focuses on the development or revision of global standards for weather information  
35 content and format, given the migration to 4-D representations of weather information, versus current text and  
36 graphics.

### 37 1.3 Element 2: Weather-Integrated Decision Support Tools

38 This element continues the evolution to the utilization of ATM decision support tools, used by ANSPs and users,  
39 which directly integrate the above weather information into their processing. Based on experiences gained from  
40 development and deployment of initial capabilities as part of module B1-105, extensions are developed to  
41 generate more efficient and operationally acceptable weather mitigation solutions. This element also develops  
42 direct automation-to-automation negotiation capabilities (both ground-based and aircraft-based) to streamline  
43 the development of mutually acceptable ATM decisions.

### 44 1.4 Element 3: Cockpit Weather Capabilities

45 This element will focus on aircraft-based capabilities that will assist pilots with weather avoidance, and thus  
46 enhance safety. Capabilities such as ADS-B In, air-to-air information exchange, and integration of weather into  
47 cockpit-based automation tools are considered. In addition, increased availability of aircraft-based weather  
48 observations will further enhance situational awareness, and help to improve weather forecasting. This element  
49 must focus on globally-harmonized standards development for weather information exchange to support these  
50 capabilities.

51

52 **2. Intended Performance Operational Improvement/Metric to determine success**

53 To assess the operational improvement by the introduction of cockpit weather capabilities, States can use, as  
 54 appropriate, a combination of the following metrics:

<i>Capacity</i>	Better information on the extent, time period and severity of weather impacts on an airspace enables more precise estimates of expected capacity of that airspace.  Advanced decision support tools, integrated with weather information, supports stakeholders in assessing the weather situation and in planning mitigation strategies, which make maximum use of available airspace.
<i>Efficiency</i>	Better information on the extent, time period and severity of weather impacts on airspace enables better utilization of available capacity and accommodation of user-preferred profiles.
<i>Safety</i>	Increased weather situational awareness by pilots, and ANSPs, enables avoidance of hazardous conditions.

<i>CBA</i>	The business case is still to be determined as part of the development of this module, which is in the research phase.
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55 **3. Necessary Procedures (Air & Ground)**

56 The necessary procedures basically exist for ANSPs and users to collaborate on weather-related decisions.  
 57 Extensions to those procedures will be developed to reflect the use of enhanced weather observation and  
 58 forecast information, plus the use of characterizations of potential weather-impacted airspace. International  
 59 standards for information exchange between systems to support these improved ATM operations must be  
 60 developed. This includes development of global standards for the delivery of weather information to aircraft.

61 The use of ADS-B/CDTI and other cockpit capabilities to support weather avoidance by pilots will necessitate  
 62 procedure development, including the roles of ANSPs. International standards for weather information exchange  
 63 between ground-based and aircraft-based systems to support these operations must be developed. This  
 64 includes development of global standards for the delivery of weather information to aircraft.

65 **4. Necessary System Capability**

66 **4.1 Avionics**

67 This module has a significant dependency on advanced aircraft capabilities being widely available. Although  
 68 aircraft-based capabilities such as ADS-B/CDTI and EFBs exist, the level of equipage is still evolving, and  
 69 applications are still being developed to support the objectives of this module. Also, integration of advanced  
 70 weather information into aircraft-based decision support tools will be needed. Increased levels of aircraft  
 71 equipage with weather sensors (e.g. turbulence, humidity, winds) will be necessary to ensure tactical weather  
 72 situational awareness for all aircraft in an area of interest..

73

74 **4.2 Ground Systems**

75 For this longer-term module, the needed ground-system technology is still in development. Research is on-going  
 76 into decision support tools that ingest weather information directly, and support the automated development of  
 77 candidate mitigation strategies. For example, conflict resolution tools will be integrated with weather information  
 78 to ensure aircraft are not inadvertently routed into adverse weather. Work is also needed to ensure a globally  
 79 harmonized, common weather information base that is available to all ANSPs and users for decision making.  
 80 Also, integration of ground-based and aircraft-based automation capabilities, including exchange of digital  
 81 weather information, is needed to support tactical weather avoidance decision making.

82

83

## 84 **5. Human Performance**

### 85 **5.1 Human Factors Considerations**

86 This module may necessitate changes in how service providers and users deal with tactical weather situations.  
 87 While pilots will continue to be responsible for the safe operation of their aircraft in adverse weather, the roles  
 88 and responsibilities of controllers (informed by conflict resolution tools) must also be considered, in order to  
 89 achieve safe and efficient approaches to weather avoidance. Also, the realization of a “common view” of the  
 90 weather situation between service providers, flight operational and pilots will require trust in a single, common  
 91 information base of weather.

### 92 **5.2 Training and Qualification Requirements**

93 Automation support, integrated with weather information is needed for flight operations, pilots and service  
 94 providers. Training in the concepts behind the automation capabilities will be necessary to enable the effective  
 95 integration of the tools into operations. Also, enhanced procedures for collaboration on tactical weather  
 96 avoidance will need to be developed and training provided, again to ensure effective operational use.

97

## 98 **6 Regulatory/Standardisation needs and Approval Plan (Air & Ground)**

99 This module requires the following:

100 Development of global standards for weather information exchange, with emphasis on exchange of 4-D (X, Y, Z,  
 101 and T [time]) gridded weather information.

102

103 Regulatory agreement on what constitutes required weather information in the age of digital exchange, versus  
 104 text and graphics.

105

106 Certification decisions on aircraft-based weather display and dissemination. Dissemination includes air-to-ground  
 107 for aircraft based observations (e.g. turbulence and humidity), as well as possible air-to-air exchange of those  
 108 observations (e.g. turbulence information to nearby aircraft) via ADS-B.

109 Certification decisions on aircraft-based weather display and dissemination. Dissemination includes air-to-ground  
 110 for aircraft based observations (e.g. turbulence and humidity), as well as possible air-to-air exchange of those  
 111 observations (e.g. turbulence information to nearby aircraft) via ADS-B.

## 112 **7. Implementation and Demonstration Activities**

### 113 **7.1 Current Use**

114 Many countries and the user community have been utilizing a Collaborative Decision Making (CDM) process for  
 115 developing coordinated strategies for dealing with adverse weather. These efforts have included the application  
 116 of enhanced weather forecast information, as it is developed. In addition, the FAA and the National Weather  
 117 Service are continuing research on aviation-related weather forecasts, at all decision time horizons. Initial  
 118 demonstrations of these candidate products are showing promise in enhancing the quality of weather  
 119 information upon which ATM decisions can be made, by ANSPs and users.

120 Since this module is in the category of Long Term Issues, there are limited examples of current operational use.  
 121 In the U.S. experience with the use of FIS-B, and the Alaska Capstone effort, has shown a significant safety  
 122 benefit, with increased cockpit weather display capabilities. Also, for General Aviation aircraft, private vendors  
 123 are making weather information available in the cockpit, as optional services. The FAA is conducting research on  
 124 ADS-B In applications that relate to weather avoidance via cockpit functionality. In Europe, FIS-B-like capabilities  
 125 are being deployed currently in Sweden and Russia that provide for enhanced weather information availability to  
 126 pilots. (Suggest ICAO amplify on this addition, as appropriate) Such U.S. and European research efforts will  
 127 help to inform the work to be done under this module.

