**EDITION 2**

**VERSION 3 DATED 15 DECEMBER 2011**

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

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| **Summary** | This is the first step toward universal implementation of GNSS-based approaches. PBN and GLS procedures enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency. These can be achieved through the application of Basic GNSS, Baro VNAV, SBAS and GBAS. The flexibility inherent in PBN approach design can be exploited to increase runway capacity. | |
| **Main Performance Impact** | KPA-01 Access and Equity, **KPA-04 Efficiency**, KPA-05 Environment, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | Approach | |
| **Applicability Considerations** | This module is applicable to all instrument and precision instrument runway ends, and to a limited extent, non-instrument runway ends | |
| **Global Concept Component(s)** | AUO – Airspace User Operations<br>AO – Aerodrome Operations | |
| **Global Plan Initiatives (GPI)** | GPI-5 RNAV and RNP (PBN)<br>GPI-14 Runway Operations<br>GPI-20 WGS84 | |
| **Pre-Requisites** | NIL | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | |
| | Avionics Availability | |
| | Ground System Availability | |
| | Procedures Available | |
| | Operations Approvals | |

## 1. Narrative

### *1.1 General*

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

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

#### 1.1.1 Baseline

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

#### 1.1.2 Change brought by the module

Conventional navigation aids (e.g. ILS, VOR, NDB) have limitations in their ability to support the lowest minima to every runway. In the case of ILS, limitations include cost, the availability of suitable sites for ground infrastructure and an inability to support multiple descent paths. VOR and NDB procedures do not support vertical guidance and have relatively high minima that depend on siting considerations. PBN procedures require no ground-based Nav Aids and allow designers complete flexibility in determining the final approach lateral and vertical paths. PBN approach procedures can be seamlessly integrated with PBN arrival procedures, including constant descent operations (CDO), thus reducing aircrew and controller workload and the probability that aircraft will not follow the expected trajectory.

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

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

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

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| *Access and Equity* | Increased aerodrome accessibility |
| *Capacity* | This module removes the requirement for sensitive and safety-critical areas on precision approaches. |
| *Efficiency* | Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely-spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds. |
| *Environment* | Environmental benefits through reduced fuel burn |
| *Safety* | Stabilized approach paths. |
| *CBA* | Aircraft operators and ANSPs can quantify the benefits of lower minima by using historical aerodrome weather observations and modelling airport accessibility with existing and new minima. Each aircraft operator can then assess benefits against the cost of any required avionics upgrade. If an operator equips such that all approaches can be made with vertical guidance, that operator can reduce training costs by deleting simulator and flight training modules. |

## 3. Necessary Procedures (Air & Ground)

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

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

# 4. Necessary System Capability

## *4.1 Avionics*

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

## *4.2 Ground Systems*

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

## *4.3 Human Factors Considerations*

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

## *4.4 Training and Qualification Requirements*

TBD

## *4.5 Others*

TBD

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

See Sections 3 and 4 above.

# 6. Implementation and Demonstration Activities

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

## *6.1 Current Use*

- **United States**

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

- **Canada**

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

- **Australia**

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

- **France**

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

- **Brazil**

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

- **India**

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

### *6.2 Planned or Ongoing Activities*

- **India**

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

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

## 7. Reference Documents

### *7.1 Standards*

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

### *7.2 Procedures*

PANS-OPS (ICAO Doc 8168)

### *7.3 Guidance Material*

- PBN Manual (ICAO Doc 9613)
- GNSS Manual (ICAO Doc 9849)
- WGS-84 Manual (Doc 9674)
- Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II
- Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5

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

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

## 1. Narrative

### *1.1 General*

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

#### 1.1.1 Baseline

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

#### 1.1.2 Change brought by the module

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

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

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

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

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

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

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

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

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

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

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

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

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

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| *Capacity* | a. Aerodrome capacity and departure/arrival rates will increase as the wake categories areincreased from 3 to 6<br>i<br>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%.<br>c. New procedures will modified the current wake mitigation measures of waiting for 2-3 minutes, and decrease the waiting time required. Aerodrome capacity and departure rates will increase. In addition, runway occupancy time will decrease as a result of this new procedure |
| *Flexibility* | ANSP have the choice to configure the aerodrome to operate on 3 or 6 categories, depending on demand. |

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| *CBA* | Benefits of this Module are to the users of the aerodrome's runways. Overly safety conservative ANSP wake separation procedures and associated separation standards do not allow the maximum utility of an aerodromes runway. 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.<br><br>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.<br><br>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. |

## 3. Necessary Procedures (Air & Ground)

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

The module implementations impacting the use of an aerodrome's CSPR for arrivals, only affect the ANSP procedures for sequencing and segregating aircraft to the CSPR. Element 2 products are additional procedures for use by the ANSP for situations when the aerodrome is operating instrument flight rules and there is a need to land more flights than can be achieved by using only one of its CSPR. The procedures implemented by Element 2 require no changes to the aircrew's procedures for accomplishing an instrument landing approach to the aerodrome.

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

# 4. Necessary System Capability

## *4.1 Avionics*

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

## *4.2 Ground Systems*

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

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

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

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

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

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

### *7.2 Planned or Ongoing Trials*

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

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

## 8. Reference Documents

### *8.1 Standards*

### *8.2 Procedures*

### *8.3 Guidance Materials*

ICAO Doc 9750 Global Air Navigational Plan.

ICAO Doc 9584 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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| **Summary** | This module provides a description of those existing facilities and procedures supporting aerodromes' initial implementations of Advanced Surface Movement and Control Systems (A-SMGCS). The facilities and procedures represent basic A-SMGCS performance levels associated to surveillance and alerting of movements of both aircraft and vehicles on aerodrome movement areas. | |
| **Main Performance Impact** | KPA-10<br>KPA-4 | |
| **Domain / Flight Phases** | Aerodrome surface movements (aircraft + vehicles), taxi, push-back, parking | |
| **Applicability Considerations** | Applicable to any aerodrome and all classes of aircraft/vehicles. Implementation to be based on requirements stemming from individual aerodrome operational and cost-benefit assessments. | |
| **Global Concept Component(s)** | AO – Aerodrome Operations<br>CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational Awareness<br>GPI-13 Aerodrome Design and Management<br>GPI-16 Decision Support Systems and Alerting Systems | |
| **Main Dependencies** | Non-cooperative aerodrome surveillance in the form of surface movement radar (SMR), although SMR could be installed simultaneously with A-SMGCS. | |
| **Global Readiness Checklist** | | **Status** (indicate ready with a tick or input date) |
| | Standards Readiness | √ |
| | Avionics Availability | √ (SSR Mode S or A/C transponders) |
| | Infrastructure Availability | √ |
| | Ground Automation Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 9. Narrative

### *9.1 General*

This module builds upon traditional SMGCS implementation (visual surveillance, aerodrome signage, lighting and markings) by the introduction of capabilities enhancing ATC situational awareness through:

- Display to the aerodrome controller of the position of all aircraft on the aerodrome movement area,
- Display to the aerodrome controller of all vehicles on the aerodrome manoeuvring area, and
- Generation of runway incursion alerts (where local operational, safety and cost-benefit analyses so warrant).

The facilities and procedures also represent a significant improvement over and above performance levels associated to conventional SMGCS. The entire A-SMGCS concept, being based on a set of forward and backward compatible groupings of modular functionalities, will ensure these B0 facilities and procedures fully support seamless transitions to the more sophisticated facilities and procedures of A-SMGCS described in B1 through B3. The B0 level of implementation, being associated to the provision of ATS, is independent of aircraft equipage beyond that associated to cooperative surveillance equipage (e.g.: SSR Mode S or A/C transponders).

### 9.1.1 Baseline

Surface operations historically have been managed by use of visual scanning by both ANSP personnel and flight crew, both as the basis for taxi management as well as aircraft navigation and separation. These operations are significantly impeded during periods of reduced visibility (weather obscuration, night) and high demand, e.g. when a large proportion of aircraft are from the same operator and/or of the same aircraft type. In addition, remote areas of the aerodrome surface are difficult to manage if out of direct visual surveillance. As a result, efficiency can be significantly degraded, and safety services are unevenly provided. Complementary to such historical means of aerodrome traffic management, enhanced surface situational awareness has been based upon use of an aerodrome surface movement primary radar system and display (SMR). This permits the surveillance of all aircraft and ground vehicles without any need for cooperative surveillance equipment installed on the aircraft/vehicles. This improvement allows ANSP personnel to better maintain awareness of ground operations during periods of low visibility. In addition, the presence of safety logic allows for limited detection of runway incursions.

### 9.1.2 Change brought by the module

This module implements additional capabilities to the aerodrome surveillance environment by taking advantage of cooperative surveillance that provides the means to establish the position of all aircraft and vehicles and to specifically identify targets with individual flight/vehicle identification. Ground vehicles operating on the manoeuvring area will be equipped with cooperative surveillance transponders compatible with the specific A-SMGCS equipment installed so as to be visible to tower ground surveillance display systems.

### *9.2 Element 1*

This element of the block enhances the primary radar surface surveillance with the addition of at least one cooperative surface surveillance system. These systems include Multilateration, secondary surveillance radar Mode S, and Automatic Dependent Surveillance – Broadcast (ADS-B). As with TMA and En Route secondary surveillance radars/ADS-B, the cooperative aspect of the surveillance allows for matching of equipped surveillance targets with flight data, and also reduces clutter and degraded operation associated with primary surveillance. The addition of cooperative surveillance of aircraft and vehicles adds a significant positive benefit to the performance of safety logic, as the tracking and short-term trajectory projection capabilities are improved with the higher quality surveillance. The addition of this capability also provides for a marginal improvement in routine management of taxi operations and more efficient sequencing of aircraft departures.

### *9.3 Element 2*

Where installed and operated, alerting with flight identification information also improves the ATC response to situations that require resolution such as runway incursion incidents and improved response times to unsafe surface situations. Levels of sophistication as regards this functionality currently vary considerable among various industrial solutions being offered. B0 implementations will serve as important initial validation for improved algorithms downstream.

## 10. Intended Performance Operational Improvement/Metric to determine success

| | |
|---|---|
| *Access and Equity* | Improves access to portions of the manoeuvring area obscured from view of the control tower for vehicles and aircraft. Sustains an improved aerodrome capacity during periods of reduced visibility. Ensures equity in ATC handling of surface traffic regardless of the traffic's position on the aerodrome. |
| *Capacity* | Sustained levels of aerodrome capacity for visual conditions reduced to minima lower than would otherwise be the case. |

| | |
|---|---|
| *Efficiency* | Reduced taxi times through diminished requirements for intermediate holdings based on reliance on visual surveillance only. |
| *Environment* | Reduced aircraft emissions stemming from improved efficiencies. |
| *Safety* | Reduced runway incursions. Improved response to unsafe situations. Improved situational awareness leading to reduced ATC workload. |

| | |
|---|---|
| *CBA* | A positive CBA can be made from improved levels of safety and improved efficiencies in surface operations leading to significant savings in aircraft fuel usage. As well, aerodrome operators' vehicles will benefit from improved access to all areas of the aerodrome, improving the efficiency of aerodrome operations, maintenance and servicing. |
| *Human Performance* | Reduced ATC workload. Improved ATC efficiencies. |

## 11. Necessary Procedures (Air & Ground)

Procedures required to support B0 operations are those associated to the provision of the aerodrome control service. Flight crew procedures specific to A-SMGCS are not necessary beyond those associated with basic operation of aircraft transponder systems and settings of aircraft identification. Vehicle drivers will need to be in a position to effectively operate vehicle transponder systems.

ATC will be required to apply procedures specific to A-SMGCS for the purpose of establishing aircraft/vehicle identification. In addition, ATC will be required to apply procedures associated specifically to the use of A-SMGCS as a replacement to visual observation.

## 12. Necessary System Capability

### *12.1 Avionics*

Existing aircraft ADS-B and/or SSR transponder systems, including correct setting of aircraft identification.

### *12.2 Vehicles*

Vehicle cooperative transponder systems, type as a function of the local A-SMGCS installation. Industry solutions readily available.

### *12.3 Ground systems*

Surface movement radar and cooperative surveillance infrastructure deployed on the aerodrome surface. Installation of A-SMGCS tower display and alerting systems.

## 13. Human Performance

Workload analyses will be necessary to ensure ATC can cope with increased aerodrome capacities in reduced visual conditions using A-SMGCS. ATC response to A-SMGCS generated runway incursion alarms and warnings will require human factors' assessments to ensure that ATC performance in this regard does in fact improve and not diminish. Human factors assessments will also be necessary for the assessment of the compatibility of A-SMGCS tower display installations with other tower surveillance display systems.

## 14. Regulatory/standardization needs and Approval Plan (Air & Ground)

Standards approved for aerodrome multilateration, ADS-B and safety logic systems exist for use in Europe, the USA and other Member States. Standards for SMR exist for use globally.

# 15. Implementation and Demonstration Activities

### *15.1 Current Use*

A-SMGCS responding to B0 functionality is already broadly deployed at a multitude of aerodromes globally. Several of those installations also include runway incursion alerting functionality, of varying degrees of sophistication and reliability.

### *15.2 Planned or on-going trials*

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

# 16. Reference Documents

### *8.1 Standards*

- Community Specification on A-SMGCS Levels 1 and 2
- ICAO Doc 9924 Aeronautical Surveillance Manual
- ICAO Doc 9871 Technical Provisions for Mode S Services and Extended Squitter9
- ICAO Doc 9830 Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual
- ICAO Doc 7030/5 EUR/NAT Regional Supplementary Procedures, Section 6.5.6 and 6.5.7
- FAA Advisory Circulars:
- AC120-86 Aircraft Surveillance Systems and Applications
- AC120-28D Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout
- AC120-57A Surface Movement Guidance and Control System
- Avionics standards developed by RTCA SC-186/Eurocae WG-51 for ADS-B
- Aerodrome map standards developed by RTCA SC-217/Eurocae WG-44

### *8.2 ATC Procedures*

ICAO PANS-ATM and ICAO Doc. 7030, Regional Supplementary Procedures (EUR SUPPS).

### *8.3 Guidance material*

- FAA NextGen Implementation Plan
- European ATM Master Plan

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

| | | |
|---|---|---|
| **Summary** | The object is to achieve Airport operational improvements through the way operational partners at airports work together. A key element will be to improve surface traffic management to reduce delays on movement & manoeuvring areas and enhance safety, efficiency and situational awareness by implementing collaborative applications sharing surface operations data among the different stakeholders on the airport. | |
| **Main Performance Impact** | KPA-02 capacity; KPA-04 – Efficiency; KPA-05 – Environment; | |
| **Operating Environment/Phases of Flight** | Aerodrome, Terminal | |
| **Applicability Considerations** | Local for equipped/capable fleets and already established airport surface infrastructure. | |
| **Global Concept Component(s)** | AO – Airport Operations<br>IM – Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-8 Collaborative airspace design and management<br>GPI-18 Aeronautical information<br>GPI-22 Communication infrastructure | |
| **Pre-Requisites** | NIL | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | Est. 2013 |
| | Avionics Availability | √ |
| | Ground System Availability | Est. 2013 |
| | Procedures Available | Est. 2013 |
| | Operations Approvals | Est. 2013 |

## 1. Narrative

### *1.1 General*

#### 1.1.1 Baseline

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

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

#### 1.1.2 Change brought by the module

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

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

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

| | |
|---|---|
| *Access and Equity* | |
| *Capacity* | Enhanced use of existing infrastructure of gate and stands (unlock latent capacity)<br>Reduced workload, better organisation of the activities to manage flights<br>Metric: airport throughput increases |
| *Efficiency* | Increased efficiency of the ATM system for all stakeholders. In particular for aircraft operators: improved situational awareness (aircraft status both home and away), enhanced fleet predictability & punctuality, improved operational efficiency (fleet management) & reduced delay |
| *Environment* | • Reduced taxi time<br>• Reduced Fuel and Carbon Emissions<br>• Lower aircraft engine run time |

| | |
|---|---|
| *CBA* | 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)<br>A detailed business case has been produced in support of the EU Regulation which was solidly positive. |

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

*No airborne equipment is required.*

### *4.2 Ground Systems*

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

### *4.3 Human Factors Considerations*

TBD

### *4.4 Training and Qualification Requirements*

TBD

### *4.5 Others*

TBD

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

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

# 6. Implementation and Demonstration Activities

## 6.1 *Current Use*

**Europe**

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

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

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

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

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

All information can be found at:

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

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

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

**United States**

TBD.