128 **7.2 *Planned or Ongoing Activities***

129 No global demonstration trials are currently planned for this module. There is a need to develop such a plan as  
130 part of the collaboration process, and as an extension of other modules.

131

132 **8. Reference Documents**

133 **8.1 Standards**

134 World Meteorological Organization standards for weather information content and format. Others TBD; to be  
135 developed as part of this research

136 **8.2 Procedures**

137 To be developed

138 **8.3 Guidance material**

139 To be developed.

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1 **Module N° B3-85: Airborne Self-Separation (SSEP):**

2

<b>Summary</b>	To create operational benefits through total delegation of responsibility to the flight deck for separation provision between suitably equipped aircraft in designated airspace, thus reducing the need for conflict resolution clearances while reducing ATC workload and enabling more efficient flight profiles  The flight crew ensures separation of their aircraft from all surrounding suitably equipped traffic. The controller has no responsibility for separation.	
<b>Main Performance Impact</b>	KPA-02 Capacity, <b>KPA-03 Cost Effectiveness</b> KPA-04 Efficiency, KPA-05 Environment	
<b>Domain / Flight Phases</b>	En-route phase, oceanic	
<b>Applicability Considerations</b>	The safety case needs to be carefully assessed and the impact on capacity is still to be assessed, implying new regulation on airborne equipment and equipment roles and responsibilities (procedure and training). First area for SSEP application is in low density areas.	
<b>Global Concept Component(s)</b>	CM- Conflict Management	
<b>Global Plan Initiatives (GPI)</b>	GPI-16 Decision support systems and alerting systems	
<b>Main Dependencies</b>	In-Trail-Procedure (ITP) B0-86 and Interval Management (IM) B1-85 and Airborne Separation B2-85	
<b>Global Readiness Checklist</b>		<b>Status (ready or date)</b>
	Standards Readiness	Est. 2028
	Avionics Availability	Est. 2028
	Ground Systems Availability	Est. 2028
	Procedures Available	Est. 2028
	Operations Approvals	Est. 2028

3 **1. Narrative**

4 **1.1 General**

5 Airborne separation is described in the Global ATM Operational concept (ICAO [Doc 9854](#)) “

6

7 **“Self-Separation**

8 Self-separation is the situation where the airspace user is the separator for its activity in respect of one or more  
9 hazards.

10

11 Full self-separation is the situation where the airspace user is the separator for its activity in respect of all  
12 hazards. In this case, no separation provision service will be involved; however, other ATM services, including  
13 strategic conflict management services, may be used.

14 **1.1.1 Baseline**

15 The baseline is provided by the first ASAS application described in the module B0-86 In-Trail Procedures, B1-85  
 16 ASAS-ASPA interval management and B2-85 Airborne separation by temporary delegation. These ASAS- SSEP  
 17 operations will be the next step, giving more autonomy to the equipped aircraft.

18 **1.1.2 Change brought by the module**

19 This module will introduce self-separation relying on aircraft capabilities including airborne surveillance  
 20 supported by ADS-B and giving responsibility for separation to the pilot in designated airspace.

21 **1.2 Element: SSEP**

22 **Airborne self-separation:** The flight crew ensures separation of their aircraft from all surrounding traffic. The  
 23 controller has no responsibility for separation. First applications are in Oceanic airspace and low density  
 24 airspace.

25 **Typical Airborne Self-separation applications include:**

- 26 • Airborne Self-separation in ATC-controlled airspace.
- 27 • Airborne Self-separation in segregated en-route airspace.
- 28 • Airborne Self-separation in mixed-equipage en-route airspace.
- 29 • SSEP – FFT Free Flight on an Oceanic Track

30 **2. Intended Performance Operational Improvement/Metric to determine success**

31 Metrics to determine the success of the module are proposed at Appendix C.

32

<i>Access and Equity</i>	Only suitably equipped aircraft can access the designated airspace
<i>Capacity</i>	Increase by allowing reduced separation minima and potential reduction of ATCO workload, and even suppression of the tactical role of the ATS in low density airspace.
<i>Efficiency</i>	More optimum flight trajectories
<i>Environment</i>	Less fuel consumption due to more optimum flight trajectories
<i>Flexibility</i>	More flexibility to take in account change in constraint, weather situation
<i>Global Interoperability</i>	The airborne systems must be standardized to ensure air-air compatibility.
<i>Participation by the ATM community</i>	Increased role of the pilot
<i>Safety</i>	To be demonstrated

<i>CBA</i>	To be determined by balancing cost of equipment and training and reduced penalties
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33 **3. Necessary Procedures (Air & Ground)**

34 ASAS- SSEP procedures need to be defined for PANS-ATM and PANS-OPS with the need to determine  
 35 applicable separation minima. Operational procedures to enter and exit the designated airspace must be  
 36 defined.

37 **4. Necessary System capability (Air & Ground)**

38 **4.1 Avionics**

39 For self-separation (SSEP) the main capabilities are on ASAS. The ASAS is composed of 3 main functions, i.e.,  
40 airborne surveillance, conflict detection and conflict resolution.

41 **4.2 Ground systems**

42 For self-separation in a mixed airspace where a mix of equipped and non-equipped is authorized, on ground  
43 there is a need for specific tools to assess the aircraft capabilities, to support and to monitor the execution of  
44 separation by self-separating aircraft, while managing the separation of the others aircraft. This requires a full  
45 sharing of the trajectory information between all the actors.

46 For self-separation in a segregated airspace, there is a need to check that the predicted density allows this  
47 mode of mitigations and that the aircraft are authorized to fly through this airspace. Specific tools could be  
48 necessary to manage the transfer from self-separation airspace to conventional airspace.

49

50 **5. Human Performance**

51 **5.1 Human Factors Considerations**

52 Change of role of controllers and pilots need to be carefully assessed

53 Specific training and qualification are required

54 **5.2 Training and Qualification Requirements**

55 The pilot need to be trained and qualified to assume the new role and responsibility and correct usage of the  
56 new procedures and avionics.

57 Automation support is needed for the pilot and the controller which therefore will have to be trained to the new  
58 environment and to identify the aircraft/facilities which can use the services in mixed mode environments.

59 **5.3 Others**

60 Liability issues are to be considered

61 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

62 Change in PANS-OPS and PANS-ATM are required

63 **7. Implementation and Demonstration Activities**

64 **7.1 Current Use**

65 None at this time.

66 **7.2 Planned or Ongoing Trials**

67 **European project**

68 **ASSTAR (2005-2007) initiated the work on ASEP and SSEP applications in Europe which has been**  
69 **pursued by SESAR projects as follows:**

70 **SESAR Project 04.07.05 Self Separation in Mixed Mode Environment**

71 One goal of the ASAS development path is to enable self separation (SSEP) in mixed mode operations. The  
72 intention is to allow self-separating flights and ANSP separated flights to operate in the same airspace. The  
73 project has 2 phases with following objectives:

74 1st phase: Assess compatibility between 4D-contract and ASEP applications as a step towards autonomous  
75 operations.

76 2nd phase: develop and validate the operating concept for the SSEP applications in mixed mode, i.e. together  
77 with conventional, new airborne mode (ASEP-C&P) and new ground modes.

78 The main objective is to validate the integration of 4D, ASAS, and conventional traffic in the separation  
79 management task. The focus will be the interaction of conventional and new separation modes and the  
80 consequences for capacity, efficiency, safety, and predictability. Moreover, relations between safety and capacity  
81 will be studied aiming at decreasing the number of critical incidents despite increasing traffic.

82

## 83 **8. Reference Documents**

### 84 **8.1 Standards**

85 To be developed

### 86 **8.2 Procedures**

87 To be developed

### 88 **8.3 Guidance materials**

- 89 • ICAO [Doc 9854](#) – Global ATM Operational Concept
- 90 • ICAO ANConf/11-IP5 draft ASAS Circular (2003)
- 91 • FAA/EUROCONTROL ACTION PLAN 23 – D3 -The Operational Role of Airborne Surveillance in  
92 Separating Traffic (November 2008)
- 93 • FAA/EUROCONTROL ACTION PLAN 23 – D4 –ASAS application elements and avionics supporting  
94 functions (2010)

95

96

# 1 Module N° B3-05: Full 4D Trajectory-based Operations

<b>Summary</b>	This module develops 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 as well as other flight improvements using 4D trajectories under RNP. A key emphasis is on integrating all flight information to obtain the most accurate trajectory model for ground automation. This module considers the development of operational and performance requirements to support these advanced concepts, as well as standards for global exchange of the information.	
<b>Main Performance Impact</b>	KPA-02 Capacity; <b>KPA-04 Efficiency</b> ; KPA-05 Environment; KPA-10 Safety;	
<b>Domain / Flight Phases</b>	En-route/Cruise, Terminal Area, Traffic Flow Management, Descent	
<b>Applicability Considerations</b>	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. 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.	
<b>Global Concept Component(s)</b>	AOM - Airspace Organization and Management DCB - Demand and Capacity Balancing AUO - Airspace User Operations TS - Traffic synchronization CM - Conflict management	
<b>Global Plan Initiatives (GPI)</b>	GPI-5- RNAV/RNP (Perf. Based Nav) GPI-11- RNP and RNAV SIDs and STARs GPI-16- Decision Support Systems and Alerting Systems	
<b>Main Dependencies</b>	B0-40, B1-10, B1-25, B1-40,	
<b>Global Readiness Checklist</b>		<b>Status</b> (indicate ready with a tick or input date)
	Standards Readiness	2025
	Avionics Availability	2028
	Ground Systems Availability	2028
	Procedures Available	2028
	Operations Approvals	2028

## 2 1. Narrative

### 3 1.1 General

4 This module implements 4D trajectory based operations that uses the capabilities of aircraft Flight Management  
5 Systems to optimise aircraft flight trajectories in four dimensions. Full TBO integrates advanced capabilities that  
6 will provide vastly improved surveillance, navigation, data communications, and automation for ground and  
7 airborne systems with changes in service provider roles and responsibilities.

### 8 **1.1.1 Baseline**

9 This module deploys an accurate four-dimensional trajectory that is shared among all of the aviation system  
10 users at the cores of the system. This provides consistent and up-to-date information system wide which is  
11 integrated into decision support tools facilitating global ATM decision-making. It continues the evolution in  
12 procedures and automation capabilities, both ground-based and aircraft-based, for using accurate trajectories to  
13 benefits the system. Optimised arrivals in dense airspace were previously enabled. Decision support capabilities  
14 are available that are integrated to assist ANSPs and users to make better decisions in arrival profile  
15 optimisation. A consistent, integrated information base is available to all ANSPs and users to inform ATM  
16 decision making.

### 17 **1.1.2 Change brought by the module**

18 In future en route airspace, mixed levels of aircraft performance and air crew authorizations are expected. High-  
19 performance aircraft will be capable of flying RNAV routes, accurately conforming to their route of flight,  
20 supporting data communications, communicating requests and aircraft state and intent information electronically  
21 with the ATC automation, and receiving clearances and other messages electronically from the ATC automation.

22 Some en route airspace will be designated for high-performance aircraft only, allowing the air traffic control  
23 (ATC) system to engage operations that fully leverage the capabilities of those aircraft. Aircraft will communicate  
24 state and intent information to the ATC automation and closely follow their intended routes of flight. As a result,  
25 the automated problem prediction and resolution capabilities will be able to maximize user benefits by supporting  
26 user-preferred flight plans, minimizing changes to those plans as aircraft traverse the NAS, and improving  
27 services provided.

28 The controller's primary responsibilities will be to respond to problems predicted by the ATC automation, and to  
29 maintain accurate flight information in the ATC automation. Predicted problems will include:

- 30 • Aircraft to aircraft conflicts
- 31 • Aircraft to special use or other types of restricted airspaces
- 32 • Aircraft to severe weather forecast areas
- 33 • Aircraft to metering constraint problems including miles in trail restrictions
- 34 • The aircraft's capability to accurately fly its cleared route of flight, coupled with the state and intent  
35 information sent from the aircraft to the ATC automation, will increase the accuracy of trajectory  
36 modeling and problem prediction. Key aspects of Full TBO are:
- 37 • The basis for all operations is an accurate four-dimensional trajectory that is shared among all of the  
38 aviation system users.
- 39 • Consistent and up-to-date information describing flights and air traffic flows are available system-wide,  
40 supporting both user and service provider operations.
- 41 • Data Communication is used between the ground and aircraft to improve the accuracy of trajectories,  
42 request changes in 4D trajectory, provide precise clearances to the flight, and exchange information  
43 without controller involvement.
- 44 • Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of  
45 navigational aids, enabling the flexibility of point-to-point aircraft operations.
- 46 • Required Navigation Performance (RNP) operations introduce the requirement for onboard  
47 performance monitoring and alerting. A critical characteristic of RNP operations is the ability of the  
48 aircraft navigation system to monitor its achieved navigation performance for a specific operation, and  
49 inform the air crew if the operational requirement is being met.
- 50 • En route controllers rely on automation to identify conflicts and propose resolutions allowing them to  
51 focus on providing improved services to the users.
- 52 • The ability of cockpit automation to fly the aircraft more precisely and predictably reduces routine  
53 tasks of controllers.