## *6.2 Planned or Ongoing Activities*

**United States**

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

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

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

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

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

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

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

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

# 7. Reference Documents

## *7.1 Standards*

ICAO CDM Manual (being finalised)
EUROCAE ED-141 Minimum Technical Specifications for Airport Collaborative Decision Making (Airport-CDM) Systems
EUROCAE ED-145 Airport-CDM Interface Specification
EC: ETSI DRAFT Community Specification – version – TBD

## *7.2 Procedures*

TBD

## *7.3 Guidance Material*

EUROCONTROL A-CDM Programme documentation, including an A-CDM Implementation Manual
FAA NextGen Implementation Plan 2011

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

| | | |
|---|---|---|
| **Summary** | Time-based metering to sequence departing and arriving flights. | |
| **Main Performance Impact** | KPA-02 Capacity; **KPA-04 Efficiency**; KPA-09 Predictability<br>KPA-06 Flexibility | |
| **Applicability Considerations** | Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.<br>The improvement is Least Complex – Runway Sequencing procedures are widely used in aerodromes globally. However, some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this block. | |
| **Global Concept Element(s)** | TS – Traffic Synchronization | |
| **Global Plan Initiative** | **GPI-6** Air Traffic Flow Management | |
| **Main Dependencies** | | |
| **Global Readiness Checklist** | | **Status** (ready or date) |
| | Standards Readiness | √ |
| | Avionics Availability | √ |
| | Ground System Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

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

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

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

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

[1] SESAR Definition Phase Deliverable 2 – Air Transport Framework: The Performance Target, page 65

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

## *1.2 Element 1: Time Based Metering*

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

## *1.3 Element 2: Departure Management*

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

# 2. Intended Performance Operational Improvement/Metric to Determine Success

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

| | |
|---|---|
| *Capacity* | Time based metering will optimize usage of terminal airspace and runway capacity.Optimize utilization of terminal and runway resources. |
| *Efficiency* | *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.*<br><br>Efficiency is positively impacted as reflected by increased runway throughput and arrival rates.<br><br>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. |
| *Predictability* | Decrease uncertainties in aerodrome/terminal demand prediction |
| *Flexibility* | Enables dynamic scheduling. |

| | |
|---|---|
| *CBA* | 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.[2]<br><br>Results from field trials of Departure Flow Management, a departure scheduling tool in the US, have been positive. Compliance rate, a metric use to gauge the conformance to assigned departure time, has increased at field trial sites from 68% to 75%. Likewise, the EuroControl's DMAN has demonstrated positive results. Departure scheduling will streamline flow of aircraft feeding the adjacent center airspace based on that center's constraints. This capability will facilitate more accurate ETAs. This allows for the continuation of metering during heavy traffic, enhanced efficiency in the NAS and fuel efficiencies. This capability is also crucial for extended metering. |

## 3. Necessary Procedures (Air & Ground)

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

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

## 4. Necessary System Capability

### *4.1 Avionics*

Initial operations based on existing aircraft FMS capabilities.

### *4.2 Ground Systems*

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

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

## 5. Human Performance

### *5.1 Human Factors Considerations*

ATM personnel responsibilities will not be affected

### *5.2 Training and Qualification Requirements*

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

[2] Exhibit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

### *5.3 Others*

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

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

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

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

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

### *7.2 Planned or Ongoing Trials*

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

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

## 8. Reference Documents

### *8.1 Standards*

### *8.2 Procedures*

### *8.3 Guidance Materials*

European ATM Master Plan,

SESAR Definition Phase Deliverable 2 – The Performance Target,

SESAR Definition Phase Deliverable 3 – The ATM Target Concept,

SESEAR Definition Phase 5 – SESAR Master Plan

TBFM Business Case Analysis Report

NextGen Midterm Concept of Operations v.2.0

RTCA Trajectory Concept of Use

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

| | | |
|---|---|---|
| **Summary** | This module supports the coordination between Air Traffic Service Units (ATSU) based using ATS Interfacility Data Communication (AIDC) defined by ICAO Doc 9694 .<br>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 | |
| **Main Performance Impact** | KPA-02 Capacity, KPA-04 Efficiency**, KPA-07 Global Interoperability**, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All flight phases and all type of ATS units | |
| **Applicability Considerations** | Applicable to at least 2 ACCs dealing with en-route and/or TMA airspace. A greater number of consecutive participating ACCs will increase the benefits. | |
| **Global Concept Component(s)** | CM - Conflict management<br>IM - Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-16 Decision Support Systems | |
| **Pre-Requisites** | Link with B0-40 | |
| **Global Readiness Checklist** | | **Status (ready now or estimated date)** |
| | Standards Readiness | √ |
| | Avionics Availability | No requirement |
| | Ground systems Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

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

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

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

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

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

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

These improvements translate directly into a combination of performance improvements.

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

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

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

### 1.1.1 Baseline

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

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

### 1.1.2 Change brought by the module

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

### 1.1.3 Other remarks

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

### *1.2 Element:*

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

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

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

| | |
|---|---|
| *Capacity* | Reduced controller workload and increased data integrity supporting reduced separations translating directly to cross sector or boundary capacity flow increases. |
| *Efficiency* | The reduced separation can also be used to offer more frequently to aircraft flight levels closer to the flight optimum; in certain cases, this also translates in reduced en-route holding. |
| *Global Interoperability* | Seamlessness: the use of standardised interfaces reduces the cost of development, allows controller to apply the same procedures at the boundaries of all participating centres and border crossing becomes more transparent to flights. |
| *Safety* | Better knowledge of more accurate flight plan information |

| | |
|---|---|
| *CBA* | Increase of throughput at ATC unit boundary, reduced ATCo Workload will exceed FDPS software changes cost. The business case is dependent on the environnement |

# 3. Necessary Procedures (Air & Ground)

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

# 4. Necessary System Capability

## *4.1 Avionics*

No specific airborne requirements

## *4.2 Ground Systems*

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

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

## *5.2 Training and Qualification Requirements*

Training for making the most of the automation support

## *5.3 Others*

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

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

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

Implementations exist in many regions.

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

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

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

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

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

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

### *7.2 Planned or Ongoing Activities*

In operation

## 8. Reference Documents

### *8.1 Standards*

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

### *8.2 Procedures*

TBD

### *8.3 Guidance Material*

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

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

| | | |
|---|---|---|
| **Summary** | Initial introduction of digital processing and management of information, by the implementation of AIS/AIM making use of AIXM, moving to electronic AIP and better quality and availability of data | |
| **Main Performance Impact** | **KPA-03 Cost-Effectiveness**, KPA-05 Environment, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All phases of flight | |
| **Applicability Considerations** | Applicable at State level, with increased benefits as more States participate | |
| **Global Concept Component(s)** | IM – Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-18 Electronic information services | |
| **Pre-Requisites** | | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | ✓ |
| | Avionics Availability | ✓ |
| | Ground Systems Availability | ✓ |
| | Procedures Available | ✓ |
| | Operations Approvals | ✓ |

## 1. Narrative

### *1.1 General*

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

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

That ICAO:

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

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

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

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

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

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

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

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

### 1.1.1 Baseline

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

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

### 1.1.2 Change brought by the module

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

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

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

| | |
|---|---|
| *Cost Effectiveness* | Reduced costs in terms of data inputs and checks, paper and post, especially when considering the overall data chain, from originators, through AIS, to the end users. |
| *Environment* | Reduced use of paper; also, more dynamic information should allow shorter flight trajectories, based on more accurate information about the current status of the airspace structure. |
| *Global Interoperability* | Essential contribution to interoperability |
| *Safety* | Reduction in the number of possible inconsistencies, as the module will allow to reduce the number of manual entries and ensure consistency among data through automatic data checking based on commonly agreed business rules. |

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

# 3. Necessary Procedures (Air & Ground)

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

# 4. Necessary System Capability

## *4.1 Avionics*

No avionics requirements.

## *4.2 Ground Systems*

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

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

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

Nil

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

No additional need.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

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

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

## *7.2 Planned or Ongoing Activities*

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

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

- Doc 8126 *Aeronautical Information Services Manual,* incl. AIXM and eAIP as per Edition 3
- Doc 8697 *Aeronautical Chart Manual*
- Manuals on AIM quality system and AIM training

# Module N° B0-10: Improved Operations through Enhanced En-Route Trajectories

<table>
<tr><td>Summary</td><td colspan="2">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.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-01 Access & Equity; KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment; KPA-06 Flexibility; KPA-09 Predictability</td></tr>
<tr><td>Operating Environment/Phases of Flight</td><td colspan="2">En-route, TMA</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">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.<br><br>Application will naturally span over a long period as traffic develops. Its features can be introduced starting with the simplest ones.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">AOM – Airspace Organisation & Management<br><br>AUO – Airspace Users Operations<br><br>DCB – Demand-Capacity Balancing</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-1 Flexible use of airspace<br><br>GPI-4 Align upper airspace classifications<br><br>GPI-7 Dynamic and Flexible Airspace Route Management<br><br>GPI-8 Collaborative airspace design and management</td></tr>
<tr><td>Pre-Requisites</td><td colspan="2"></td></tr>
<tr><td rowspan="6">Global Readiness Checklist</td><td></td><td>Status (ready now or estimated date)</td></tr>
<tr><td>Standards Readiness</td><td>✓</td></tr>
<tr><td>Avionics Availability</td><td>✓</td></tr>
<tr><td>Ground Systems Availability</td><td>✓</td></tr>
<tr><td>Procedures Available</td><td>✓</td></tr>
<tr><td>Operations Approvals</td><td>✓</td></tr>
</table>

## 1. Narrative

### *1.1 General*

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

The navigational capabilities of modern aircraft make a compelling argument to migrate away from the fixed route structure towards a more flexible alternative. Constantly changing upper winds have a direct influence on fuel burn and, proportionately, on the carbon footprint. Therein lies the benefit of daily flexible routings. Sophisticated flight planning systems in use at airlines now have the capability to predict and validate optimum daily routings. Likewise, ground systems used by ATC have significantly improved their communication, surveillance and flight data management capabilities.

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

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

The module is made of the following elements:

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

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

## *1.2 Element 1: Airspace Planning*

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

## *1.3 Element 2: FUA*

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

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

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

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

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

FUA should be governed by the following principles:

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

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

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

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

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

### *1.4 Element 3: Flexible Routing*

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

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

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

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

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

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

| | |
|---|---|
| *Access and Equity* | Better access to airspace by a reduction of the permanently segregated volumes. |
| *Capacity* | 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. |
| *Efficiency* | 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. |

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

| | |
|---|---|
| *CBA* | The ground costs are significantly lower than the benefits to airspace users. |

### *2.1 Element 1: Airspace Planning*

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

### *2.2 Element 2: FUA*

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

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

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

- 4.9 million litres of fuel
- 581 flight hours.

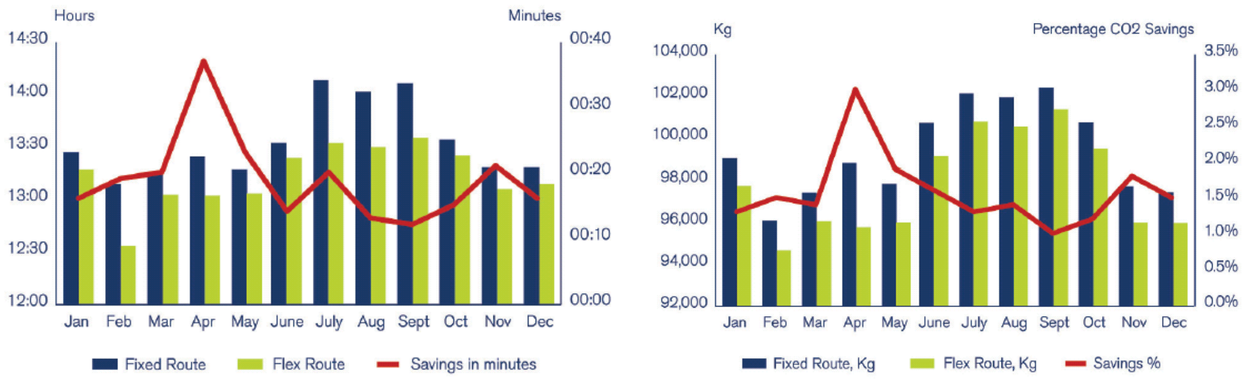
In the U.S. a study for NASA by Datta and Barington showed maximum savings of dynamic use of SUA of $7.8M (1995 $).

### *2.3 Element 3: Flexible Routing*

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

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

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




**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)**

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).

## 3. Necessary Procedures (Air & Ground)

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.

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.

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.

### *3.1 Element 1: Airspace Planning*

See general remarks above.

### *3.2 Element 2: FUA*

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.

### *3.3 Element 3: Flexible Routing*

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:

- 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;

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

## 4. Necessary System Capability

### *4.1 Avionics*

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

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

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

### *4.2 Ground Systems*

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

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

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

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

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

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

The roles and responsibilities of controller/pilot are not affected

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

Nil

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

ICAO material is available.

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

## *6.1 Element 1: Airspace Planning*

See general remarks above.

## *6.2 Element 2: FUA*

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

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

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

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

## *6.3 Element 3: Flexible Routing*

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

## *6.4 Common Enabler: PBN Procedures*

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

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

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

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

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

### 7.1.1 Element 1: Airspace Planning

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

  LARA

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

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

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

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

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

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

### 7.1.2 Element 2: FUA

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

CDM is implemented in the US NASCSC.

### 7.1.3 Element 3: Flexible Routing

- **North-Atlantic**: Implemented with two daily sets of Organised Track Systems
- **Japan**: Coordination of Airspace Use: In the coordination of rerouting for avoidance of airspace capacity saturation or adverse weather conditions, ATMC and Airline Operators share and use “Rerouting List” of

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

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

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

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

- **Oceanic areas**:

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

### *7.2 Planned or Ongoing Activities*

- ASPIRE

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

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

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

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

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

- DARP: Dynamic Airborne Reroute Procedure (DARP)

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

# 8. Reference Documents

## *8.1 Standards*

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

## *8.2 Procedures*

Nil

## *8.3 Guidance Material*

- Doc 9426, Air Traffic Services Planning Manual
- Doc 9689, Manual on Airspace Planning Methodology for the Determination of Separation Minima
- Doc 9613, Performance-based Navigation (PBN) Manual
- Doc 9554, Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to Civil Aircraft Operations
- Doc 9750, Global Air Navigation Plan
- Doc 9854, Global Air Traffic Management Operational Concept
- ICAO Global Collaborative Decision Making (CDM) Guidelines (under development)
- ICAO Circular 330 AN/189 Civil/Military Cooperation in Air Traffic Management

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

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

## 1. Narrative

### *1.1 General*

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

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

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

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

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

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

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

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

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

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

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

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

| | |
|---|---|
| *Access and Equity* | Improved access by avoiding disruption of air traffic in periods of demand higher than capacity;<br>ATFM processes take care of equitable distribution of delays. |
| *Capacity* | 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. |
| *Efficiency* | Reduced fuel burn due to better anticipation of flow issues; a positive effect to reduce the impact of inefficiencies in the ATM system or to dimension it at a size that would not always justify its costs (balance between cost of delays and cost of unused capacity);<br>Reduced block times and times with engines on. |
| *Environment* | 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. |
| *Participation by the ATM community* | Common understanding of operational constraints, capabilities and needs. |
| *Predictability* | Increased predictability of schedules as the ATFM algorithms tends to limit the number of large delays. |
| *Safety* | Reduced occurrences of undesired sector overloads. |

| | |
|---|---|
| *CBA* | The business case has proven to be positive due to the benefits that flights can obtain in terms of delay reduction. |

## 3. Necessary Procedures (Air & Ground)

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

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

## 4. Necessary System Capability

### *4.1 Avionics*

No avionics requirements.

### *4.2 Ground Systems*

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

Some vendors propose light ATFM systems.

## 5. Human Performance

### *5.1 Human Factors Considerations*

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

### 5.2 Training and Qualification Requirements

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

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

Training material is available.

### 5.3 Others

Nil

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

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

## 7. Implementation and Demonstration Activities

### 7.1 Current Use

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

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

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

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

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

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

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

- **US**: Detailed Example – National Playbook (USA)

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

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

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

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

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

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

### *7.2 Planned or Ongoing Activities*

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

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

- Enhanced ASM/ATFCM coordination Process
- Short Term ATFCM Measures
- Interactive Network Capacity Planning
- SWIM enabled NOP
- Management of Critical Events
- Collaborative Management of Flight updates
- ATFM Slot Swapping
- Manual User Driven Prioritisation Process

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

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

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

| | | |
|---|---|---|
| **Summary** | 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:<br>• *AIRB (Enhanced Traffic Situational Awareness during Flight Operations)*<br>• *VSA (Enhanced Visual Separation on Approach).* | |
| **Main Performance Impact** | KPA-04 – Efficiency; KPA-09 – Safety | |
| **Operating Environment/Phases of Flight** | En-route, Terminal and Approach. | |
| **Applicability Considerations** | 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.<br>Avionics availability at low enough costs for GA is not yet available. | |
| **Global Concept Component(s)** | CM – Conflict Management; TS – Traffic Synchronisation | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational Awareness; GPI-15 Match IMC and VMC operating capacity. | |
| **Pre-Requisites** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

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

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

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

#### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

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

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

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

### 1.1.3 Other remarks

## *1.2 Element 1: ATSA-AIRB*

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

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

## *1.3 Element 2: ATSA-VSA*

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

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

| | |
|---|---|
| *Efficiency* | |
| *Safety* | |

| | |
|---|---|
| *CBA* | The benefit is largely driven by higher flight efficiency and consequent savings in contingency fuel.<br>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<br>- saving 36 million Euro (50k Euro per aircraft) annually and<br>- reducing carbon dioxide emissions by 160,000 tonnes annually.<br>The majority of these benefits are attributed to AIRB. Findings will be refined after the completion of the pioneer operations starting in December 2011. |

## 3. Necessary Procedures (Air & Ground)

## 4. Necessary System Capability

### *4.1 Avionics*

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

### *4.2 Ground Systems*

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

## 5. Human Performance

### *5.1 Human Factors Considerations*

TBD

### *5.2 Training and Qualification Requirements*

TBD

### *5.3 Others*

TBD

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

## *7.2 6.2 Planned or Ongoing Activities*

EUROPE – Pioneer projects to be progressed.