- 54 • Performance-based services that require minimum flight performance levels are provided in  
55 designated airspace.
- 56 • Flow management automation will propose incremental congestion resolutions that will maintain  
57 congestion risk at an acceptable level, using flight-specific alternative intent options to the extent  
58 possible. Flight operation centers (FOC) will dynamically re-calculate and furnish the flight crew and  
59 flow management updated intent options and priority of the options as conditions change.
- 60 • Time-based flow management that coordinates arrival flows for high traffic airports.

61 **1.2 Element 1: Advance Aircraft Capabilities**

62 This element focuses on aircraft-based capabilities that assists pilots with weather and other aircraft avoidance,  
63 and thus enhance safety. Such capabilities as ADS-B In, air-to-air information exchange, and integration of  
64 weather into cockpit-based automation tools. This element also focuses on globally-harmonized standards  
65 development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

66 **1.3 Element 2: Problem Detection and Resolution**

67 This element will continue the evolution to the use of ATM decision support tools, by ANSPs and users, which  
68 provide manoeuvres for flying the most economical descent profiles. Based on experiences gained from  
69 development and deployment of initial capabilities, extensions will be developed to generate more efficient and  
70 operationally acceptable arrival profile solutions. This element will also explore direct automation-to-automation  
71 negotiation capabilities to streamline the development of mutually acceptable ATM solutions. This element is will  
72 also focus on getting the most accurate trajectory model in the system for use by all automation functions. This  
73 entails putting every clearance given to the aircraft into the automation, using automation generated resolutions  
74 to make it easier for the controllers to enter the clearance, and receiving flight specific data from the aircraft to  
75 include in the trajectory calculation and any resolution options.

76 **1.4 Element 3: Traffic Flow Management and Time-Based Metering**

77 This element will harmonize the Traffic Flow Management automation which continuously predicts the demand  
78 and capacity of all system resources, and will identify when the congestion risk for any resource (airport or  
79 airspace) is predicted to exceed an acceptable risk. Information from FOCs or flight crews indicates intent  
80 options and preferences, so that user reactions and adjustments to the 4DT to address constraints such as  
81 weather are accounted before the ANSP would take action. Traffic Management will take action in the form of  
82 just in time reroutes and metering times to congested resources. The problem resolution element will create a  
83 manoeuvre that meets all system constraints.

84 **2. Intended Performance Operational Improvement/Metric to determine success**

85 To assess the operational improvement by the introduction of this element, States can use, as appropriate, a  
86 combination of the following metrics:

<i>Capacity</i>	<ul style="list-style-type: none"> <li>a. Additional flights can be accommodated 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.</li> <li>i. Applied horizontal separation</li> </ul>
<i>Efficiency</i>	<ul style="list-style-type: none"> <li>Harmonized avionics standards</li> <li>a. cost savings and environmental benefits through reduced fuel burn <ul style="list-style-type: none"> <li>i. Level flight time</li> <li>ii. Level distance time</li> <li>iii. Fuel burn</li> </ul> </li> <li>a. Users will be better able to plan and receive their preferred trajectory <ul style="list-style-type: none"> <li>i. Number of user-preferred profiles that can be accommodated</li> </ul> </li> </ul>



<i>Environment</i>	<ul style="list-style-type: none"> <li>a. Users will be better able to plan and receive their preferred trajectory                             <ul style="list-style-type: none"> <li>i. Number of user-preferred profiles that can be accommodated</li> </ul> </li> <li>a. Cost savings and environmental benefits through reduced fuel burn                             <ul style="list-style-type: none"> <li>i. Level flight time</li> <li>ii. Level distance time</li> <li>ii. Fuel burn</li> </ul> </li> </ul>
<i>Safety</i>	<ul style="list-style-type: none"> <li>a. Increased flight crew situational awareness</li> <li>b. Reduction of conflicts between aircraft and more lead time in resolving those conflicts that exist.</li> <li>c. Number of incident occurrences</li> </ul>

<i>CBA</i>	The business case is still to be determined as part of the development of this module, which is in the research phase. Current experience with utilization of enhanced weather information to improve ATM decision making by stakeholders has proven to be positive due to the benefits of more efficient flight planning and less disruption to user-preferred trajectories.
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88 **3. Necessary Procedures (Air & Ground)**

89 The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and  
 90 will necessitate procedures development, including the roles of ANSPs.

91

92 For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on flight path  
 93 decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision  
 94 support automation capabilities, including automation-to-automation negotiation.

95

96 For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on flight path  
 97 decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision  
 98 support automation capabilities, including automation-to-automation negotiation.

99 **4. Necessary System Capability (Air & Ground)**

100 **4.1 Avionics**

101 For this longer-term element, the needed technology is still in development. Aircraft-based capabilities, such as  
 102 ADS-B/CDTI, exist, but applications are still being developed to support the objectives of this element.

103 **4.2 Ground Systems**

104 For the longer-term element, the needed technology is still in development. For ground-based technology,  
 105 research is on-going into decision support tools that produce fuel efficient resolutions, and support the  
 106 automated development of candidate mitigation strategies. Work is also needed to incorporate data from aircraft  
 107 systems into ground trajectory models to ensure the most accurate trajectory.

108 **5. Human Performance**

109 **5.1 Human Factor Considerations**

110 TBD

111 **5.2 Training and Qualifications Requirements**

112 TBD

113 **5.3 Others**

114 TBD

115 **6. Regulatory/Standardisation needs and Approval Plan (Air & Ground)**

116 **6.1 Element 1: Advance Aircraft Capabilities**

117 International standards for information exchange between systems to support these operations need to be  
118 developed. This includes development of global standards for the exchange of trajectory information between  
119 ground and air.

120 International standards for information exchange between systems to support these operations need to be  
121 developed. This includes development of global standards for the exchange of trajectory information between  
122 ground and air. Included in this is development of global standards for trajectory information exchange and  
123 certification decision on aircraft-based aircraft display and dissemination. Dissemination includes air-to-ground  
124 as well as air-to-air exchange of those observations via ADS-B.

125 **7. Implementation and Demonstration Activities**

126 **7.1 Current Use**

127 Since this module is in the category of Long Term Issues, there are no examples of current operational use.  
128 Numerous entities are conducting research on ADS-B In applications that relate to aircraft avoidance via cockpit  
129 functionality. Such research efforts will help to inform the work to be done under this block.

130 **7.2 Planned or Ongoing Trials**

131 **7.2.1 Element 1: Advance Aircraft Capabilities**

132 No global demonstration trials are currently planned for this module. There is a need to develop such a plan as  
133 part of the collaboration on this module.

134 **8. Reference Documents**

- 135
- NextGen and SESAR Operational Concepts
  - 136 • Doc 4444 & Annex 10, [Volume 2](#)
  - 137 • Manual of Air Traffic Services Data Link Applications ([DOC 9694](#))
  - 138 • EUROCOAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305,  
139 ED110B/DO280
  - 140 • EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability  
141 requirements.