# 8. Reference Documents

## *8.1 Standards*

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

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

## *8.2 Procedures*

## *8.3 Guidance Material*

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

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

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity, KPA -04 Efficiency and KPA-05 Environment. | |
| **Operating Environment/Phases of Flight** | En-Route | |
| **Applicability Considerations** | Oceanic and potentially continental en-route | |
| **Global Concept Component(s)** | CM, AUO, AOM | |
| **Global Plan Initiatives (GPI)** | GPI-9, GPI-7 | |
| **Pre-Requisites** | NIL | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | √ |
| | Avionics Availability | √ |
| | Infrastructure Availability | √ |
| | Ground Automation Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

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

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

#### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

### 1.1.3 Other remarks

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

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

| | |
|---|---|
| *Capacity* | improvement in capacity on a given air route |
| *Efficiency* | increased efficiency on oceanic and potentially continental en-route. |
| *Environment* | reduced emissions |

| | |
|---|---|
| *CBA* | |

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

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

### *4.2 Ground Systems*

NIL

## 5. Human Performance

### *5.1 Human Factors Considerations*

TBD

### *5.2 Training and Qualification Requirements*

TBD

### *5.3 Others*

TBD

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

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

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

# 7. Implementation and Demonstration Activities

## 7.1 *Current Use*

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

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

## *7.2 Planned or Ongoing Activities*

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

# 8. Reference Documents

## *8.1 Standards*

- EUROCONTROL ATSAW Deployment Plan(Draft)
- RTCA DO-312: “Safety, Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application”.
- EUROCAE ED-159: “Safety, Performance and Interoperability Requirements Document for ATSA-ITP Application”

## *8.2 Procedures*

## *8.3 Guidance Material*

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# Module N° B0-101: ACAS Improvements

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-04 Efficiency, **KPA-10 Safety** | |
| **Domain / Flight Phases** | En-route flight phases and approach flight phases. | |
| **Applicability Considerations** | Safety and operational benefits increase with the proportion of equipped aircraft. | |
| **Global Concept Component(s)** | CM – Conflict Management. | |
| **Global Plan Initiatives (GPI)** | GPI-2 reduced vertical separation minima<br>GPI-9 situational awareness<br>GPI-16 Decision support systems and alerting systems | |
| **Pre-Requisites** | No | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | √ |
| | Avionics Availability | √ |
| | Ground Systems Availability | N/A |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

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

#### 1.1.1 Baseline

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

#### 1.1.2 Change brought by the module

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

### *1.2 Element: Improved ACAS operations*

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

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. ACAS II SARPS are aligned with RTCA/EUROCAE MOPS. The SARPS and the MOPS have been upgraded in 2009/2010 to resolve safety issues and to improve operational performance. The RTCA DO185B and EUROCAE ED143 include these improvements also known as TCAS V7.1.

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

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

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

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

In addition, two optional features can enhance ACAS performance:

1) Coupling TCAS and Auto-Pilot/Flight Director to ensure accurate responses to RAs either automatically or manually thanks to flight director (APFD function)

2) Introducing a new altitude capture law to improve TCAS compatibility with ATM (TCAP function)

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

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

| | |
|---|---|
| *Efficiency* | ACAS improvement will reduce unnecessary RA and then reduce trajectory perturbation |
| *Safety* | ACAS increase safety, as collision avoidance system and case of failure of the separation provision. |

| | |
|---|---|
| *CBA* | TBD |

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

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

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

### *4.2 Ground Systems*

Not Applicable

## 5. Human Performance

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

### *5.1 Human Factors Considerations*

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

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

### *5.2 Training and Qualification Requirements*

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

### 5.3 Others

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

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

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

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

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

## 7. Implementation and Demonstration Activities

### 7.1 Current Use

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

### 7.2 Planned or Ongoing Trials

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

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

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

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

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

## 8. Reference Documents

### 8.1 Standards

- Annex 10 Volume IV (Including Amendment 85- July 2010)
- RTCA DO185B, EUROCAE ED143 – April 2009
- *RTCA DO325 Annex C estimated for Q1 2013*
- *Annex 6 part I –carriage requirements*

### 8.2 Procedures

- PANS-ATM doc 4444 and PANS-OPS Volume I (Doc 8168)

### 8.3 Guidance Material

- ACAS Manual (Doc 9863)

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

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-03 – Cost-effectiveness; **KPA-04 – Efficiency**; KPA-09 - Predictability | |
| **Operating Environment/Phases of Flight** | Approach/Arrivals and En-Route. | |
| **Applicability Considerations** | Regions, States or individual locations most in need of these improvements. For simplicity and implementation success, complexity can be divided into three tiers:<br>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.<br>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.<br>3. Most Complex – Regional/States/Locations in this tier will be the most challenging and complex to introduce integrated and optimized PBN operations. Traffic volume and airspace constraints are added complexities that must be confronted. Operational changes to these areas can have a profound effect on the entire State, Region or location. | |
| **Global Concept Component(s)** | AOM – Airspace Organisation and Management<br>AO – Aerodrome Operations<br>TS – Traffic Synchronisation, AOM | |
| **Global Plan Initiatives (GPI)** | GPI-10- Terminal Area Design and Management;<br>GPI-11- RNP and RNAV Standard instrument Departures (SIDS)and Standard Terminal Arrivals (STARS); | |
| **Pre-Requisites** | NIL | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | √ |
| | Avionics Availability | √ |
| | Ground System Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

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

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

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

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

### 1.1.1 Baseline

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

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

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

### 1.1.2 Change brought by the module

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

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

## *1.2 Element 1: Continuous Descent Operations*

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

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

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

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

## *1.3 Element 2: Performance Based Navigation*

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

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

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

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

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

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

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

| | |
|---|---|
| CBA | The following savings are an example of potential savings as a result of CDO implementation. *It is important to consider that CDO benefits are heavily dependent on each specific ATM environment.*<br><br>Nevertheless, if implemented within the ICAO CDO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive.<br><br>Example of savings after CDO implementation in Los Angeles TMA (KLAX)<br>• CDOs RIIVR2/SEAVU2/OLDEE1 & 4 ILS'<br>o Implemented September 25, 2008, and in use full time at KLAX.<br>• About 300-400 aircraft per day fly RIIVR2/SEAVU2/OLDEE1 STARs representing approximately half of all jet arrivals into KLAX<br>o 50% reduction in radio transmissions.<br>• Significant fuel savings – average 125 pounds per flight.<br>o 300 flights/day * 125 pounds per flight * 365 days = 13.7 million pounds/year<br>o More than 2 million gallons/year saved = more than 41 million pounds of CO2 avoided.<br><br>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.<br><br>The safety benefits to PBN are significant, as even airports located in the poorest areas of the world can have runway aligned approaches with horizontal and vertical guidance to any runway end without having to install, calibrate and monitor expensive ground based navigation aids. Therefore, with PBN all airports can have a stabilized instrument approach that will allow aircraft to land into the wind, as opposed to a tail wind landing. |

## 3. Necessary Procedures (Air & Ground)

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

It therefore provides background and implementation guidance for:

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

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

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

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

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

# 4. Necessary System Capability

## *4.1 Avionics*

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

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

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

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

## *4.2 Ground Systems*

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

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

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

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

### *5.2 Training and Qualification Requirements*

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

### *5.3 Others*

TBD

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

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

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

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

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

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

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

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

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

TBD

### *7.2 Planned or Ongoing Activities*

TBD

## 8. Reference Documents

### *8.1 Standards*

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

### *8.2 Procedures*

### *8.3 Guidance Material*

- The ICAO Continuous Descent Operations (CDO) Manual (ICAO Document 9931)

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

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

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

## 1. Narrative

### *1.1 General*

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

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

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

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

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

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

### *1.3 Element 2: Continental CPDLC*

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

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

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

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

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

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

| | |
|---|---|
| *CBA* | The business case has proven to be positive due to the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts).<br><br>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. |

### *2.2 Element 2: Continental CPDLC*

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

| | |
|---|---|
| *Capacity* | Reduced communication workload and better organisation of controller tasks allow to increase sector capacity |
| *Safety* | Increased situational awareness; reduced occurrences of misunderstandings; solution to stuck mike situations |

| | |
|---|---|
| *CBA* | The European business case has proven to be positive due to<br>• the benefits that flights can obtain in terms of better flight efficiency (better routes and vertical profiles; better and tactical resolution of conflicts).<br>• Reduced controller workload and increased capacity.<br><br>A detailed business case has been produced in support of the EU Regulation which was solidly positive.<br><br>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. |

## 3. Necessary Procedures (Air & Ground)

Procedures have been described and are available in ICAO documents.

## 4. Necessary System Capability

### *4.1 Avionics*

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

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

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

### *4.2 Ground Systems*

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

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

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

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

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

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

Nil

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

Specifications are already available in RTCA and EUROCAE documents.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

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

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

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

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

Note: The decision of implementation is accompanied by an economic appraisal, business case and other guidance material available at the following address: http://www.eurocontrol.int/link2000/public/site_preferences/display_library_list_public.html#6 .

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

### *7.2 Planned or Ongoing Trials*

- **Africa, ACAC:** tbc.

## 8. Reference Documents

### *8.1 Standards*

- EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280
- EC Regulation No. 29/2009: the Datalink Services Implementing Rule

### *8.2 Procedures*

Nil

### *8.3 Guidance Material*

- Manual of Air Traffic Services Data Link Applications (Doc 9694)
- New OPLINK Ops Guidance under development

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

| | | |
|---|---|---|
| ***Summary*** | Flight operations in many terminal areas precipitate the majority of current airspace delays in many states. Opportunities to optimize throughput, improve flexibility, enable fuel-efficient climb profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term. | |
| ***Main Performance Impact*** | **KPA-04 – Efficiency;** KPA-05 – Environment; KPA-10 - Safety | |
| ***Operating Environment/Phases of Flight*** | Departure and En-Route | |
| ***Applicability Considerations*** | Regions, States or individual Locations most in need of these improvements. For simplicity and implementation success, complexity can be divided into three tiers:<br>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.<br>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.<br>3. Most Complex – Regional/States/Locations in this tier will be the most challenging and complex to introduce integrated and optimized PBN operations. Traffic volume and airspace constraints are added complexities that must be confronted. Operational changes to these areas can have a profound effect on the entire State, Region or location. | |
| ***Global Concept Component(s)*** | AUO – Airspace user operations<br>TS – Traffic synchronization<br>AOM – Airspace organization and management | |
| ***Global Plan Initiatives (GPI)*** | GPI 5- RNAV/RNP (Performance. Based Navigation)<br>GPI-10- Terminal Area Design and Management<br>GPI-11- RNP and RNAV SIDs and STARs | |
| ***Pre-Requisites*** | *NIL* | |
| | | ***Status** (ready now or estimated date).* |
| ***Global Readiness Checklist*** | *Standards Readiness* | √ |
| | *Avionics Availability* | √ |
| | *Infrastructure Availability* | √ |
| | *Ground Automation Availability* | √ |
| | *Procedures Available* | √ |
| | *Operations Approvals* | √ |

## 1. Narrative

### *1.1 General*

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

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

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

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

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

### 1.1.1 Baseline

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

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

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

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

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

### 1.1.2 Change brought by the module

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

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

### 1.1.3 Other remarks

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

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

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

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

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

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

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

| | |
|---|---|
| *Efficiency* | Cost savings through reduced fuel burn and efficient aircraft operating profiles.<br>Reduction in the number of required radio transmissions. |
| *Environment* | Authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted.<br>Environmental benefits through reduced emissions. |
| *Safety* | More consistent flight paths.<br>Reduction in the number of required radio transmissions.<br>Lower pilot and Air Traffic Control workload. |
| *CBA* | It is important to consider that CCO benefits are heavily dependent on each specific ATM environment.<br>Nevertheless, if implemented within the ICAO CCO manual framework, it is envisaged that the benefit/cost ratio (BCR) will be positive. |

## 3. Necessary Procedures (Air & Ground)

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

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

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

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

It therefore provides background and implementation guidance for:

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

## 4. Necessary System Capability

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

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

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

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

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

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

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

## 6. Implementation and Demonstration Activities

TBD

### *6.1 Current Use*

### *6.2 Planned or Ongoing Activities*

## 7. Reference Documents

### *7.1 Standards*

### *7.2 Procedures*

ICAO Doc 4444, *PANS-ATM*

### *7.3 Guidance Material*

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

ICAO Doc 9613, *Performance-based Navigation (PBN) Manual*

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# BLOCK 1

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# Module N° B1-65: Optimised Airport Accessibility

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|---|---|---|
| **Summary** | This is the further transition in the universal implementation of GNSS-based approaches.<br>PBN and GLS (CAT II/III) procedures enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency. Key aspects included:<br>• Increased availability and reliability through Mutli-Frequency/Constellation use of GNSS<br>• GNSS-based CAT II/III approach capability<br>Curved/segmented approaches with RNP to XLS transition | |
| **Main Performance Impact** | **KPA-04 Efficiency**, KPA-05 Environment, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | Approach and landing | |
| **Applicability Considerations** | This module is applicable to all runway ends. | |
| **Global Concept Component(s)** | AUO – Airspace User Operations<br>AO – Aerodrome Operations | |
| **Global Plan Initiatives (GPI)** | GPI-5 RNAV and RNP (PBN)<br>GPI-14 Runway Operations<br>GPI-20 WGS84 | |
| **Pre-Requisites** | B0-65 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | Est. 2014 |
| | Avionics Availability | Est. 2018 |
| | Ground System Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | Est. 2018 |

## 1. Narrative

### *1.1 General*

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

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

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

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

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

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

| | |
|---|---|
| *Efficiency* | Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely-spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds. |
| *Environment* | Environmental benefits through reduced fuel burn |
| *Safety* | Stabilized approach paths. |
| *CBA* | Aircraft operators and ANSPs can quantify the benefits of lower minima by modelling airport accessibility with existing and new minima. Operators can then assess benefits against avionics and other costs. The GBAS Cat II/III business case needs to consider the cost of retaining ILS or MLS to allow continued operations during an interference event. The potential for increased runway capacity benefits with GBAS is complicated at airports where a significant proportion of aircraft are not equipped with GBAS avionics. |

## 3. Necessary Procedures (Air & Ground)

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

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

## 4. Necessary System Capability

### *4.1 Avionics*

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

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

### *4.2 Ground Systems*

Cat II/III GBAS Ground Stations.

### *4.3 Human Factors Considerations*

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

### *4.4 Training and Qualification Requirements*

TBD

### *4.5 Others*

TBD

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

See Sections 3 and 4 above.

## 6. Implementation and Demonstration Activities

### *6.1 Current Use*

### *6.2 Planned or Ongoing Activities*

- **United States**

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

- **Canada**

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

- **Australia**

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

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- **France**

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

- **Brazil**

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

## 7. Reference Documents

### *7.1 Standards*

- Annex 10

### *7.2 Procedures*

- PANS-OPS

### *7.3 Guidance Material*

- PBN Manual (ICAO Doc 9613)
- GNSS Manual (ICAO Doc 9849)
- WGS-84 Manual (Doc 9674)
- Manual on Testing of Radio Navigation Aids (Doc 8071), Volume II (Cat-I only)
- Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume 5

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

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| **Summary** | 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. | |
| **Main Performance Impact** | **KPA-02 Capacity,** KPA-04 Efficiency, KPA-05 Environment, KPA-06 Flexibility. | |
| **Domain / Flight Phases** | Aerodrome | |
| **Applicability Considerations** | Least Complex – Implementation of re-categorized wake turbulence is mainly procedural. No changes to automation systems are needed. | |
| **Global Concept Component(s)** | CM - Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-13- Aerodrome Design; GPI 14 – Runway Operations | |
| **Main Dependencies** | | |
| **Global Readiness Checklist** | | **Status** (ready or date) |
| | Standards Readiness | Est. 2018 |
| | Avionics Availability | N/A |
| | Ground System Availability | Est. 2018 |
| | Procedures Available | Est. 2018 |
| | Operations Approvals | Est. 2018 |

## 1. Narrative

### *1.1 General*

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

#### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

### 1.1.3 Other Remarks

The work accomplished in Block 1 builds on the upgrades of Block 0 and will be the basis for further enhancement in wake mitigation procedures and standards that will occur in Block 2 developments. The Wake Turbulence Separation - Refined Module is a progression of steps to have available to global aviation, means to acquire more capacity from existing airport runway structure and to place new airport runways for minimizing wake turbulence landing and departure restrictions. The effort in Block 1 will not provide the major capacity increases needed to meet the overall demand envisioned for the 2025 time frame. However it does provide incremental capacity increases using today's runways and minor modifications to air traffic control procedures. Block 1 and subsequent Block 2 will address developing wake mitigation procedures and separation standards that will assure the wake safety of innovations (Trajectory Based, High Density, Intended Performance Operational Improvement/Metric to determine success. Flexible Terminal) in air traffic contr9ol while at the same time provide the least wake safety constraints on the air traffic control innovation. The upgrades of block 1 will incorporate the experience obtained with the Block 0 upgrades.

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

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

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

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

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

Block 0 Element 2 upgrade provided a dependent diagonal paired instrument approach wake separation procedure (FAA Order 7110.308) for operational use in 2008 at five airports that had CSPR configurations meeting the runway layout criteria of the developed procedure. Use of the procedure provided an increase of up to 10 more arrival operations per hour on the airport CSPR during airport operations requiring instrument approaches. By the end of 2010 the approval to use the procedure was expanded to two additional airports. An enhanced version of FAA Order 7110.308 will be approved in 2012 for use by up to6 more U.S. airports who use their CSPR for arrival operations.

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

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

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

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

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

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

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

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

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| *CBA* | 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.<br><br>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.<br><br>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. |

# 3. Necessary Procedures (Air & Ground)

**Element 1**

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

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

**Element 2**

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

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

**Element 3**

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

# 4. Necessary System Capability

## *4.1 Avionics*

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

## *4.2 Ground Systems*

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

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

**Element 1**

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

## Element 2 and 3

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

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

# 7. Implementation and Demonstration Activities

## 7.1 *Current Use*

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

## *7.2 Planned or Ongoing Trials*

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

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

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

# 8. Reference Documents

## *8.1 Standards*

## *8.2 Procedures*

## *8.3 Guidance Material*

ICAO Doc 9584 Global ATM Operational Concept,
ICAO Doc 9750 Global Air Navigational Plan

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

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| **Summary** | 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. | |
| **Main Performance Impact** | KPA-10 Safety (reduced runway incursions)<br>KPA-4 Efficiency (shared ground ops situational awareness) | |
| **Domain / Phase of Flight** | Aerodrome operations | |
| **Applicability Considerations** | 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. | |
| **Global Concept Component(s)** | AO - Aerodrome Operations<br>CM - Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational Awareness<br>GPI-13 Aerodrome Design and Management<br>GPI-16 Decision Support Systems and Alerting Systems | |
| **Pre-Requisites** | B0-75 (Surface Surveillance); | |
| **Global Readiness Checklist** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

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

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

#### 1.1.1 Baseline

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

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

### 1.1.2 Change brought by the module

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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| *CBA* | 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.<br>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. |

## 3. Necessary Procedures (Air & Ground)

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

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

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

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

## 4. Necessary System Capability

### *4.1 Avionics*

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

**4.2 Ground Systems**

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

## 5. Human Performance

### *5.1 Human Factors Considerations*

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

### *5.2 Training and Qualification Requirements*

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

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

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

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

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

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

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

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

### *7.2 Planned or Ongoing Trials*

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

## 8. Reference Documents

### *8.1 Standards*

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

### *8.2 Procedures*

Much is contained in other guidance materials.

### *8.3 Guidance material*

- FAA NextGen Implementation Plan
- European ATM Master Plan

Morgan, C.E., "A high-level description of Air Traffic Management Decision Support Tool Capabilities for NextGen Surface Operations", MP100131, July 2010

FAA, March 1996, *Reports by Airline Pilots on Airport Surface Operations: Part 2: Identified Problems and Proposed Solutions for Surface Operational Procedures and Factors Affecting Pilot Performance*.

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

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity; KPA-03 Cost-Effectiveness; **KPA-04 Efficiency;** | |
| **Operating Environment/Flight Phases** | Surface in, turn around, surface out | |
| **Applicability Considerations** | AOP: for use at all the airports (sophistication will depend on the complexity of the operations and their impact on the network).<br>APOC: will be implemented at major/complex airports (sophistication will depend on the complexity of the operations and their impact on the network).<br>Not applicable to aircraft. | |
| **Global Concept Component(s)** | AO – Airport Operations<br>IM – Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-13 Aerodrome design and management | |
| **Pre-Requisites** | B0-80, B0-35 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2018** |
| | Avionics Availability | NA |
| | Ground System Availability | **Est. 2018** |
| | Procedures Available | **Est. 2018** |
| | Operations Approvals | **Est. 2018** |

## 1. Narrative

### *1.1 General*

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

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

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

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

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

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

### 1.1.1 Baseline

The baseline for this module is Airport CDM as described in module N°B0-80 and Air Traffic Flow and Capacity Management as described in module N° B0-35.

### 1.1.2 Change brought by the module

This module provides enhancement to the planning and management of airport operations and allows their full integration in the air traffic management through the implementation of the following:

- A collaborative Airport Operations Plan (AOP) which encompasses ‘local’ airport information as well as content which is ‘shared’ with the ATM system in order to permit airports to be fully integrated into the overall ATM network.
- An Airport Performance framework with specific performance targets fully integrated into the AOP and compliant with the regional / national performance targets.
- A decision making process permitting stakeholders to communicate and co-ordinate, to develop and maintain dynamically joint plans and to execute those in their respective area of responsibility. In support of the decision making process, information will be integrated and collated into a consistent and pertinent view for the different operational units on the airport and elsewhere in ATM. To support the process, a real-time monitoring system, a decision support tool, and a set of collaborative procedures will ensure a fully integrated management of airside airport processes, taking the impact on landside processes into account supported by up-to-date and pertinent meteorological information.

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

| | |
|---|---|
| *Capacity* | **Moderate** – 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.<br><br>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. |
| *Cost-Effectiveness* | **Major** – 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. |
| *Efficiency* | **Major** – 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. |
| *Environment* | **Significant** – 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 |

| | |
|---|---|
| | pollution in the vicinity of the airport. |
| *Predictability* | **Major** –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). |
| *Safety* | **Minor** – 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. |

| | |
|---|---|
| *CBA* | TBD |

## 3. Necessary Procedures (Air & Ground)

Procedures to instantiate and update the AOP, collaboratively manage the airport operations and allow communication between all the airport stakeholders and the ATM System are needed.

## 4. Necessary System Capability

### *4.1 Avionics*

### *4.2 Ground Systems*

The following supporting systems need to be developed and implemented:

- A data repository supporting the AOP and allowing communication with the airport stakeholders and the ATM System
- Airport Performance Monitoring tools
    - With real-time capabilities
- Decision support tools to manage the airport operations

## 5. Human Performance

### *5.1 Human Factors Considerations*

TBD

### *5.2 Training and Qualification Requirements*

TBD

### *5.3 Others*

TBD

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

TBD

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

- **None at this time**

## *7.2 Planned or Ongoing Trials*

- **Europe**: For SESAR validation carried out by 2015.
- **USA**: For NextGen validation carried out by 2015

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

TBD

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

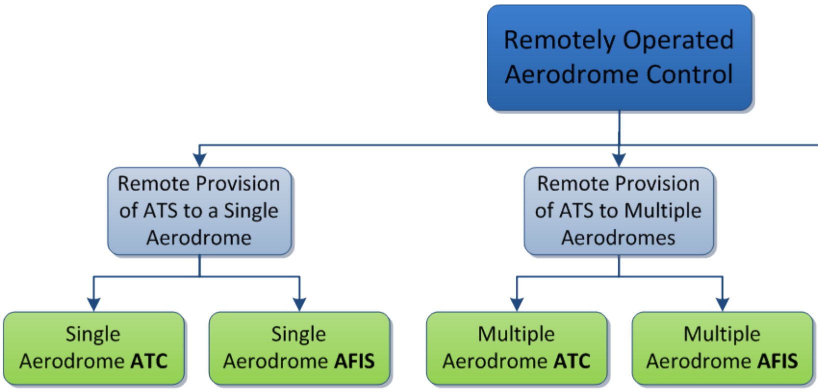
<table>
<tr><td>Summary</td><td colspan="2">The performance objective is to provide a safe and cost effective ATS to aerodromes where dedicated, local ATS is no longer sustainable or cost effective, but there is a local economic and social benefit from aviation<br><br>Remotely Operated Aerodrome Control 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.<br><br>.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-04 Efficiency; KPA-10 Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">TMA, Descent, Airport Surface, Climb Out.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">The main target for the Single and Multiple Remote Tower Services are small rural airports, which today are struggling with low business margins. Both ATC and AFIS aerodromes are expected to benefit.<br><br>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.<br><br>Although some cost benefits are possible with remote provision of ATS to a single aerodrome, maximum benefit is expected with the remote of ATS to multiple aerodromes.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">CM: Conflict Management<br><br>AO: Airport Operations</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-13 Aerodrome design and management<br><br>GPI-15 Match IMC and VMC operating capacity<br><br>GPI-9 Situational awareness</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">None</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>Est. 2018</td></tr>
<tr><td>Avionics Availability</td><td>Est. 2018</td></tr>
<tr><td>Infrastructure Availability</td><td>Est. 2018</td></tr>
<tr><td>Ground Automation Availability</td><td>Est. 2018</td></tr>
<tr><td>Procedures Available</td><td>Est. 2018</td></tr>
<tr><td>Operations Approvals</td><td>Est. 2018</td></tr>
</table>

## 1. Narrative

### *1.1 General*

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

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




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

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

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

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

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

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

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

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

### 1.1.1 Baseline

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

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

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

### 1.1.2 Change brought by the module

The main improvements will be:

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

## *1.2 Element 1: Remote Provision of ATS for Single Aerodromes*

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

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

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

## *1.3 Element 2: Remote Provision of ATS for Multiple Aerodromes*

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

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

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

- Resource Management – balancing of shift size according to the number of aerodromes, traffic demand, and the number of aerodromes a single ATCO/AFISO can provide service to;
- Controller Working Positions – the number and configuration of CWP in the RTC. A single CWP may serve one aerodrome, several aerodromes, or share service provision to the same aerodrome with other CWP (larger aerodromes only);

- Operating Methods – it is expected that the ATCO/AFISO will be able to provide ATS to more aerodromes when there are no current aircraft movements at those aerodromes yet the airspace is Established and provision of ATS is required. As traffic increases, the maximum number of aerodromes per single ATCO/AFISO will decrease;
- Air Traffic Management – The ability to accommodate both IFR and VFR traffic requires management – demand and capacity balance. Slot coordination and traffic synchronisation across multiple aerodromes will help extract maximum benefit from Multiple Tower by reducing the occasions when several aerodromes have simultaneous aircraft movements;
- Aerodrome clustering – the selection of which aerodromes can be operated in parallel by a single ATCO/AFISO;
- Approach Control – whether the approach control is also provided by the multiple aerodrome ATCO/AFISO, whether it is provided by a dedicated APP controller, or a combination of both;
- Each factor contains several options and it is the combination of these options for a given set of aerodromes that determines the make-up of an RTC.

### *1.4 Element 3: Remote Provision of ATS for Contingency Situations*

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

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

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

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

### *1.5 Element 4:*

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

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|---|---|
| *Capacity* | Capacity should not be reduced through the removal of local facilities, or through the sharing of resources across multiple aerodromes. It may even be increased through the use of digital enhancements in low visibility |
| *Efficiency* | Efficiency benefits are provided in three main areas. The first is the cost effectiveness benefits described above, centred around using assets and resources more efficiently thus leading to a more cost effective service. The second is the ability to exploit the use of technology in the provision of the services. Digital enhancements can be used to maintain throughput in low visibility conditions, thus making a more efficient use of available capacity |
| *Cost Effectiveness* | This is the main benefit delivered by the Remote Tower. The benefit is expected through provision of air traffic services from remote facilities. For single aerodromes these facilities will be cheaper to maintain, able to operate for longer periods and enable lower staffing costs (through centralised training and resource pools). For multiple aerodrome additional cost effectiveness benefits can be achieved through the ability to control a greater number of aerodromes with fewer individual facilities and controllers. |

| | |
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| *Flexibility* | The implementation of the concept, especially the Multiple Aerodrome service must not affect the ability to provide a flexible service to the airspace users. It may even be increased through a greater possibility to extend opening hours when through remote operations |
| *Safety* | Safety is the number one concern for air traffic. The provision of air traffic services (facilities and staff) from a remote location should provide the same, or greater if possible, levels of safety as if the services were provided locally. The use of the digital visual technologies used in the RVT may provide some safety enhancements in low visibility. |

| | |
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| *CBA* | Cost Benefit Assessments for previous remote tower research programs have shown a cost benefit to exist in the target environment. Since there are no current operational remote towers these CBA were necessarily based on some assumptions. However, these assumptions were developed by a working group of subject matter experts and considered reasonable working assumptions.<br>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.<br>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.<br>The CBA concluded that remote tower does produce positive financial benefits for ANSP. Further Assessment of Costs and Benefits (ACB) will be conducted during 2012 and 2013 using a range of implementation scenarios (Single, Multiple, Contingency). |

## 3. Necessary Procedures (Air & Ground)

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

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

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

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

# 4. Necessary System Capability

## *4.1 Avionics*

NIL

## *4.2 Ground Systems*

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

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

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

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

Specification are already available in RTCA and EUROCAE documents.

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

TBD

## *5.3 Others*

TBD

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

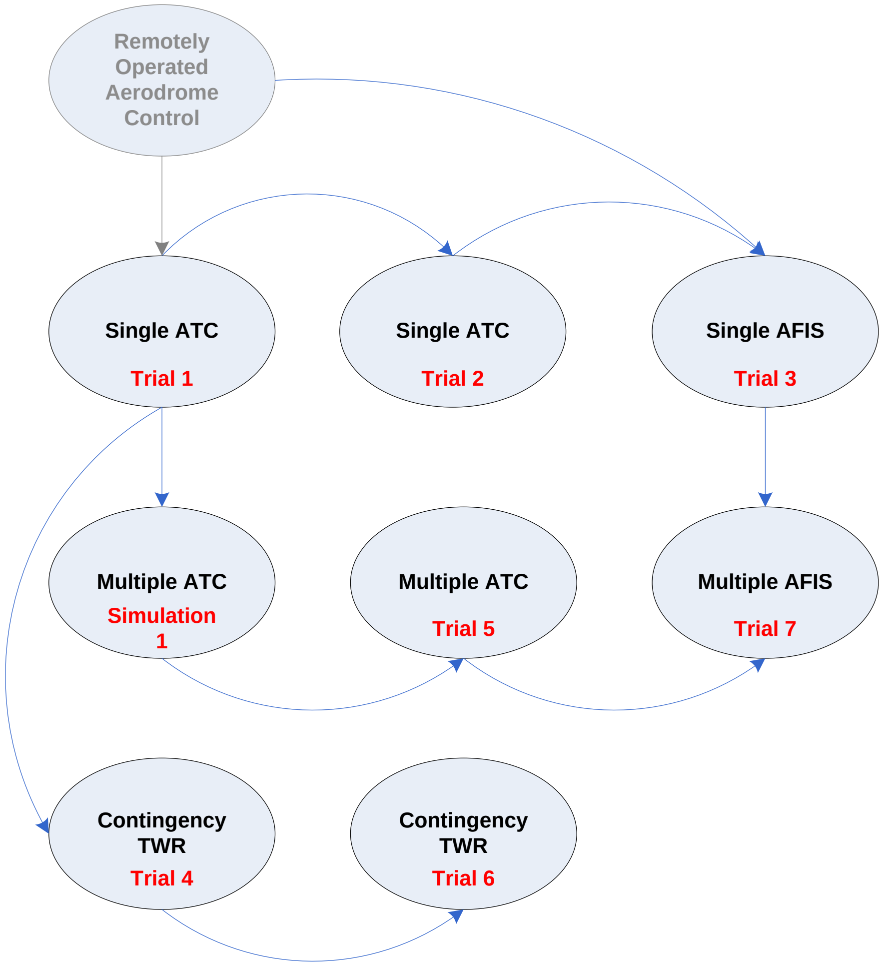
There is no current operational use of Remotely Operated Aerodrome Control in normal operations. Some aerodromes have contingency facilities, but none that include an OTW view.

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

## *7.2 Planned or Ongoing Trials*

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

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




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

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

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

TBD

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# Module N° B1-15: Improved Airport operations through Departure, Surface and Arrival Management

| | | |
|---|---|---|
| **Summary** | Extended arrival metering, Integration of surface management with departure sequencing bring robustness to runways management and increase airport performances and flight efficiency. | |
| **Main Performance Impact** | KPA-02 Capacity; KPA-04 Efficiency; **KPA-09 Predictability**, KPA-06 Flexibility | |
| **Domain/ Flight Phases** | Aerodrome and Terminal | |
| **Applicability Considerations** | Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.<br>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. | |
| **Global Concept Element(s)** | TS – Traffic Synchronization<br>AO – Airport operations | |
| **Global Plan Initiative** | GPI-6 Air Traffic Flow Management<br>GPI-12 Functional integration of ground systems with airborne systems<br>GPI-14 Runway operations<br>GPI-16 Decision support systems and alerting systems | |
| **Pre-Requisites** | B0-15, B0-75 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | 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** |

## 1. Narrative

### *1.1 General*

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

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

In particular, improved surface surveillance and management will facilitate the optimal use of movement areas.

The synergy of precise surface management and departure sequencing will further hone the predictability and accuracy of departure times assigned to flights. It will enable departure dynamic spacing and sequencing, leading to a higher departure rate. Departure and arrival patterns can be adjusted to lessen the impact separation procedures posed.

<u>Flights can be sequenced such that the effect of natural phenomena (i.e. wake turbulence) can be mitigated.</u> Wake turbulence effects can be minimized by putting a series of heavy aircrafts behind light aircrafts, as wake turbulence generated by light aircrafts dissipates quickly. The coupling of surface and departure management enables greater flexibility in runway balancing. Runway can be re-configured to adapt and support the ever changing arrival and departure scenarios. The runway can be configured such that wake turbulence effects can be circumvented, e.g. dedicated runways for heavies and light aircrafts that diverge into different directions.

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

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

This module also seeks to increase the utilisation of performance based navigation procedures such as RNAV/RNP procedures in high density areas. RNAV/RNP procedures can efficiently direct flights into arrival and departure metering fixes. Procedures such as Standard Terminal Arrival (STAR) and Standard Instrument Departure (SID) are of tremendous efficacy in managing strained resources at high density areas. This will further optimize both aerodrome and terminal resource allocation.

### 1.1.1 Baseline

Module B0-15 introduced time based arrival metering, arrival and departure management automation. These automations work independently, with the ATC personnel serving as the integrator of information generated by these systems.

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

**Departure management automation** provides departure scheduling. Departure scheduling will optimise the sequence in which the flow is fed to the adjacent ATC authorities. Departure is sequenced based on flights' arrival flow constraints if necessary (non specialized or runways, departure/arrival interference). Departure management also provides automated disseminations and communication of departure restriction, clearance, and other relevant information.

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

### 1.1.2 Change brought by the module

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

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

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

### *1.2 Element 1: Surface Management*

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

### *1.3 Element 2: Departure and Surface Integration*

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

These measures serve to increase aerodrome throughput and departure rates.