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1 **Module N° B3-90: Remotely Piloted Aircraft (RPA) Transparent**  
 2 **Management**  
 3

<b>Summary</b>	RPA operate on the aerodrome surface and in non-segregated airspace just like any other aircraft 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 Sense and Avoid (ABSAA) algorithms, and integration of RPA into aerodrome procedures.	
<b>Main Performance Impact</b>	KPA-01 Access & Equity, KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment, KPA-09 Predictability, KPA-10 Safety	
<b>Domain Flight Phases</b>	En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing)	
<b>Applicability Considerations</b>	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.	
<b>Global Concept Component(s)</b>	AOM - Airspace Organization and Management CM - Conflict Management AUO - Airspace User Operations	
<b>Global Plan Initiatives (GPI)</b>	GPI-6, Air traffic flow management GPI-9, Situational awareness GPI-12, Functional integration of ground systems with airborne systems	
<b>Pre-Requisites</b>	B2-90	
<b>Global Readiness Checklist</b>		<b>Status</b> (indicate ready with a tick or input date)
	Standards Readiness	Est. 2028
	Avionics Availability	Est. 2028
	Ground Systems Availability	Est. 2028
	Procedures Available	Est. 2028
	Operations Approvals	Est. 2028

4 **1. Narrative**

5 **1.1 General**

6 Based on block 2 upgrades and procedures

7 **1.1.1 Baseline**

8 The baseline contains procedures that accommodate and allow for the evolution of RPA's into the airspace. This includes the  
 9 improvements addressed in Block 2-90, which are:

- 10 • Access to most airspace for select airframes without specific authorization or experimental aircraft waiver
- 11 • RPAS certification procedures
- 12 • New special purpose transponder code for lost link
- 13 • Standardized lost link procedures
- 14 • Revised separation criteria and/or handling procedures (i.e. moving airspace)
- 15 • ADS-B on most RPA classes
- 16 • Detect and Avoid technologies improvements
- 17 • Automatic position reporting to ATC capability for lost link over high seas

18

Block 3	Fully Controlled Terminal Airspace (Class B, C)	En Route Class A Airspace	High Seas Class A Airspace	Uncontrolled and Partially Controlled Airspace (Class D, E, F, and G)
<b>Authorization</b>	Strict compliance with standard regulations is required.			
<b>C2 Link Failure Procedures</b>	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
<b>Communications</b>	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
<b>Separation Standards</b>	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
<b>ATC Instructions</b>	RPAS will comply with ATC instructions as required			N/A
<b>RPA Observers</b>	Not required if RPAS is equipped for GBSAA flight in a GBSAA approved area, or is equipped for ABSAA	Not required		N/A
<b>Medical</b>	Remote pilots shall have an appropriate medical certificate			
<b>Presence of Other Aircraft</b>	RPA shall not increase safety risk to the air navigation system			
<b>Visual Separation</b>	Visual separation will be permitted if RPAS is equipped for GBDAA flight in a GBSAA approved area, or is equipped for ABDAA		TBD	RPA must use GBDAA or ABDAA for separation at all times
<b>Responsibility of Remote Pilot</b>	Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization			
<b>Populated Areas</b>	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
<b>ATC Services</b>	Consistent with Annex 11, Appendix 4			N/A
<b>Flight Plan</b>	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.			
<b>Meteorological Conditions</b>	Restrictions to be determined by the State			

<b>Transponder</b>	Shall have and use ADS-B	N/A
<b>Safety</b>	Identify the hazards and mitigate the safety risks; adhere to the authorization	
<b>NOTAMs</b>	NOTAM requirements, if any, to be determined by the State	
<b>Certification</b>	TBD	

19

20 **1.1.2 Changes brought by the module**

- 21 • **Certification for RPA’s flying in all classes of airspace:** Here the RPA operates in the non-segregated airspace  
22 just like any other aircraft. Certification has been defined based on standards, and the safety case has been proven  
23 for each aircraft type. The Air Traffic Management (ATM) procedures (identification of aircraft type, separation  
24 standards, and lost communications procedures are well defined in Block 3 to allow for this type of operations.
- 25 • **Reliable C2 link:** This improvement continues from the work done in block 2 and the procedures and standards will  
26 be fully vetted and certified during this block.
- 27 • **Certified autonomous response:** The ability to respond autonomously in any situation to provide both self-  
28 separation and collision avoidance maneuvers. This is needed to ensure safety even during a lost link event. The  
29 pilot can still have the ability to override the autonomous actions whenever the C2 link is operational.
- 30 • **Certified ABSAA algorithms:** During this block the procedures and standards for autonomous operations, based  
31 on an ABSAA solution and algorithm set, will be developed and certified.
- 32 • **Aerodrome procedures<sup>5</sup>:** During this block, RPA will be integrated into aerodrome operations. Consideration may  
33 have to be given to the creation of airports that would support RPA operations only. The unique characteristics of  
34 the RPA need to be considered, some of the areas to be considered are:
  - 35 ○ Applicability of aerodrome signs and markings for RPAs
  - 36 ○ Integration of RPA with manned aircraft operations on the maneuvering area of an aerodrome
  - 37 ○ Issues surrounding the ability of RPA to avoid collisions while maneuvering
  - 38 ○ Issues surrounding the ability of RPA to follow ATC instructions in the air or on the maneuvering area (e.g.  
39 “follow green Cessna 172” or “cross behind the Air France A320”)
  - 40 ○ Applicability of instrument approach minima to RPA operations
  - 41 ○ Necessity of RPA observers at aerodromes to assist the remote pilot with collision avoidance  
42 requirements
  - 43 ○ Implications for aerodrome requirements of RPA infrastructure, such as approach aids, ground handling  
44 vehicles, landing aids, launch/recovery aids, etc.
  - 45 ○ Rescue and fire fighting requirements for RPA (and remote pilot station, if applicable)
  - 46 ○ RPA launch/recovery at sites other than aerodromes
  - 47 ○ Integration of RPA with manned aircraft in the vicinity of an aerodrome
  - 48 ○ Aerodrome implications for RPAS-specific equipment (e.g. remote pilot stations)

49 **2. Intended Performance Operational Improvement/Metric to determine success**

<i>Capacity</i>	Could be negatively impacted due to larger separations being applied for safety reasons between RPA and traditional traffic. Metric: sector capacity
<i>Efficiency</i>	Transparent access to airspace by RPAS Metric: volume of RPA traffic
<i>Environment</i>	The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States. Metric: volume of interstate RPA traffic
<i>Predictability</i>	Increased predictability of RPA through global interoperability of communications and situational awareness.
<i>Safety</i>	Increased situational awareness; controlled use of aircraft Metric: incident occurrences

50

<sup>5 5</sup> ICAO Cir 328, Unmanned Aircraft Systems (UAS)

	CBA The business case is directly related to the economic value of the aviation applications supported by RPAS.
--	---

51

52 **3. Necessary Procedures (Air & Ground)**

- 53 • Certified ATM procedures for RPAS to operate in all classes of airspace
- 54 • Procedures that allow for multiple RPA's in the same airspace at the same time
- 55 • Procedures that allow RPA's to operate out of all classes of airports
- 56 • Procedures that allow for autonomous operations including autonomous responses in any situation
- 57 • Where RPAs are operating alongside manned aircraft there needs to be ground and air procedures that insure
- 58 harmonious operations.