### *1.4 Element 3: Extended Arrival Metering*

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

### *1.5 Element 4: Utilization of RNAV/RNP routes*

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

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

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

| | |
|---|---|
| *Capacity* | Time based metering will optimize usage of terminal airspace and runway capacity. Optimize utilization of terminal and runway resources. |
| *Efficiency* | Surface Management decreases runway occupancy time, more robust departure rates, and enables dynamic runway rebalancing and re-configuration.<br>Departure/Surface integration enables dynamic runway rebalancing to better accommodate arrival and departure patterns.<br>Reduction in airborne delay/holding<br>*Traffic flow synchronization between en-route and terminal domain.*<br>RNAV/RNP procedures will optimize aerodrome/terminal resource utilization. |
| *Predictability* | Decrease uncertainties in aerodrome/terminal demand prediction.<br>Increased compliance with assigned departure time and more predictable and orderly flow into metering points<br>Greater compliance to Controlled Time of Arrival (CTA) and more accurate assigned arrival time and greater compliance |
| *Flexibility* | Enables dynamic scheduling. |
| *Safety* | Greater precision in surface movement tracking |
| *Environmental* | Reduction in fuel burn and environment impact (emission and noise) |

| | |
|---|---|
| *CBA* | 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.<br>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<br>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.<br>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. |

# 3. Necessary Procedures (Air & Ground)

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

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

# 4. Necessary System Capability

## *4.1 Avionics*

No additional avionics is required beyond block 0 requirements for the implementation of this module, i.e; FMS and RNP plus Data-link for transmission of the clearance (D-TAXI, CTA transmission,)

## *4.2 Ground Systems*

Surface management requires more precise surface movement tracking. (B0-75 A-SMGCS )

Ground automation support is required with appropriate information exchange between ATC, Airport operations and airlines operations. (see B0-80 and B1-80)

Mechanism to share surface information effectively and in a timely manner is essential to this element and also fosters greater common situational awareness between all users of the aerodrome surface.

Extended transmission of CTA to the upstream ATC authorities (B0-25 B1-25, SWIM B1-31)

# 5. Human Performance

## *5.1 Human Factors Considerations*

Automation support is needed for Air Traffic Management in airspace with high demands

## *5.2 Training and Qualification Requirements*

Training on the required automation is needed for ATM personnel. ATM personnel responsibilities will not be affected

## *5.3 Others*

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

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

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

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

**US:** Surface movement tracking and navigational systems, such as the ASDE-X, are deployed to support tracking, guidance, routing and planning of surface operations.

**Europe:** initial A-SMGCS (Advanced Surface Movement Guidance and Control System) is deployed to support tracking, guidance, routing and planning of surface operations.

Departure and surface management synchronization is currently achieved mostly through human coordination in both US and Europe.

In Airport CDM there is a first of integration of Departure Management and Surface Management in connection with AFTM measures. At Paris CDG the synchronisation of Departure of the gate and departure at the runways is in operation since end of 2010.

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

RNAV/RNP routes are implemented at the all most metroplexes across the US and Europe

## *7.2 Planned or Ongoing Trials*

SMAN (Surface Manager) will be introduced as the go-to surface management tool in Europe. Similarly, Tower Flight Data Manager (TFDM) will be introduced in the US to fulfil the same role. SMAN is a function in the ASMGCS tool to maintain a safe and efficient traffic flow on the surface.

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

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

Extended AMAN is considered in Initial 4D SESAR project

The aims of the US and European efforts are congruous.

Extended metering will be implemented along with these capabilities as they mature.

# 8. Reference Documents

## *8.1 Standards*

## *8.2 Procedures*

## *8.3 Guidance Material*

- European ATM Master Plan,
- SESAR Definition Phase Deliverable 2 – The Performance Target,
- SESAR Definition Phase Deliverable 3 – The ATM Target Concept,
- SESEAR Definition Phase 5 – SESAR Master Plan
- TBFM Business Case Analysis Report
- NextGen Midterm Concept of Operations v.2.0
- RTCA Trajectory Concept of Use

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

| | | |
|---|---|---|
| **Summary** | Introduction of FF-ICE step 1, to implement ground-ground exchanges using common flight information reference model (FIXM) and XML standard format used before departure. | |
| **Main Performance Impact** | KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, **KPA-07 Global Interoperability,** KPA-10 Safety, | |
| **Domain / Flight Phases** | Planning phase for FF-ICE/1 | |
| **Applicability Considerations** | Applicable between ATC units and to facilitate exchange between ASP, Airspace user operations and airport operations. | |
| **Global Concept Component(s)** | DCB – Demand capacity Balancing<br>CM - Conflict management<br>IM - Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-6 ATFM<br>GPI-7 Dynamic and flexible route management<br>GPI-16 Decision Support Systems | |
| **Main Dependencies** | Successor of B0-25 and B0-30 (AIXM)<br>Connection to B1-30 (AIRM) and B1-31 (SWIM) | |
| **Global Readiness Checklist** | | **Status (ready or estimated date)** |
| | Standards Readiness | Est 2016 |
| | Avionics Availability | No requirement |
| | Ground systems Availability | Est 2018 |
| | Procedures Available | Est 2018 |
| | Operations Approvals | Est 2018 |

## 1. Narrative

### *1.1 General*

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

#### 1.1.1 Baseline

The baseline for this module is present process for submission of FPL through ICAO standardized FPL/2012 messages (Amdt 1 to PANS/ATM) and automated standard for information exchange through a set of messages and limited need for direct speech coordination (B0-25).

#### 1.1.2 Change brought by the module

### *1.2 Element 1: FF-ICE/1 before departure*

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

The objective of FF-ICE/1 is to establish the basis for transition towards a full FF-ICE deployment. This basis consists of:

- Introduction of a Globally Unique Flight Identifier: GUFI

- Introduction of common data format i.e.Flight Information eXchange Model (FIXM) in the context of the overall transition to XML for aeronautical information.
- Introduction of basic roles, rules and procedures for submission and maintenance of FF-ICE information including provisions for the early sharing of trajectory information.

The use of the new format will facilitate the evolution of the contents of FPL to introduce new data and solve specific regional needs.

List of changes included in FF-ICE/1

1. Support for early provision of flight intention information.
2. Support for exchange of 4D Trajectory information between the AOC and the ASP
3. New format for flight and flow information using internet protocol and XML
4. Globally Unique Flight Identifier (GUFI)
5. FF-ICE/1 Information Elements (first list of Information elements).

The foreseen Services related to Flight Information Submission and Management in the frame of FF-ICE/1 are:

- Initial submission
- Validation
- GUFI Allocation (after the initial submission)
- Nominal trajectory Generation (in absence of Airspace users defined trajectory
- Flight Information Negotiation (to solve conflict between Airspace users flight and existing constraints)
- Flight Information Update (to change or add to current flight information)
- Acknowledgement/rejection
- Flight Information Publication
- Flight Information Subscription
- Flight Information Cancellation
- Flight Suspension
- Flight Information

### *1.3 Other remarks*

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

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

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

| | |
|---|---|
| *Capacity* | Reduced controller workload and increased data integrity supporting reduced separations translating directly to cross sector or boundary capacity flow increases. |
| *Efficiency* | Better knowledge of aircraft capabilities allows trajectories closer to Airspace user preferred trajectories and better planning |
| *Global Interoperability* | The use of new mechanism for FPL filling and information sharing will facilitate the Flight data sharing among the actors. |
| *Participation by the ATM community* | FF-ICE/1 for Ground-Ground application will facilitate CDM, the implementation or the systems interconnection for Information sharing, trajectory or slot negotiation before departure providing better use of capacity and better flight efficiency... |
| *Safety* | More accurate flight information |

| | |
|---|---|
| *CBA* | The new services have to be balanced by the cost of software change in the ASP, AOC and airport ground systems |

# 3. Necessary Procedures (Air & Ground)

- Required procedures exist. They need local instantiation on the specific flows; the experience from other regions can be a useful reference.
- Means of compliance: EUROCONTROL On-Line Data Interchange (OLDI) standard
- FF-ICE/1 Manual, SARPS and concept of use to be developed.

# 4. Necessary System Capability

## *4.1 Avionics*

There are no specific airborne requirements, but use of Electronic Flight Bag onboard associated to high speed connection, in particular when aircraft is on the ground, could facilitate the FF-ICE information sharing with both AOC and ASP.

## *4.2 Ground Systems*

FF-ICE/1 SARPS, FIXM and Interface need to be used and require further developments in ground systems.

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

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

Training to the new procedures and change in flight data information is required for operators in charge of their provision and for the users of these informations.

## *5.3 Others*

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

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

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

For FF-ICE/1 SARPS should be developed and validated (cf ATMRPP tasks, ref WP470, 479, 480)

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

## *7.2 Planned or Ongoing Trials*

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

# 8. Reference Documents

Same as B0-25 +

## *8.1 Standards*

- Eurocae ED-133 June 09 Flight Object Interoperability Specification
- FF-ICE/1 based on FIXM to be developped

### *8.2 Procedures*

### *8.3 Guidance Material*

- FF-ICE concept document
- Eurocontrol OLDI V4.2

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

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-01 Access & Equity; **KPA-03 Cost-Effectiveness**; KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All phases of flight | |
| **Applicability Considerations** | Applicable at State level, with increased benefits as more States participate | |
| **Global Concept Component(s)** | IM – Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-18 Electronic information services | |
| **Pre-Requisites** | Successor of: B0-30<br>Parallel progress with: B1-25, B1-31 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2018** |
| | Avionics Availability | **NA** |
| | Ground Systems Availability | **Est. 2018** |
| | Procedures Available | ✓ |
| | Operations Approvals | **Est. 2018** |

## 1. Narrative

### *1.1 General*

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

#### 1.1.1 Baseline

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

#### 1.1.2 Change brought by the module

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

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

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

| | |
|---|---|
| *Access and Equity* | Greater and timelier access to up-to-date information by a wider set of users. |
| *Cost Effectiveness* | Reduction of time to process a new piece of information; reduced use of paper; higher agility of the system to create new applications through the availability of standardised data. |
| *Global Interoperability* | Essential for global interoperability. |
| *Safety* | Reduced probability of error or inconsistency in/across data; reduced possibility to introduce additional errors by subsequent manual inputs. |
| *Security* | Information security considerations are embedded in the developments. |

| | |
|---|---|
| *CBA* | Business case to be established in the course of the projects defining the models and their possible implementation. |

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

No avionics requirement.

### *4.2 Ground Systems*

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

## 5. Human Performance

### *5.1 Human Factors Considerations*

The use of a common model supported by the industrial IT tools is of a nature reduce errors in manual transcription of data and in the management of information.

### *5.2 Training and Qualification Requirements*

Training is required for personnel managing the ATM information and for their users if the interfaces and access conditions change.

### *5.3 Others*

Nil

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

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

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

None at this time.

### *7.2 Planned or Ongoing Activities*

- **Europe**: SESAR is currently defining and validating the ATM Information Reference Model (AIRM) & Information Service Reference Model (ISRM) including the specific data models Weather Exchange model (WXXM), Flight Information Exchange Model (FIXM). For more information see www.aixm.aero, www.wxxm.aero and www.fixm.aero.
- **US:** This is covered through the EA OV-7 and associated service model activities of the NextGen programme.
- US-Europe cooperation is in place on the joint development and maintenance of the data models AIXM/WXXM/FIXM and the overall AIRM framework (OV-7 view in FAA Enterprise Architecture)

## 8. Reference Documents

### *8.1 Standards*

- New PANS-AIM document (2016) to address all formatting/template type information of Annex 15 & Doc8126

### *8.2 Procedures*

TBD

### *8.3 Guidance Material*

- WXXM available in 2012

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

| | | |
|---|---|---|
| **Summary** | Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximise interoperability. | |
| **Main Performance Impact** | **KPA-03 Cost-Effectiveness**, KPA-05 Environment, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All phases of flight | |
| **Applicability Considerations** | Applicable at State level, with increased benefits as more States participate | |
| **Global Concept Component(s)** | IM – Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-18 Electronic information services | |
| **Pre-Requisites** | Successor of: B0-30<br>Parallel progress with: B1-30 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2016** |
| | Avionics Availability | **NA** |
| | Ground Systems Availability | **Est. 2018** |
| | Procedures Available | **Est. 2016** |
| | Operations Approvals | **Est. 2016** |

## 1. Narrative

### *1.1 General*

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

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

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

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

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

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

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

### 1.1.1 Baseline

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

### 1.1.2 Change brought by the module

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

The module addresses applications of SWIM on the ground. Most of the air ground data exchanges will remain based on point-to-point communication.

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

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

| | |
|---|---|
| *Cost Effectiveness* | further reduction of costs; all information can be managed consistently across the network, limiting bespoke developments, flexible to adapt to state-of-the-art industrial products and making use of scale economies for the exchanged volumes |
| *Efficiency* | (indirect) Using better information allows operators and service providers to plan and execute better trajectories |
| *Environment* | further reduction of paper usage |

| | |
|---|---|
| | (indirect) more cost-efficient flights as the most up to data is available to all stakeholders in the ATM system |
| *Safety* | access protocols and data quality will be designed to reduce current limitations in these area |
| *Security* | access protocols and data quality will be designed to reduce current limitations in these area |

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

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

No avionics requirement.

### *4.2 Ground Systems*

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

## 5. Human Performance

### *5.1 Human Factors Considerations*

SWIM is a new concept to address information and its use. In essence it is close to the notion of an intranet. It therefore needs to be understood as such by all personnel, which will need to be aware of the principles and conditions of use. In addition, the architecture (logical and physical) and the management of the information data will be different from today and affect those that were in charge of these functions. End-users will be affected only if their access to data via interfaces does not remain stable.

### *5.2 Training and Qualification Requirements*

Training will be requirements will be high.

### *5.3 Others*

Nil

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

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

SWIM governance (set of policies, best practices, roles and responsibilities apportionment) and rules for SWIM enabling services (as part of the infrastructure: Service catalogue, Information discovery, SWIM security, SWIM supervision, SWIM Recording – not limited to the legacy infrastructure) should be established.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

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

- **US**: tbc.

### 7.2 Planned or Ongoing Activities

- **Europe:**
  - o SWIM Step1 infrastructure demonstration by the end of 2011
  - o Planned Release 2 V&V SWIM-enabled exercises:
    - "IOP Validation": ATC-ATC Coordination by means of a new mechanism based on the Flight Object
    - "Slot Swapping": DMEAN implemented improvement (slot swapping). Prototype of enhanced slot swapping function to cover extension to all flights from/to a given airport.
    - "UDPP extension to 4D BT FTS": Extension to full 4D business/mission trajectory. Testing of different models for priority rules and collaborative prioritization. UDPP extended to en-route congestion.
    - "AIMQuick win (Step1)": Validate new ways of publishing complex up-to-date aeronautical information based on the Digital NOTAM concept with its particular temporality data representation.
  - o SESAR trials in 2013-16 for SWIM protocols and prototype
- **US:** tbc.

## 8. Reference Documents

### 8.1 Standards

- New PANS-AIM document (2016) to address all formatting/template type information of Annex 15 & Doc8126

### 8.2 Procedures

TBD

### 8.3 Guidance Material

- WXXM available in 2012

# Module N° B1-10: Improved Operations through Free Routing

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity, **KPA-04 Efficiency**, KPA-05 Environment | |
| **Operating Environment/Phases of Flight** | En-route, TMA, incl. Oceanic & Remote areas | |
| **Applicability Considerations** | 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. | |
| **Global Concept Component(s)** | AOM – Airspace Organisation and Management | |
| **Global Plan Initiatives (GPI)** | GPI-1 Flexible use of airspace<br>GPI-8 Collaborative airspace design and management | |
| **Pre-Requisites** | Successor of: B0-10<br>Predecessor of: B3-10 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | ✓ |
| | Avionics Availability | ✓ |
| | Ground System Availability | ✓ |
| | Procedures Available | **Est. 2018** |
| | Operations Approvals | **Est. 2018** |

## 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.

The module is made of the following elements:

- Free routing;
- Reduced route spacing;
- Dynamic sectorisation.

### *1.2 Element 1: Free Routing*

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

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

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

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

The benefits of free routing are primarily in terms of adherence to the user-preferred profile. ATC may need to be provided with the necessary tools to ensure flight progress monitoring and coordination activities, and conflict prediction.

### *1.3 Element 2: Reduced Route Spacing*

A key tenet of the PBN concept is to combine the accuracy and functionality of navigation in specifications which can be tailored to the intended operations.

A serious problem with the use of classical RVAV in the last decades has not been the achieved accuracy on straight segments, but the behaviour of aircraft in transiting phases, especially turns, where significant differences are noted from one aircraft to the next and depending on conditions such as wind. This has resulted in the inability to exploit the intrinsic accuracy and to design better routes, due to the need to protect large volumes of airspace.

This element addresses not only routes. It also provides improvements to other issues related to lateral navigation and can be summarised as follows:

- Closer route spacing, particularly en route;
- Maintaining same spacing between routes on straight and turning segments without a need to increase route spacing on the turn;
- Reduction of the size of the holding area to permit holds to be placed closer together or in more optimum locations;
- Aircraft ability to comply with tactical parallel offset instructions as an alternative to radar vectoring;
- Means of enabling curved approaches, particularly through terrain rich areas.

The selection of a suitable PBN specification will eliminate the above shortcomings, and allow to design in both en-route and TMA routes which require lower spacing between them, directly resulting in higher airspace capacity, additional design flexibility and generally more efficient routes as well.

### *1.4 Element 3: Dynamic Sectorisation*

The improvements in the design of the route network or the possibility to fly outside of a fixed route network make the pattern and concentration of traffic not always the same. Where sectorisation is designed to create capacity for ATC, the implementation of the above elements requires that the sectorisation be adjusted more dynamically than only in strategic ATC phases.

This dynamic sectorisation can take several forms, the most complex/dynamic ones with real-time design computing are considered beyond Block 1. In this module, dynamic sectorisation can take simple forms such as:

- a pre-defined volume of airspace being swapped from a sector to an adjacent sector;

- catalogues of pre-defined sector configurations based on a defined mosaic of elementary volumes, allowing a more general application of the above;

- sectors based on an organised (dynamic) track structure.

The dynamic sectorisation is applied in real-time by selecting the most suitable configuration among those available. Unlike grouping/degrouping of sectors, it does not affect the number of control position in use. Dynamic sectorisation should be based on an assessment of the traffic situation expected in the next minute/hour.

Dynamic sectorisation can also be applied across FIR/ANSP boundaries.

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

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

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|---|---|
| *Capacity* | The availability of a greater set of routing possibilities allows reducing potential congestion on trunk routes and at busy crossing points. This in turn allows reducing controller workload by flight.<br><br>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.<br><br>Reduced route spacing means reduced consumption of airspace by the route network and greater possibility to match it with flows. |
| *Efficiency* | 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.<br><br>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.<br><br>Easier design of high-level Temporary Segregated Airspace (TSAs). |
| *Environment* | Fuel burn and emissions will be reduced; however, the area where emissions and contrails will be formed may be larger. |
| *Flexibility* | 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. |

| | |
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| *CBA* | 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). |

## 3. Necessary Procedures (Air & Ground)

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

# 4. Necessary System Capability

## 4.1 Avionics

Aircraft need to be suitably equipped. This is a matter of accuracy and functionality, i.e. a suitable PBN specification(s).

## 4.2 Ground Systems

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

Dynamic sectorisation requires the FDPS to be able to work with different sector configurations and sector grouping/degrouping functionality, which is available in many systems today.

# 5. Human Performance

## 5.1 Human Factors Considerations

The change step is achievable from a human factors perspective. The roles and responsibilities of controller/pilot are not affected. Free routing, when compared to a structured route system, can reduce the number of potential interactions between flights but makes their occurrence less predictable and their configurations more variable. This is why it needs to be supported by automated assistance to understand/visualise the flight paths and their interactions as soon as traffic is significant. It is easier to implement it progressively, e.g. starting in low traffic conditions/periods.

Reduced route spacing has no direct human performance incidence.

## 5.2 Training and Qualification Requirements

The required training is available.

## 5.3 Others

Nil

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

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

# 7. Implementation and Demonstration Activities

## 7.1 Current Use

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

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

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

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

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

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

The A-RNP specification is being proposed for a European regulation to progressively enter into force in 2018. Advanced RNP is set to become the next ECAC-wide navigation specification used in en-route and terminal airspace, including the approach, missed approach and departure phases of flights. It serves an airspace concept, extending well beyond PBN, and having the following characteristics: parallel network of ATS routes, based; system of feeder or link routes which connect to P-RNAV or Conventional SIDs and STARs starting at the nominal TMA boundary; organised track system (OTS ) in the north Atlantic based on MNPS; airspace Classification Class C above FL195; extensive use of the Flexible Use of Airspace concept; limited use of Free Route Airspace; evolution from State managed upper airspace to Functional Airspace Blocks.

- **US**: tbc
- **Australia**: tbc

### 7.2 Planned or Ongoing Activities

- **Terra X:** tbc.

## 8. Reference Documents

### 8.1 Standards

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

### 8.2 Procedures

TBD

### 8.3 Guidance Material

- Doc 9426, Air Traffic Services Planning Manual
- Doc 9689, Manual on Airspace Planning Methodology for the Determination of Separation Minima
- Doc 9613, Performance-based Navigation (PBN) Manual
- Doc 9554, Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to Civil Aircraft Operations
- Doc 9750, Global Air Navigation Plan
- Doc 9854, Global Air Traffic Management Operational Concept
- ICAO Global Collaborative Decision Making (CDM) Guidelines (under development)
- ICAO Circular 330 AN/189 Civil/Military Cooperation in Air Traffic Management

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# Module N° B1-35: Enhanced Flow Performance through Network Operational Planning

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| **Summary** | 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. | |
| **Main Performance Impact** | **KPA-02 Capacity**; KPA-04 Efficiency; KPA-08 Participation by the ATM Community; KPA-09 Predictability | |
| **Operating Environment/Phases of Flight** | Pre-flight phases, some action during actual flight | |
| **Applicability Considerations** | 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 | |
| **Global Concept Component(s)** | DCB Demand-Capacity Balancing<br>TS Traffic Synchronisation<br>AOM Airspace Organisation and Management | |
| **Global Plan Initiatives (GPI)** | GPI-1 Flexible use of airspace<br>GPI-6 Air traffic flow management<br>GPI-8 Collaborative airspace design and management | |
| **Pre-Requisites** | Successor of: B0-35, B0-10 (FUA aspects in particular)<br>Predecessor of B2-35 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2018** |
| | Avionics Availability | **NA** |
| | Ground Systems Availability | **Est. 2018** |
| | Procedures Available | **Est. 2018** |
| | Operations Approvals | **Est. 2018** |

## 1. Narrative

### *1.1 General*

This module introduces enhanced processes to manage flows or groups of flights in order to improve overall fluidity. It also increases the collaboration among stakeholders in real time so as to better know user preferences, inform on system capabilities, and further apply CDM in a certain set of problems/circumstances, in particular to take into account priorities of an airline among flights within its schedule. It also extends the notion of flexible use of airspace so as to include network efficiency considerations.

#### 1.1.1 Baseline

The previous module, B0-35, provided a solid foundation for regulating traffic flows, and B0-10 introduced flexible use of airspace (FUA). The experience shows that further improvements can be introduced: managing airspace and traffic flows needs to be better integrated into the notion of network operations, ATFM techniques and algorithms can be improved and in particular could better take into account user preferences.

### 1.1.2 Change brought by the module

This module introduces enhanced processes to manage flows or groups of flights in order to improve overall fluidity. This module refines ATFM techniques, integrates the management of airspace and traffic flows in order to achieve greater efficiency in their management. It also increases the collaboration among stakeholders in real time so as to better know user preferences, inform on system capabilities, further apply CDM in a certain set of problems/circumstances in particular to take into account priorities of an airline among flight within its schedule.

### *1.2 Element 1: Improved ATFM and AFTM-AOM integration*

Studies have shown that there is room for improvement of the ATFM algorithms and techniques. The module will implement those that will have been validated in the period of reference.

A particular development is required to accommodate the use of free routings implemented in B1-10.

In addition, with ATFM having introduced the notion of re-routing, either for ATC capacity constraints or to avoid other phenomena such as severe weather, it appears that a greater integration of ATFM and airspace management would bring significant benefits to traffic, not only civil traffic, but also for the more dynamic definition of areas which may be used for military.

### *1.3 Element 2: Synchronisation*

When getting really closer to capacity limits, the small variations in take-off time allowed by ATFM slots may still generate local bunching of traffic at times, which are extremely sensitive at a small number of choke-points in the network. It would therefore be useful to be able to anticipate on these situations once the flight is airborne and the uncertainties on its trajectory are reduced compared to before take-off, by using trajectory predictions and perform additional smoothing, not only along a flow (miles in trail) but for several converging flows at a few number of most critical choke points in a given airspace.

### *1.4 Element 3: Initial UDPP*

User Driven Prioritisation Process is designed to allow airspace users to intervene more directly in the implementation of flow regulations, in particular in cases where an unplanned degradation of capacity significantly impacts the realisation of their schedule. The module proposes a simple mechanism by which the affected airlines can collaboratively among themselves and with ATFM come to a solution which takes into account their commercial/operational priorities which are not known by ATM. Due to the potential complexity of several intricate prioritisation and allocation processes, this module will implement UDPP only in specific situations, e.g. when the perturbation affects one airport.

### *1.5 Element 4: Full FUA*

ICAO development of FUA documentation on civil/military cooperation.

The full FUA introduces mechanisms, in conjunction with the more dynamic ATS routes (module B1-10) to make the airspace and its use as flexible as possible and a continuum that can be used in an optimal manner by the civil and military users.

### *1.6 Element 5: Complexity Management*

The introduction of improved complexity and workload assessment tools is a means to improve the accuracy and reliability of the identification and mitigation of capacity constraints, both in the tactical ATFM phase as well as during the flight. This exploits information on planned incoming traffic.

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

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

| | |
|---|---|
| *Capacity* | Better use of the airspace and ATM network, with positive effects on the overall cost-efficiency of ATM.<br>Optimisation of DCB measures by using assessment of workload/complexity as a complement to capacity. |
| *Efficiency* | Reduction of flight penalties supported by airspace users. |
| *Environment* | Some minor improvement is expected compared to the module's baseline. |

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| *Predictability* | Airspace users have a greater visibility and say on the likelihood to respect their schedule and can make better choices based on their priorities. |
| *Safety* | The module is expected to further reduce the number of situations where capacity or acceptable workload would be exceeded. |

| | |
|---|---|
| *CBA* | The business case will be a result of the validation work being undertaken. |

# 3. Necessary Procedures (Air & Ground)

New procedures to exploit the new techniques: for ATC to communicate in-flight measures to crews; for informing operators before departure.

UDPP rules and application criteria will need be defined.

# 4. Necessary System Capability

## *4.1 Avionics*

No avionics impact.

## *4.2 Ground Systems*

Ground ATFM/AOM tools, offering access to aircraft operators and ANSPs.

# 5. Human Performance

## *5.1 Human Factors Considerations*

Roles and responsibilities of controllers and pilots are expected not to be much affected in tactical operations (except by the more tactical re-routings or sequencing), but will need to understand that the decisions made on flights are for the common good.

## *5.2 Training and Qualification Requirements*

The new procedures will require training adapted to the collaborative nature of the interactions, in particular between ATFM and airline operations personnel.

## *5.3 Others*

Nil

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

Standards would avoid misunderstandings from one region to the next.

Some elements such as rules of the game and respect of equity may require standards and/or regulation.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

- **Europe**: Some European ACCs already exploit complexity management tools to better predict sector workloads and take measures such as de-grouping to absorb traffic bunching effects.
- **US**: tbc

## *7.2 Planned or Ongoing Activities*

- **Europe**: SESAR will validate the initial UDPP requirements and procedures, as well as the airspace management and network operations related to the module.

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

EUROCONTROL AFUA Concept

# Module N° B1-105: Better Operational Decisions through Integrated Weather Information (Planning and Near-term Service)

| | |
|---|---|
| **Summary** | 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. |
| **Main Performance Impact** | KPA-02 Capacity; KPA-04 Efficiency; KPA-09 Predictability, KPA-10 Safety |
| **Operating Environment/Phases of Flight** | All flight phases |
| **Applicability Considerations** | Applicable to traffic flow planning, and to all aircraft operations in all domains and flight phases, regardless of level of aircraft equipage. |
| **Global Concept Component(s)** | AOM - Airspace Operations and Management<br>DCB - Demand and Capacity Balancing<br>AO - Aerodrome Operations |
| **Global Plan Initiatives (GPI)** | GPI-19 Meteorological Systems<br>GPI-6 Air Traffic Flow Management<br>GPI-16 Decision Support Systems and Alerting Systems |
| **Pre-Requisites** | Module B0-10: Improved En-Route Profiles,<br>Module B0-15: Runway Arrival Sequencing;<br>Module B0-35: Air Traffic Flow Management/Network Operations Procedures (ATFM/NOP) and Collaborative Decision Making (CDM);<br>Parallel development with;<br>Module B1-15 Arrival Management/Departure Management (AMAN/DMAN) Metroplex and Linked DMAN/Surface Management (SMAN);<br>Module B1-35: Enhanced NOP, Integrated Airspace/Flow Management |

| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
|---|---|---|
| | Standards Readiness | Est 2018 |
| | Avionics Availability | 2018 |
| | Infrastructure Availability | Est 2018 |
| | Ground Automation Availability | Est 2018 |
| | Procedures Available | Est 2018 |
| | Operations Approvals | Est 2018 |

## 1. Narrative

### *1.1 General*

This module improves the current baseline case where ATM decision makers manually determine the amount of change in capacity associated with an actual or forecast weather phenomenon, manually compare the resultant capacity with the actual or projected demand for the airspace or aerodrome, and then manually devise ATM solutions when the demand exceeds the weather-constrained capacity value. This module also improves in-flight avoidance of weather by providing more precise information on the location, extent and severity of weather affecting specific flights.

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

### 1.1.1 Baseline

Weather is a major cause of flight delay in many airspace systems. Research analyses have suggested that a significant portion of that delay could be mitigated if weather forecasts were "perfect" and appropriate air traffic management (ATM) solutions were able to be consistently devised and employed. Rigid airspace structures often preclude the consistent employment of the best ATM solutions.

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

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

### 1.1.2 Change brought by the module

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

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

## *1.2 Element 1: Weather Information*

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

## *1.3 Element 2: Weather Translation*

Weather Translation refers to automated processes which ingest raw weather information and translate them into characterized weather constraints and aerodrome threshold events. The output of the Weather Translation process is a non-meteorological value which represents a potential change in the permeability of airspace or capacity of the aerodrome.

It is unlikely that future automation systems will incorporate Weather Translation methodology without also including ATM Impact Conversion components. As such, this element is likely to be more of an enabler of the next element and the entire process as opposed to an interim end state.

### *1.4 Element 3: ATM Impact Conversion*

The ATM Impact Conversion element determines the anticipated weather-constrained capacity of the airspace or aerodrome and compares this to the projected demand. If an imbalance exists between the two, this information is provided to the system user and/or the ATM Decision Support element to inform development of mitigation strategies for dealing with the imbalance.

### *1.5 Element 4: Weather Integrated Decision Support*

The final element is Weather Integrated Decision Support, which is comprised of automated systems and processes that create ranked mitigation strategies for consideration and execution by ATM decision makers. The solutions are based on requirements and rules established by the ATM community. These improvements also augment the communication and display of weather information to service providers and operators to support tactical avoidance.

## *2. Intended Performance or Operational Improvement / Metric for Success*

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| *Capacity* | Improvements in weather information lead to better data concerning the extent, time period and severity of weather impacts on airspace. This in turn enables more precise estimates of expected capacity of that airspace. Associated Metric: Improved weather information in reference to the number of user-preferred profiles that can be accommodated.<br><br>Maximum use of available airspace capacity. Associated Metric: With respect to capacity, the number of user-preferred profiles that can be accommodated would be an appropriate metric for Weather Integrated Decision Support. |
| *Efficiency* | Improvements in weather information lead to better data concerning the extent, time period and severity of weather impacts on airspace. Associated Metric: An improvement in efficiency associated with improved weather information would be the number of deviations from user-preferred profiles.<br><br>Advanced decision support tools, fully integrated with weather information, support stakeholders in planning for the most efficient routes possible, given the anticipated weather situation. Associated Metric: 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. |
| *Environment* | More precise planning for weather mitigation produces more efficient routes, less fuel burn, and reduction of emissions due to fewer ground hold/delay actions. Associated Metric: Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected. |
| *Flexibility* | Users have greater flexibility in selecting trajectories that best meet their needs, in the face of weather situations. Associated Metric: Fewer reroutes and less variability in associated traffic management initiatives (TMIs) can be expected. |
| *Predictability* | 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. Associated Metric: 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.<br><br>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 |

| | |
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| | fuel burn. Associated Metric: 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.<br><br>Advanced decision support tools, fully integrated with weather information, produce consistent, optimal solution sets, and allow users to plan trajectories that are more likely to be acceptable from the standpoint of the ANSP. Fewer reroutes and less variability in other associated traffic management initiatives (TMIs) can be expected. In turn, this will allow users to carry less contingency fuel than is felt necessary today, resulting in lower fuel burn. Associated Metric: Decreases in the variability and numbers of ATM responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation. |
| *Safety* | Weather information improvements lead to increased situation awareness by pilots, AOCs and ANSPs, enabling avoidance of hazardous weather conditions. Associated Metric: Safety improvement associated with better weather information would be the number of weather-related aircraft incidents and accidents.<br><br>Advanced decision support tools, fully integrated with weather information, produce solution sets which minimize pilot exposure to hazardous weather. This, combined with increased weather situational awareness by pilots and ANSPs, enables avoidance of hazardous conditions. Associated Metric: Decreases in the variability and numbers of responses to a given weather situation, along with reduced contingency fuel carriage for the same weather situation. |

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| *CBA* | 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. |

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

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

## 4. 4. Necessary System Capability

### 4.1 *Avionics*

This module does not depend on significant avionics additions. Improved weather information can be disseminated to the pilot via flight operations centers, controllers, or via air-ground links (e.g. FIS) where available. The extensive use of aircraft-based capabilities to support tactical weather avoidance is the focus of module B3-105.

### 4.2 *Ground Systems*

Technology development in support of this element will include the creation and implementation of a consistent, integrated 4-D database of global weather observations and forecasts, including linkage (data exchange and communications standards) between global weather information systems.

Technology development in support will include the introduction of automated weather translation methodologies based on the operational needs for such information.

Technology development in support will include the introduction of automated methodologies that use weather translation information to assess the impact on ATM operations, for flows and individual flights.

Technology development in support of this element will include the introduction of decision support tools, for both ANSPs and users, which automatically ingest ATM Weather Impact information, and support decision making via generation of candidate mitigation strategies.