59 **4. Necessary System Capability (Air & Ground)**60 **4.1 Avionics**

- 61 • Certified ABSAA algorithms
- 62 • Reliable C2 links
- 63 • Equipage of all aircraft, with proven detect and avoid technology
- 64 • Equipage of RPAS with necessary equipment to work within existing aerodrome parameters to the greatest extent
- 65 practicable.

66 **4.2 Ground Systems**

- 67 • GBSAA to supplement where applicable
- 68 • Certified autonomous algorithms

69 **5. Human Performance**70 **5.1 Human Factor Considerations**

71 The controller-pilot relationship is well established.

72 **5.2 Training and Qualifications Requirements**

73 TBD

74 **5.3 Others**

75 TBD

76 **6. Regulatory/standardisation needs and Approval Plan (Air & Ground)**

77 TBD

78 **7. Implementation and Demonstration Activities**

79 TBD

80 **7.1 Current Use**

81 TBD

82 **7.2 Planned or On-going Trials**

83 TBD

84 **8. Reference Documents**

- 85 • [ICAO Circ 328](#) – Unmanned Aircraft Systems (UAS)
- 86 • [Annex 2](#) — Rules of the Air proposal for amendment

- 87 • U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- 88 • NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*
- 89 • EUROCAE Document (under development)
- 90



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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  
**FMTF.** 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  
**GUFU.** 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

**OSD** 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  
**TMI.** 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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**OPERATIONAL ENHANCEMENTS****Status of implementation**

(Version6/ROs)

Attachment to IOM 17/4-11-12 dated 4 August 2011

Operational improvement & Performance monitoring-Metrics <b>1</b>	Availability of necessary procedures Air/Ground <b>2</b>	Availability of necessary technology Air/Ground <b>3</b>	Availability of Regulatory approvals <b>4</b>	Development of business case <b>5</b>	Conduct of Operational trials <b>6</b>	Status of implementation/Challenges, if any <b>7</b>	Way forward to expedite implementation <b>8</b>
<p><b>Improved Airport Accessibility</b></p> <p><b>Performance monitoring</b></p> <p>Metrics:</p> <ol style="list-style-type: none"> <li>1. Number of runways ends with vertical guidance.</li> <li>2. Movement rate at airports during LVP operations.</li> <li>3. Number of flight disruptions</li> <li>4. CO2 savings.</li> <li>5. Ratio of vertically-guided to total procedures.</li> <li>6. Ratio of circling to total procedures</li> </ol>	<p>The PBN Manual, GNSS Manual, Annex 10 and PANS-OPS Volume I .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. 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.</p>	<p>PBN approach procedures can be flown with basic IFR GNSS avionics. These 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 can fly approaches with vertical guidance to LPV minima. A GBAS station can support vertically guided Cat I approaches to all runways. Aircraft require TSO C161/162 avionics to fly GBAS approaches.</p>	<p>Ops approval hand book and PBN Model regulations have been published</p>	<p>Guidance for the Development of CBA and Business case is available.</p> <p>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.</p>	<p>Many States started developing GPS-based RNAV approach procedures. The United States commissioned WAAS (SBAS) in 2003, and EGNOS in early 2011. International air carriers have not adopted SBAS.</p> <p>SBAS is more attractive to regional and other domestic air carriers, as well as general aviation aircraft.</p>		

## OPERATIONAL ENHANCEMENTS

### Status of implementation

(Version6/ROs)

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Operational improvement & Performance monitoring-Metrics	Availability of necessary procedures  Air/Ground	Availability of necessary technology  Air/Ground	Availability of Regulatory approvals	Development of business case	Conduct of Operational trials	Status of implementation/Challenges, if any	Way forward to expedite implementation
1	2	3	4	5	6	7	8
<p><b>Increased Runway Throughput through Wake Vortex Separation</b></p> <p><b>Element 1-</b> Revision of Current ICAO Wake Separation Standards.</p> <p><b>Element 2-</b> Increasing Aerodrome Arrival Operational Capacity.</p> <p><b>Element 3-</b> Increasing Aerodrome Departure Operational Capacity</p> <p><b>Performance monitoring</b></p> <p>Metrics: 1. Increased number of arrival/departure operations/hr achieved</p>	<p>Wake Vortex Separation will be implemented mainly via changes to ANSP wake mitigation procedures and associated wake vortex separation standards.</p> <p>All the three elements require no changes to the aircrew's procedures.</p>	<p>Element 1.</p> <p>No need for additional aircraft technology/additional aircrew certifications. 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.</p> <p>The Element 2 and Element 3</p> <p>These products vary on their dependency to newly applied technology.</p>	<p>Element 1: A set of changes to the ICAO wake separation standards and supporting documentation is needed and <b>currently under ICAO's ANB review.</b></p> <p>Element 2: These products are U.S. aerodrome specific.</p> <p>Element 3: The WIDAO has</p>	<p>This module is procedural with some technological applications. 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. No aircraft</p>	<p>Element 1: Not applicable. Awaiting ICAO approval.</p> <p>Element 2: The FAA Order 7110.308 procedure use has been approved for 7 U.S. aerodromes</p> <p>Element 3: The WIDAO relaxation of wake separation constraints at CDG (first and second sets of constraints) were approved in November 2008 and March 2009</p>		



## OPERATIONAL ENHANCEMENTS

### Status of implementation

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1	2	3	4	5	6	7	8
<p><b>Improved Airport Operations through A-CDM</b></p> <p><b>Performance monitoring</b></p> <p>Metric:</p> <p>1. Efficiency at airports will increase as runways are used at their highest capacity while not congesting the taxiways.</p> <p>2. The environment will benefit from reduced time idling of the aircraft, thus reducing carbon dioxide emissions.</p>	<p>For surface-CDM to work effectively, the roles and responsibilities of stakeholders become a collaborative decision made together to make the best decisions for the ATM system operations as a whole.</p> <p>Each airport operation will conduct modelling and testing in order to make the most efficient use of the airport architecture to maintain an</p>	<p>The Surface Decision Support System (SDSS) will need to be implemented allowing for data exchange between stakeholders and providing a framework within which the departure operation can be proactively managed. Operational capabilities are dependent on how effectively the SDSS interfaces with user data-sharing information.</p>	<p>There will be a need to develop procedures for aircraft/vehicles that do not participate in the collaboration aspects.</p>	<p>CDQM has been found to provide reduced taxi times, and resultant reduced fuel usage and emissions, while maintaining full use of departure capacity. Additional research and development of the Surface CDM Concept of Operations, CDQM and the Collaborative Departure Scheduling concept is being further developed.</p>	<p>In order to minimize disruption during construction, JFK decided to use a collaborative effort using departure queue metering. The procedures used during the construction project worked so well that they were extended after the runway work was completed.</p>		