# 5. Human Performance

### 5.1 Human Factors Considerations

This module will necessitate significant changes in how service providers and users deal with weather situations. The availability of decision support tools, integrated with enhanced observation and forecast information, will enable more efficient and effective development of mitigation strategies. But, procedures will need to be developed, and changes to cultural aspects of how decision making is done today will need to be considered. Also, the realization of a "common view" of the weather situation between service providers, flight operational and pilots will require trust in a single, common information base of weather.

### 5.2 Training and Qualification Requirements

Automation support, integrated with weather information is needed for flight operations, pilots and service providers. Training in the concepts behind the automation capabilities will be necessary to enable the effective integration of the tools into operations. Also, enhanced procedures for collaboration on ATM decision making will need to be developed and training provided, again to ensure effective operational use.

# 6. Regulatory/Standardisation needs and Approval Plan (Air & Ground)

This module requires the development of global standards for weather information exchange, with emphasis on the exchange of 4-D (X, Y, Z and T [time]) gridded weather information, and regulatory agreement on what constitutes required weather information in the age of digital exchange, versus text and graphics. Standardised Weather Translation parameters and ATM Impact Conversion parameters will also require development.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

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

## *7.2 Planned or Ongoing Activities*

No global demonstration trials are currently planned for this element. There is a need to develop such a plan as part of the collaboration on this module.

# 8. Reference Documents

### 8.1 Standards

World Meteorological Organization standards for weather information content and format. Others TBD; to be developed as part of this research

### 8.2 Procedures

To be developed

### 8.3 Guidance material

To be developed.

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# Module N° B1-85: Increased Capacity and Flexibility through Interval Management

<table>
<tr><td>Summary</td><td colspan="2">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.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 Capacity, KPA-03 Cost-Effectiveness, KPA-04 Efficiency, KPA-05 Environment and KPA-06 Flexibility.</td></tr>
<tr><td>Operating Environment/Phases of Flight</td><td colspan="2">Cruise, Arrival, Approach, Departure.</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">En-route and terminal areas.</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">DCB – Demand and Capacity Balancing; TS –Traffic Synchronisation; CM – Conflict Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-7 Dynamic and Flexible ATS Route Management;GPI-9 Situational Awareness; GPI-17 Data Link Applications.</td></tr>
<tr><td>Pre-Requisites</td><td colspan="2">B0-85</td></tr>
<tr><td rowspan="6">Global Readiness Checklist</td><td></td><td>Status (ready now or estimated date).</td></tr>
<tr><td>Standards Readiness</td><td>Est. 2014</td></tr>
<tr><td>Avionics Availability</td><td>Est. 2015</td></tr>
<tr><td>Ground System Availability</td><td>Est. 2018</td></tr>
<tr><td>Procedures Available</td><td>Est. 2015</td></tr>
<tr><td>Operations Approvals</td><td>Est. 2015</td></tr>
</table>

## 1. Narrative

### *1.1 General*

IM is defined as the overall system that enables the improved means for managing traffic flows and aircraft spacing, it may include the use of ground tools that assist the controller in evaluating the traffic picture and determining appropriate clearances to merge and space aircraft efficiently and safely and the use of airborne tools that allow the flight crew to conform with the IM Clearance. IM operations in the first phase will cover the arrival phase of flight (from the end of cruise to final approach) of airspace under surveillance, where Direct Controller Pilot Communications (such as voice or CPDLC) exist. As the applications evolve they will be applied to other phases of flight.

IM includes both the ground capabilities needed for the controller to support an IM Clearance and the airborne capabilities needed for the flight crew to follow the IM Clearance.

#### 1.1.1 Baseline

Current Ground-Based ATM.

### 1.1.2 Change brought by the module

Interval Management is a suite of functional capabilities that can be combined to produce operational applications to achieve or maintain an interval or spacing from a target aircraft. ATC will be provided with a new set of (voice or datalink) instructions directing, for example, that the flight crew establish and maintain a given time from a reference aircraft. These new instructions will reduce the use of ATC vectoring and speed control, which is expected to reduce the overall number of transmissions. These reductions are expected to reduce ATC workload per aircraft.

The flight crew will perform these new tasks using new avionics functions e.g. airborne surveillance, display of traffic information, and spacing functions with advisories. A few examples of IM in various phases of flight include: Cruise - delivering metering or miles-in-trail prior to top-of-descent; Arrival – interval management during optimum profile descents to merge (if applicable); Approach – achieve and maintain appropriate interval to stabilized approach point; and Departure – maintain interval no-closer-than to previous departure. These examples provide more efficient flight trajectories, better scheduling performance, reduced fuel burn and decreased environmental impacts.

Benefits of the interval management include;

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

| | |
|---|---|
| *Cost-Effectiveness* | 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. |
| *Efficiency* | Early speed advisories removing requirement for later path-lengthening<br>Continued Optimized Profile Descents (OPDs) in medium density environments<br>o expected to allow OPDs when demand <=70%<br>o<br>Resulting in reduced holding times and flight times. |
| *Environment* | All efficiency benefits have an impact of the environment. Resulting in reduced emissions. |
| *Safety* | Reduced ATC instructions and workload<br>o Without unacceptable increase in flight crew workload |

| | |
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| *CBA* | **TBD** |

## 3. Necessary Procedures (Air & Ground)

Procedures for Interval Management have yet to be developed.

# 4. Necessary System Capability

## *4.1 Avionics*

Necessary technology includes ADS-B OUT and ADS-B IN capability and a cockpit based Cockpit Display of Traffic information (CDTI) to have situational awareness for performing interval management operations. CPDLC in accordance with message set developed by SC-214 and WG-78 may be required. ADS-B OUT is required for surrounding aircraft.

## *4.2 Ground Systems*

Ground automation to support the Interval Management application may be required. Where implemented this will most likely be customised based on the set of interval management procedures allowed in a given terminal area.

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

TBD

## *5.3 Others*

TBD

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

TBD

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

None at this time.

## *7.2 Planned or Ongoing Activities*

None at this time.

# 8. Reference Documents

## *8.1 Standards*

RTCA Document DO-328 and EUROCAE ED-195, Safety, Performance and Interoperability Requirements Document for Airborne Spacing – Flight Deck Interval Management (ASPA-FIM)

## *8.2 Procedures*

## *8.3 Guidance Material*

EUROCONTROL Documents – Flight Crew Guidance on Enhanced Traffic Situational Awareness during Flight Operations; Flight Crew Guidance on Enhanced Situational Awareness on the Airport Surface; Flight Crew Guidance on Enhanced Visual Separation on Approach;

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# Module N° B1-05: Improved Flexibility and Efficiency in Descent Profiles (OPDs)

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|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity, **KPA-04 Efficiency,** KPA-06 Predictability, KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | Descent, Arrival, Flight in Terminal Area | |
| **Applicability Considerations** | | |
| **Global Concept Component(s)** | Airspace Organization and Management (AOM)<br>Demand and Capacity Balancing (DCB)<br>Airspace User Operations (AUO)<br>Aerodrome operations (AO)<br>Traffic synchronization (TS)<br>Conflict management (CM) | |
| **Global Plan Initiatives (GPI)** | GPI-2 Reduced vertical separation minima<br>GPI-5 RNAV and RNP (Performance-Based Navigation)<br>GPI-9 Situational Awareness | |
| **Pre-Requisites** | NIL | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | 2018 |
| | Avionics Availability | √ |
| | Ground System Availability | 2018 |
| | Procedures Available | √ |
| | Operations Approvals | 2018 |

## 1. Narrative

### *1.1 General*

RNP with Vertical Containment is an altimetry-based capability which enables an equipped aircraft to precisely descend on a vertical path, as computed by the Flight Management Computer (FMC), within a tolerance set in feet, while providing the flight crew with navigation performance information though avionics monitoring and alerting. The system defaults to an initial tolerance set by the individual operator, but a crew may select a new tolerance (e.g., 75 feet in the terminal area.) It is similar to lateral containment of RNP, but in the vertical plane.

### 1.1.1 Baseline

The baseline for this block is Improved Flight Descent Profile enabled by Block B0-5. This block is a component of Trajectory-Based Operations (TBO).

### 1.1.2 Change brought by the module

Vertical RNP contributes to Terminal airspace design and efficiency due to an aircraft's ability to maintain a vertical path during descent thus enabling vertical corridors for ingressing and egressing traffic. Other benefits include reduced aircraft level-offs, enhanced vertical precision in the terminal airspace, de-confliction of arrival and departure procedures and adjacent airport traffic flows, and the ability of an aircraft to fly an approach procedure not reliant upon ground based equipment for vertical navigation. This ultimately leads to higher utilization of airports and runways lacking vertical approach guidance.

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

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|---|---|
| *Capacity* | Vertical RNP allows for precision flight in a non precision environment. This capability allows for the potential to expand the applications of standard terminal arrival and departure procedures for improved capacity and throughput, and improve the implementation of precision approaches. |
| *Efficiency* | Enabling an aircraft to maintain a vertical path during descent allows for vertical corridors for ingressing and egressing traffic thus increasing the efficiency of the airspace. Additionally, Vertical RNP promotes the efficient use of airspace through the ability for aircraft to fly a more precisely constrained descent profile allowing the potential for further reduced separation and increased capacity. |
| *Predictability* | Vertical RNP allows for enhanced predictability of flight paths which leads to better planning of flights and flows. |
| *Safety* | Precise altitude tracking along a vertical descent path leads to improvements in overall system safety. |

| | |
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| *CBA* | Safety Enhancement: Flying more precise vertical profiles<br><br>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<br><br>Economic: Vertical RNP allows for reduced aircraft level-offs, resulting in fuel and time savings. |

## 3. Necessary Procedures (Air & Ground)

Flight crews require training in the proper use of the Vertical RNP functions of the FMC. Standard procedures guide the flight crews on which altitude tolerances may be selected for a particular phase of flight.

## 4. Necessary System Capability

### *4.1 Avionics*

The technology for Vertical RNP is contained within the Flight Management Computer.

### 4.2 Ground Systems

N/A

## 5. Human Performance

### 5.1 Human Factors Considerations

TBD

### 5.2 Training and Qualification Requirements

TBD

### 5.3 Others

TBD

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

Vertical RNP availability is better than 99.9%/hour for a single FMC installation. From an equipment certification standpoint, the loss of function is probable. Redundant equipment installation supports improbable loss of function, where required.

## 7. Implementation and Demonstration Activities

### 7.1 Current Use

RNP with Vertical Containment is currently being used on Boeing aircraft during the descent phase of flight.

### 7.2 Planned or Ongoing Activities

No demonstration trials are currently planned for this module. There is a need to develop a trial plan as part of the collaboration on this module.

## 8. Reference Documents

### 8.1 Standards

ED-75B 'MASPS required navigation performance for area navigation.

RTCA DO-236B, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation

Boeing Document D6-39067-3, RNP Capability of FMC Equipped 737, Generation 3

Boeing Document D243W018-13 Rev D, 777 RNP Navigation Capabilities, Generation 1

### 8.2 Procedures

### 8.3 Guidance Material

ICAO Document 9750, Global Air Navigation Plan

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# Module N° B1-40: Improved Traffic Synchronisation and Initial Trajectory-Based Operation

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|---|---|---|
| **Summary** | 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). | |
| **Main Performance Impact** | KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment; **KPA-09 Predictability** KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All flight phases | |
| **Applicability Considerations** | Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those equipped. Benefit increases with size of equipped aircraft population in the area where the services are provided.<br>Not applicable to light aircraft. | |
| **Global Concept Component(s)** | IM – Information Management<br>TS – Traffic Synchronisation<br>CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational awareness<br>GPI-17 Implementation of data link applications<br>GPI-18 Electronic information services | |
| **Pre-Requisites** | None | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **2013** |
| | Avionics Availability | **Est. 2016** |
| | Ground Systems Availability | **Est. 2016** |
| | Procedures Available | **Est. 2018** |
| | Operations Approvals | **Est. 2018** |

## 1. Narrative

### *1.1 General*

This module is a step towards the goal to introduce 4D trajectory based operations that uses the capabilities of aircraft Flight Management Systems to optimise aircraft flight trajectories in four dimensions. Trajectory Based Operations will manage uncertainty by improving predictability for all ATM Stakeholders across all boundaries or ATM sector structures. In this context it will facilitate Traffic Synchronisation and strategic Conflict Management supported by Separation Provision that minimises tactical "radar type" intervention (e.g. open loop vectoring). It also introduces a number of Airport applications that increase safety and reduce controller-pilot workload.

### 1.1.1 Baseline

Traffic synchronisation is based on the flight data processing information fed by flight plan data with current positions updated by radar information and on mental extrapolation by controllers. This is not accurate and represents a workload for assessing the situation and monitoring its evolution. Actions are difficult to anticipate in upstream sectors which may not be aware of the problem to be solved.

The transmission of information at and around airports, including for complex routings is done through voice radio, implying a high workload for pilots and controllers, frequent misunderstandings and repetitions.

### 1.1.2 Change brought by the module

This module implements additional air-ground data link applications to: download trajectory information and improve the synchronisation of traffic flows at merging points, in particular in view of optimising an approach sequence, with negotiation of a required time of arrival using the FMS functionality. Existing ground-ground coordination capabilities will be improved to allow complex route clearances to be exchanged across multiple airspace boundaries.

The module will also implement data transmission for airport/TMA related information and clearances.

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

Supporting this is 4DTRAD, a recognised approach to initial Trajectory Based Operations which offers an advanced view of the future ATM environment including seamless integration of operational goals through an increased situational awareness and by the sharing of air ground data in a strategic and tactical collaborative decision making environment.

4DTRAD requires the availability of sophisticated air ground data exchange that includes use of new ADS-C and data link functionality beyond current capabilities and performance requirements. Furthermore, ground-ground data exchange to exchange complex clearances needs to be secure, widely available.

As a step transition to Trajectory Based Operations, the introduction of a common time reference with the use of aircraft FMS required time of arrival (RTA) and speed control with less demanding performance and technology requirements to that of 4DTRAD promises early predictability and efficiency benefits to airspace users and service providers.

Using the aircraft RTA for planning arrival flows from En-route (or Oceanic) into Terminal airspace is feasible using current aircraft capability with lower performance requirements than for example 4DTRAD. This would only focus on building traffic flows and sequences leaving more precise metering and separation provision to be achieved through current operations or with new RNAV performance based navigation procedures.

Synchronising the RTA and Controlled Time of Arrival (CTA) with appropriate PBN levels offers the opportunity to further develop stable and predictable traffic flows into a Terminal area, letting the pilot optimise the flight profile (e.g. top of descent and descent profile).

Furthermore, predictable pre-planned traffic flows facilitate consistent application of Continuous Decent Operations and Tailored Arrival procedures whilst Terminal holding can be avoided through pre-planned path stretching undertaken by the aircraft using the RTA or speed control as well as integrating both long and short haul flights into arrival sequences.

The deployment of RNP/RNAV procedures and use of techniques such as “Point Merge” and others provide the opportunity to manage aircraft without recourse to radar vectoring intervention, leading to a closed loop FMS operation and an informed ground system supporting efficient aircraft profiles and predictable ATM operations.

To realise such benefits, communication between en-route and terminal control units is needed to coordinate the CTA constraint which may be achieved through existing mechanisms such as on-line data exchange with delivery to the aircraft via R/T or coordination with the airline operations centres to deliver to long haul aircraft by company data link.

A wider approach to the block will consider the combination with arrival management techniques using currently available ground based tools providing a more demanding performance facilitating refined metering of traffic into Terminal airspace and existing CPDLC capability to deliver the CTA.

A first step which relies on existing systems and capabilities or requiring only minor modifications will make use of current FMS capability to define and output an RTA or speed control. Existing data link capabilities such as CPDLC, AOC, or even voice could be used to agree this RTA or speed control with the ground CTA. Most ground systems are incorporating trajectory prediction functionality and existing AMAN calculate the equivalent of a CTA. Ground-ground communications infrastructure will enable the exchange of flight plan and can be updated to exchange CTA.

Beyond this first step more significant changes are anticipated to enable 4DTRAD and trajectory based operations with advanced, and standardised FMS functionality able to provide more accurate and complete trajectory information which could be down linked with new ADS-C or CPDLC protocols. Depending on the definition of this trajectory information for download new data link technology may be required in the long term. The ground-ground communication infrastructure, in the context of SWIM will enable this trajectory information to be made available to the various en-route, terminal and airport systems which can use the common trajectory reference. System modifications to make full use of this trajectory information must also be planned.

Initial 4D operations can be broken down in to two steps; the first is the synchronisation between air and ground of the flight plan or Reference Business Trajectory. The second step is imposing a time constraint and allowing the aircraft to fly its profile in the most optimal way to meet that constraint.

***Trajectory Synchronisation and Monitoring***

The ATM system relies on all actors having the same view; it is therefore essential that the trajectory in the Flight Management System (FMS) is synchronised with that held on the ground in the Flight Data Processing Systems (FDPS) and the wider Network systems.

The crew and the ATC agree on the trajectory to be flown and during the entire execution, they continuously check if it is, and will be, followed by the aircraft. In case of non-conformance warning are raised and a new interaction between the crew and the responsible ATC occurs.

The early air/ground agreement on the trajectory to be flown and its execution allows the FMS to optimize the trajectory providing efficiency benefits to the User in terms of aircraft flight profile optimisation and ensuring maximum environmental benefits, both through reduced fuel burn and optimum routings en-route, in the Terminal Area and in the vicinity of the airport avoiding noise sensitive areas.