## OPERATIONAL ENHANCEMENTS

### Status of implementation

(Version6/ROs)

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Operational improvement & Performance monitoring-Metrics  1	Availability of necessary procedures  Air/Ground  2	Availability of necessary technology  Air/Ground  3	Availability of Regulatory approvals  4	Development of business case  5	Conduct of Operational trials  6	Status of implementation/Challenges, if any  7	Way forward to expedite implementation  8
	appropriate allocation of departure capacity.						
<b>Improved Traffic Flow through Runway Metering</b>  <b>Performance monitoring</b>  Metrics: 1. Decreased lead time for departure request; decreased time between CFR and departure time; increased tower productivity; and , increased Center TMU productivity. 2. Optimize usage of	The ICAO Manual on Global Performance DOC 9883) provides guidance on implementing integrated arrival and departure capability.  The Time based Flow management (TBFM) and Arrival/Departure management (AMAN/DMAN) efforts provide the systems and operational	The Global ATM Operational Concept (DOC 9854) presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM System.  Both TBFM and Arrival/Departure Management (AMAN/DMAN) application and existing technologies can be	This TBFM and AMAN/DMAN implementation will impact ICAO Annex 1, the PANS-ATM document (DOC 4444), Global Air Navigational Plan (DOC 9750) and the Global ATM Operational Concepts	Time Base Flow Manager Business Case Analysis Report - Should reduce environmental effects (emission, noise, and fuel burn).			

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terminal airspace; optimize utilization of runway capacity. 3. Dynamic scheduling; 4. Aerodrome/terminal demand prediction.	procedures necessary.  RNAV/RNP for arrival will also be crucial as well. The Manual on ATM System Requirements (DOC 9882) is relevant.	leveraged, but require site adaptation and maintenance. Both efforts will take incremental steps toward the long term capability described in their respective strategic documents.	(DOC 9584).				
<b>Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration -AIDC-</b>  <b>Performance monitoring</b>  Metrics: 1. Reduced controller workload and increased data integrity	Required procedures exist. The experience from other regions can be a useful reference.	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.	ICAO material is available (PANS-ATM, DOC 4444). Regions should consider the possible mandating of AIDC. Means of compliance are also	Guidance for the Development of CBA and Business case is available.			



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<p>2. Reduced separation can also be used to offer more frequently to aircraft flight levels closer to the flight optimum;</p> <p>3. Use of standardised interfaces reduces the cost of development, allows controller to apply the same procedures at the boundaries</p>			described in EUROCONTROL standards and EU regulations.				
<p><b>Service Improvement through Digital Aeronautical Information Management</b></p> <p><b>Performance monitoring</b></p> <p>Metrics: 1. Reduction in the number of possible</p>	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 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	No additional need.	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			

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inconsistencies, 2. 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. 3. 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.	the digital AIS data in the on-board devices, in particular Electronic Flight Bags.	services. The physical support does not need to be standardised.		regional cooperation and it remains low compared with the cost of other ATM systems.			
<b>Improved Operations through Enhanced En-Route Trajectories.</b>  <b>Element 1 :</b> Flexible Tracking <b>Element 2:</b> CDM for enroute airspace	Require new procedures which will be implemented initially as unpublished routes, but will become established and published as RNAV routes with increased	Equipage with FANS or ATN with VDL-2 is required to enable this operation.  A web based portal constantly updated during specified	FANS 1A+, DO-280/DO-290, RTCA 214 standards in the near-term. Requires National Defense,	FUA will reduce flight time and distance with enhanced awareness, better use of airspace and use of more efficient routes. In the U.S. a study			

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<p><b>Element 3:</b> PBN <b>Element 4:</b> FUA <b>Element 5:</b> Airspace planning</p> <p><b>Performance monitoring</b></p> <p>Metrics: Increased predictability Increased communication and shared knowledge Reduce delays Reduced flight times Reduced miles flown Reduced emissions</p>	<p>flexibility. Establishment of National Defense/ATM/User coordination procedures to handle ingress, egress, Department of Defense reclamation, and deviation situations. New RNAV, random and designated RNAV routes through the SUA must be designated. Airspace planning will require RNAV procedures which may enhance the predictability of operations.</p>	<p>weather, TFM, delays, Reroutes, TMI circumstances will inform stakeholders of impacted routes . Some technology is currently under development and will likely be available system wide in the near term.</p> <p>RNAV equipped aircraft is needed.</p> <p>No equipage requirement. Applies to all arriving aircraft where implemented.</p>	<p>ATM, and civilian operator policy to support comprehensive SUA status information. ATM and National Defense must standardize how SUA are managed across the NAS. SUA management across the NAS must be automated.</p>	<p>shows maximum savings of dynamic use of SUA of \$7.8M (1995 \$). In the U.S. the RTCA NextGen Task Force found that in the near term TMA will reduce gate arrival delay by 2 to 4 minutes; reduce airborne holding circuits by 90%; also small increases in arrival rates will be possible. RPI benefits of \$70M-\$100M per year for OEP airports.</p>			
<p><b>Improved Flow Performance through Planning based on a Network-Wide view</b></p> <p><b>Performance</b></p>	<p>Need to expedite the ICAO manual, but US/Europe experience is enough to initiate application in other regions.</p>	<p>At that stage, no specific technology apart from current IT. Some vendors propose light ATFM systems.</p>	<p>Establishing standard ATFM messages in order to ensure</p>	<p>The cost of 1 minute ATFM delay is estimated to 81€in Europe, and the airborne delay cost is higher. Avoiding</p>	<p>The following improvement items are being validated or implemented in Europe .</p>		

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1	2	3	4	5	6	7	8
<b>monitoring</b>  Metrics: 1. Better utilisation of available capacity, network-wide; 2. Increased predictability of schedules as the ATFM algorithms tend to limit the number of large delays. 3. Reduced fuel burn; 4. Environment: reduced fuel burn 5 Improved access by avoiding disruption of air traffic in periods of demand higher than capacity; 6. ATFM processes take care of equitable distribution of delays  .	New procedures are required to link much closer the ATFM with ATS in the case of using miles-in-trail.		common understanding & behaviour for operators flying in several regions and to ensure exchange ATFM data across regions would be an advantage.	significant amounts of airborne delays and properly managing the ATFM delays compensates many times the cost of the service in regions where traffic density is high.	Enhanced Flight Plan Filing Facilitation, - Use of Free Routing for flight in special Airspace volumes, Use of Aircraft Derived Data to enhance ATM ground system performance - - Network Performance Assessment, - Real-time Civil-Military Coordination of Airspace Utilisation, - Flexible Sectorisation		
<b>Improved access to Optimum Flight Levels through</b>	Different procedures will be required for each version of In-	The necessary technology for ITP using ADS-C will	For ITP using ADS-B, the following	Guidance for the Development of CBA and Business	Both ITP with ADS-C and ADS-B are a		

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<p><b>Climb/Descent Procedures using ADS-B</b></p> <p><b>Performance monitoring</b></p> <p>Metrics: 1. Cost Effectiveness: reduced fuel burn. 2. Environment: reduced emissions. 3. Capacity: improvement in capacity.</p>	<p>Trail Procedure (ITP). For oceanic ITP (using ADS-C) refer to GOLD document .Procedures for IPT 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)</p>	<p>be the FANS-1/A package on the aircraft. The corresponding ATSU on the ground will need a data link workstation supporting CPDLC and ADS-C with a conflict probe. The necessary technology for IPT using ADS-B on board the aircraft will be an ACAS conforming to DO-312. Although CPDLC is not a prerequisite for ITP using ADS-B, many FIRs will only approve ITP supported by CPDLC. In which case, the aircraft and ATSU will need to support CPDLC.</p>	<p>documents apply: a. AC 20-172 b. TSO C195</p>	<p>case is available.</p> <p>For ITP using ADS-C, total fuel savings in the Oakland FIR have been projected to be approx. \$16M per year with a 35% equipage rate. CO2 savings of 51M Kg per annum have been predicted..</p> <p>For ITP using ADS-B, the business case for one major carrier operating in the South Pacific was as follows:</p> <ul style="list-style-type: none"> <li>• Per annum savings per aircraft : \$202K</li> <li>• Benefit to Cost Ratio : 10.7</li> <li>• Time to Payback : 3 years</li> <li>• Internal Rate of Return : 68%</li> </ul>	<p>part of trials to be undertaken under the ASPIRE programme.</p> <p>Once the above trials have been completed, it is expected that ITP will become operational</p>		

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<b>Air Traffic Situational Awareness (ATSA)</b> ATSA provides a cockpit display of a graphical depiction of traffic to assist the pilot in out-the-window visual acquisition of traffic:  <b>Performance monitoring</b>  Metric:	Being developed	Being developed	Being developed	Being developed	Being developed		

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<p><b>Improved Flexibility and Efficiency in Descent Profiles (CDOs)</b></p> <p><b>Element 1:</b> Continuous Descent Operations</p> <p><b>Element 2:</b> Performance Based Navigation</p> <p><b>Performance monitoring</b></p> <p>Metrics: 1. reduced fuel burn: 2. reduction in the number of required radio transmissions: 3. Number of unstable approaches, 4. Number of CFIT</p>	<p>Element 1: The ICAO Continuous Descent Operations (CDO) Manual (DOC 9931) provides guidance on all aspects of CDO.</p> <p>Element 2: The ICAO Performance-based Navigation Manual (ICAO Document 9613) provides general guidance on PBN implementation.</p>	<p>Element 1: CDO is an aircraft operating technique aided by appropriate airspace and procedure design. This is most readily determined by the onboard FMS.</p> <p>Element 2: PBN requirements will be affected by the CNS/ATM systems. The plan for RNAV or RNP has to be decided in consultation with the airspace user. Some areas need only a simple RNAV, while other areas such as nearby steep terrain or dense air traffic may</p>	<p>Element 1: CDO may be a strategic objective. In addition to a safety assessment, impact of CDO on other air traffic operations should be developed.</p> <p>Element 2: International public standards for PBN are still evolving. There is a need for forward fit and retrofit</p>	<p>Element 1: CDO in Los Angeles TMA benefited 50% reduction in radio transmissions; fuel savings – average 125 pounds per flight; more than 41 million pounds of CO2 avoided.</p> <p>Element 2: The PBN avoids the need to purchase and deploy navigation aids for each new route or instrument procedure. With PBN all airports can have a stabilized instrument approach that will allow</p>	<p>Element 1: Many trials and actual implementation have already occurred globally.</p> <p>Element 2: PBN is being implemented in many parts of the world.</p>		

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		require the most stringent RNP. .	requirements including GNSS.	aircraft to land into the wind, as opposed to a tail wind landing.			
<p><b>Improved Safety and Efficiency through the initial application of Data Link En-Route</b></p> <p><b>Element 1-</b> ADS-C: <b>Element 2-</b> CPDLC, FANS1/A: Link</p> <p>Performance monitoring Element 1- Metrics: 1. Increased situational awareness; 2. Better support to SAR. 3. Reduced separations 4. Apply flexible routings</p> <p>Element 2- Metrics: 1.Increased situational awareness</p>	Already available in ICAO documents	Already available in ICAO documents	Already available in RTCA and EUROCAE documents.	<p>Element 1</p> <p>The business case has proven to be positive due to the benefits that flights can obtain in terms of better flight efficiency</p> <p>Element 2:</p> <p>A detailed business case has been developed in support of the EU Regulation which was positive.</p>	<p>Element 1</p> <p>Data link is operational at the Maastricht UAC since 2003.</p> <p>Element 2:</p> <p>US: Domestic Airspace: Beginning in 2014 Departure Clearance Services will be deployed using FANS-1/A+. In 2017.</p> <p>In Europe the ATN B1 package is currently being</p>		



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2. Reduced occurrences of misunderstandings; 3. Solution to stuck mike situations. 4 Reduced communication load					deployed in 32 European Flight Information Regions.		
<b>Improved Flexibility and Efficiency in Departure Profiles</b>  <b>Element 1:</b> Continuous Climb Operations  <b>Element 2:</b> Performance Based Navigation  <b>Performance monitoring</b>  Metrics: 1. reduced fuel burn: 2. reduction in the number of required radio transmissions:	Element 1  ICAO Continuous Climb Operations (CCO) Manual (ICAO Document xxxx) provides guidance on all aspects of CCO.  Element 2:  The ICAO Performance-based Navigation Manual (ICAO Document 9613) provides general guidance on PBN implementation	Element 1  CCO does not require a specific air or ground technology. It is an aircraft operating technique aided by appropriate airspace and procedure design.  Element 2:  PBN requirements will be affected by the CNS/ATM systems. The plan for RNAV or RNP has to be decided in consultation with	Element 1:  CCO may be a strategic objective. In addition to a safety assessment, impact of CCO on other air traffic operations should be developed.  Element 2:  International public standards for	Element 1:  CCO benefits are heavily dependent on each specific ATM environment. Nevertheless, the benefit/cost ratio is positive.  Element 2:  The PBN avoids the need to purchase and deploy navigation aids for each new route or instrument procedure. With PBN all airports can have a stabilized	Element 1:  Many trials are ongoing.  Element 2:  PBN is being implemented in many parts of the world		

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3. Number of unstable approaches, 4. Number of CFIT		the airspace user. Some areas need only a simple RNAV, while other areas such as nearby steep terrain or dense air traffic may require the most stringent RNP.	PBN are still evolving. There is a need for forward fit and retrofit requirements including GNSS.	instrument approach that will allow aircraft to land into the wind, as opposed to a tail wind landing.			

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