Improved consistency between air & ground trajectory ensures that controllers have highly reliable information on aircraft behaviour. This more accurate trajectory prediction enables better performance from the decision support tools providing a better anticipation of congestion by allowing early detection of traffic bunching providing better adaptation to the real traffic situation and reduced inefficient radar based tactical intervention.

The increased levels of predictability mean that potential conflicts within a medium-term time horizon will be identified and resolved early while the increased accuracy of ground computed trajectory, especially for short term prediction, reduces the risk of unexpected events.

***Required Time of Arrival***

The avionics function, Required Time of Arrival (RTA), can be exploited by both en-route and TMA controllers for demand/capacity balancing, metering of flows and sequencing for arrival management.

By preparing the metering of aircraft at an earlier stage of their flight the impact of the constraint is minimised. This allows ATC to make optimum use of capacity at the right time, minimising risks through complexity reduction to ensure that human capabilities are not exceeded. This also supports optimised aircraft profile management by the pilot.

Reduction of inefficient ATC tactical interventions through early planning of traffic en-route and in to the arrival management phase avoids severe and costly sequencing measures. This process enhances aircraft profile optimisation, flight predictability and allows improvements in the stability and reliability of the sequence built by ATC.

It should lead to reduced need for aircraft to hold, inefficiently burning fuel with the associated chemical and noise pollution. Aircraft will be able to plan better and adhere more accurate to arrival schedules leading to better planning for the airlines due to increased flight predictability.

### *1.3 Element 2: Data Link Operational Terminal Information Service (D-OTIS)*

Before flight departure, the flight crew may request meteorological and operational flight information and NOTAMs of the departure and destination aerodrome using a single data link service - Data link-Operational Terminal Information Service (D-OTIS).

At any time during the flight, the pilot may receive automatic updates of the meteo data, operational information and NOTAMS of the destination or alternate aerodromes. D-OTIS may be tailored for the specific flight crew needs and so the pilot can readily form a picture from meteo and operational perspectives.

### *1.4 Element 3: Departure Clearance (DCL)*

The implementation of DCL eliminates potential misunderstandings due to VHF voice, hence enabling the ATC to provide a safer and more efficient service to their users. DCL also enables to reduce controllers' workload. DCL supports the airport system automation and information sharing with other ground systems.

For busy airports, the use of DCL data link results in a significant decrease in ATC tower frequency congestion. CPDLC systems that are integrated with FMS allow direct input of more complex clearances into the FMS.

### *1.5 Element 4: Data link TAXI (DTAXI)*

This provides automated assistance and additional means of communication to controllers and pilots when performing routine communication exchanges during ground movement operations, Start-up, Pushback, Routine taxi messages and Special airport operations.

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

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

| | |
|---|---|
| *Capacity* | Positively affected because of the reduction of workload associated to the establishment of the sequence close to the convergence point and related tactical interventions.<br><br>Positively affected because of the reduction of workload associated to the delivery of departure and taxi clearances. |
| *Efficiency* | Increased by using the aircraft RTA capability for traffic synchronisation planning through en-route and into Terminal Airspace. "Closed loop" operations on RNAV procedures ensure common air and ground system awareness of traffic evolution and facilitate its optimisation.<br><br>Flight efficiency is increased through proactive planning of top of descent, descent profile and en-route delay actions, and enhanced terminal airspace route efficiency. |
| *Environment* | More economic and environmentally friendly trajectories, in particular absorption of some delays. |
| *Predictability* | Increased predictability of the ATM system for all stakeholders through greater strategic management of traffic flow between and within FIRs en-route and Terminal Airspace using the aircraft RTA capability or speed control to manage a ground CTA;<br><br>Predictable and repeatable sequencing and metering.<br><br>"Closed loop" operations on RNAV procedures ensuring common air and ground system awareness of traffic evolution. |
| *Safety* | Safety at/around airports by a reduction of the misinterpretations and errors in the interpretation of the complex departure and taxi clearances. |

| | |
|---|---|
| *CBA* | Establishment of the business case is underway.<br>The Benefits of the proposed Airport services were already demonstrated in the EUROCONTROL CASCADE Programme. |

# 3. Necessary Procedures (Air & Ground)

TBD

# 4. Necessary System Capability

## *4.1 Avionics*

Initial operations based on existing aircraft FMS capability, air-ground data link. The necessary technology is defined in the EUROCAE WG78/RTCA SC 214 standards and comprises converged CPDLC and ADS-C implementations.

## *4.2 Ground Systems*

For ground systems, the necessary technology includes the ground-ground data interchange and the ability to negotiate a time constraint over a given metering fix as well as to process the aircraft trajectory. It also includes the ability to facilitate the provision of start-up, push-back and taxi clearances via data link. Enhanced surveillance through multi-sensor data fusion is required.

# 5. Human Performance

## *5.1 Human Factors Considerations*

Data communications reduce the workload and the risk to misinterpret information in clearances, in particular when typing them in FMS. They allow reducing the congestion of the voice channel with overall understanding benefits and more flexible management of air-ground exchanges.

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

## *5.2 Training and Qualification Requirements*

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

## *5.3 Others*

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

Related to airspace and procedures design based on existing guidance and ICAO material.

Publication of the EUROCAE WG78/RTCA SC 214 standards.

Air and ground certification and approvals basis.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

- Capability used ad hoc for tailored arrivals with RTA as well as arrival planning for Oceanic arrivals plus wide scale trials of point merge techniques now focused on deployment in European Terminal airspace and Approach areas with available OSED SPR material.
- Australia: Planned or Ongoing Trials

- **Europe**: CASCADE D-TAXI and D-OTIS Trials (2007)
- **Europe**: For Initial 4D and Airport Services, SESAR Release 1 and 2 (2011 & 2012).

# 8. Reference Documents

## *8.1 Standards*

- EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280
- EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.
- Point Merge: Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent. Operational Services and Environment Definition – EUROCONTROL, July 2010

## *8.2 Procedures*

## *8.3 Guidance Material*

- Manual of Air Traffic Services Data Link Applications (Doc 9694)
- New OPLINK Ops Guidance under development
- 4DTRAD: Initial 4D – 4D Trajectory Data Link (4DTRAD) Concept of Operations – EUROCONTROL, December 2008
-

# Module N° B1-90 Initial Integration of Remotely-Piloted Aircraft (RPA) Systems into non-segregated airspace

| | | |
|---|---|---|
| **Summary** | Implementation of basic procedures for operating RPAs in non-segregated airspace including detect and avoid. | |
| **Main Performance Impact** | KPA-01 Access & Equity, KPA-10 Safety | |
| **Domain/Flight Phases** | En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing) | |
| **Applicability Considerations** | Applies to all RPAS operating in controlled airspace and at aerodromes. Requires good synchronization of airborne and ground deployment to generate significant benefits, in particular to those able to meet minimum certification and equipment requirements. | |
| **Global Concept Component(s)** | AOM - Airspace Organization and Management<br>CM - Conflict Management<br>AUO - Airspace User Operations | |
| **Global Plan Initiatives (GPI)** | GPI-6, Air traffic flow management<br>GPI-9, Situational awareness<br>GPI-12, Functional integration of ground systems with airborne systems<br>GPI-17, Data link applications | |
| **Main Dependencies** | | |
| **Global Readiness Checklists** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

This module will discuss the baseline from which the improvements discussed will be based. The aim is to move from accommodation of RPA, to integration into traffic within controlled airspace and at controlled aerodromes, and finally to full transparent operation within the airspace. Block 1 is the first step in this process. The Block 1 improvements are:

- Streamline process to access non-segregated controlled airspace
- Define airworthiness certification for RPA
- Define operator certification
- Define remote pilot licensing requirements
- Define detect and avoid technology performance requirements

The United States, specifically the FAA, is in the review process for defining "small UAS" procedures: Once small UAS procedures are approved, small UAS operations in the U.S., outside of military operating areas may be permitted, first in unpopulated, then sparsely populated areas. Small UAS policy will be based on the successive expansions of use and the rules and procedures that are established. These small UAS procedures will continue to be developed to allow small UAS to operate in more types of airspace. VLOS will be used to provide detect and avoid mitigation for these UAS. This is a U.S.-focused approach that currently may not apply for other States.

Some States are looking at localized ground-based detect and avoid (GBDAA) technology to support the detect and avoid requirements.

Below is a list of definitions that are used in the development of this block.

- ***Command and control (C2) link.*** The data link between the remotely-piloted aircraft and the remote pilot station for the purposes of managing the flight.
- ***Controlled airspace.*** An airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification.
- ***Segregated airspace.*** Airspace of specified dimensions allocated for exclusive use to a specific user(s).
- ***Detect and avoid.*** The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.
- ***Remote pilot.*** A person charged by the operator with duties essential to the operation of a remotely-piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.
- ***Remote pilot station.*** The component of the remotely-piloted aircraft system containing the equipment used to pilot the remotely-piloted aircraft.
- ***Remotely-piloted aircraft (RPA).*** An unmanned aircraft which is piloted from a remote pilot station.
- ***Remotely-piloted aircraft system (RPAS).*** A remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links, and any other components as specified in the approved type design.
- ***RPA observer.*** A trained and competent person designated by the operator who, by visual observation of the remotely-piloted aircraft, assists the remote pilot in the safe conduct of the flight.
- ***Visual line-of-sight (VLOS) operation.*** An operation in which the remote pilot or RPA observer maintains direct visual contact with the remotely-piloted aircraft.

### 1.1.1. Baseline

The baseline is applicable to RPA IFR operations in non-segregated controlled airspace, including over the high seas, and at controlled aerodromes.

| Block 1 | Class B and C Airspace | Class A Airspace (Other than High Seas) | High Seas (Class A Airspace) | Class D, E, F, and G |
|---|---|---|---|---|
| **Authorization** | Strict compliance with the provisions of the authorization is required | | | Operations not permitted, unless by waiver or authorization |
| **C2 Link Failure Procedures** | Must be clearly defined. Will be pre-coordinated with the appropriate ATC facility and included in the authorization. Will include as determined by State authorities: C2 link failure route of flight, transponder use including a standard squawk code, emergency orbit points, communications procedures, and pre-planned flight termination points in the event recovery of the RPA is not feasible. | | | |
| **Communications** | Continuous two-way communications as required for the airspace. RPA will squawk 7600 in case of communications failure. | | Continuous two-way communications will be maintained directly or via a service provider (e.g. ARINC or SITA) depending on location and operation. | |
| **Separation Standards** | TBD<br>(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 | | | |

| | | |
|---|---|---|
| **Populated Areas** | Restrictions to be determined by the State | |
| **ATC Services** | Consistent with Annex 11 | |
| **Flight Plan** | RPA operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed. | |
| **Meteorological Conditions** | Restrictions to be determined by the State | |
| **Transponder** | RPA shall have and use an operating mode C/S transponder | |
| **Safety** | Identify the hazards and mitigate the safety risks; adhere to the authorization | |
| **NOTAMs** | NOTAM requirements, if any, to be determined by the State | |

### 1.1.2. Change brought by the module

**Streamline process to access non-segregated controlled airspace**. State authorities will need to consider if current national/regional processes are adequate for enabling the level of airspace access necessary to accomplish all missions proposed or envisioned for RPA flights. While international RPAS standards and certification requirements are being developed, national and/or regional authorization processes will be used to access airspace. Methods for improving and streamlining these processes will be worked on during this time frame. Approval to use existing technologies, such as ground-based detect and avoid systems, may support access to airspace through enhanced collision avoidance capability. This will allow authorities to streamline the process to grant authorization for airspace access.

**Defining airworthiness certification for RPAS**: Standards committees (such as RTCA SC-203, ASTM F 38, EUROCAE WG 73, and others) will continue their work in the Block 1 timeframe, developing minimum aviation system performance standards (MASPS). Certification takes into account system configuration, usage, environment, and the hardware and software of the entire system (e.g. aircraft, remote pilot stations, C2 links). It also considers design characteristics, production processes, reliability, and in-service maintenance procedures that adequately mitigate risk of injury/damage to people, property or other aircraft. EASA's Rulemaking Directorate has issued policy statement E. Y013-01 for Airworthiness Certification of RPAS that outlines procedures for type certification of civil RPA once standards have been established. Technical standards might be used to certify specific components of the RPAS. The certificate of Airworthiness will be issued to the aircraft while considering the entire system. The C2 links will have to meet identified performance criteria. Certification standards and procedures will need to be worked out during this time frame.

**Define operator certification:**

(This is being worked on by UASSG)TBD

**Define remote pilot licensing requirements:**

(This is being worked on by UASSG, EASA and some States)TBD

**Define detect and avoid** technology performance requirements. These performance-based requirements will be developed and certified to support the RPAS operational improvements as discussed above. The technology will be developed in conjunction with other risk mitigation efforts to gain incremental access to the airspace. Initial capabilities may include ground-based detect and avoid systems consisting of any combination of policy, procedures, and technology derived from ground-based sensors intended to facilitate safe airspace access over land or water. Surveillance (radar, ADS-B) initiatives will help gather, test, and verify data, along with the appropriate modeling and simulation activities, to establish requirements and build an overall safety case for detect and avoid. The detect and avoid technology will be used by the remote pilot to meet collision and hazard avoidance responsibility and provide situational awareness.

#### 1.1.1 Other Remarks

This module describes the baseline and consists of only one element, accommodation of RPA operating in controlled airspace. All of the improvements are related to this activity of accommodating the RPA in the controlled airspace.

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

| | |
|---|---|
| *Capacity* | Could be negatively impacted due to larger separations being applied for safety reasons between RPA and traditional traffic |
| *Efficiency* | Access to airspace by a new category of users. |
| *Environment* | The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States. |
| *Predictability* | Increased predictability of RPA through global interoperability of communications and situational awareness. |
| *Safety* | Increased situational awareness; controlled use of aircraft |

| | |
|---|---|
| *CBA* | The business case is directly related to the economic value of the aviation applications supported by RPAS. |

## 3. Necessary Procedures (Air & Ground)

It is anticipated that as the improvements take shape in this block, air traffic services and procedures will have to change to accommodate these new airspace users. RPAS procedures such as C2 link failure will need to be standardized. These procedures may include a specific transponder code or ADS-B emergency mode to indicate a C2 link failure.

## 4. Necessary System Capability (Air & Ground)

### *4.1 Avionics*

Communications includes traditional voice/data communications as well as all data related to command and control of the RPA. Current air-to-ground communications networks presume the pilot is on board the aircraft. The implications of the remote pilot being external to the aircraft will require a review and revision to preferred communications networks as well as bandwidth to support the amount of data required to operate and manage the RPA (STANAG 4586).

### *4.2 Ground Systems*

Ground-based Detect and Avoid (GBDAA) is the technology in this time frame envisioned to afford the greatest return on investment to allow better access to non-segregated airspace. This technology will improve the “detect and avoid” situational awareness for the remote pilot within the specific coverage areas defined by the systems and has the potential to be the near/midterm solution to the detect and avoid problem plaguing the RPAS community. This approach is currently utilized on a limited basis and may become a global approach in this time frame.

## 5. Human Performance

### *5.1 Human Factor Considerations*

The controller-pilot relationship is changing and will need to be investigated. Specific training for controllers, remote pilots and pilots will be required, in particular with respect to the new detect and avoid situations.

### *5.2 Training and Qualifications Requirements*

### *5.3 Others*

## 6. Regulatory/standardization needs and Approval Plan (Air & Ground)

- Certificate of airworthiness
- Operator certificate
- Remote pilot licence
- Frequency spectrum
- Communications (including C2 link failure)
- Detect and avoid

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

None at this time.

## *7.2 Planned or On Going Trials*

- In the US and Europe, several civil applications, initially VLOS and more integration of civil IFR/VFR operations in this time frame are expected based on full certification and special authorization
- Requirements for frequency spectrum for RPAS will be established in this time frame
- SESAR addresses UAS within WP 9, 11 and 15
- The European Defence Agency has launched the MIDCAS project. It is addressing detect and avoid from both military and civil perspectives. The budget is 50 million euros and it is expected to produce a working prototype for detect and avoid application by the end of 2013.
- Mercator, an ultra-light UAS that is solar/battery powered for long duration flights at around FL450 is being tested in Belgian airspace to demonstrate a UAS flight in a busy ATM environment.

### 7.2.1 Europe

- EUROCONTROL is in the process of integrating an RPAS in Class C and D airspace under IFR and VFR. Detect and avoid is mitigated through GBDAA and scanning through the on-board camera system. This will enable further integration.
- The MIDCAS consortium is developing a detect and avoid test bed that should be available for testing beginning in 2012
- In regard to VLOS, the Netherlands will certify an RPAS this year (civil certified)
- Euro Hawk is flying in controlled airspace as “operational air traffic”
- EUROCAE (EC) has finalized their work on a guidance document for VLOS
- A strategy document outlining EC policy on UAS is in preparation through an EC UAS panel, addressing industry and market issues, UAS insertion and spectrum, safety, societal dimensions and R&D
- Legal framework for the development of AMC (???) is in place. EASA will only deal with UAS with a mass greater than 150 kg.

### 7.2.2 United States

The baseline is currently being used in the U.S. The Army has an authorization for ground-based sense and avoid (GBSAA) operations of their Medium/Large RPA, the Sky Warrior (Predator variant) at El Mirage, CA. The Marines/Navy are in the process of getting authorization for GBSAA operations at Cherry Point, SC. The USAF is looking at a corridor for Predator/Reaper aircraft climbing out of Cannon AFB, NM. This GBSAA concept will include a 12 NM corridor between the military Class D airspace and nearby restricted airspace. By 2013, the USAF will have developed a Dynamic Protection Zone (DPZ) concept that will shrink these large exclusion zones down to non-cooperative aircraft self-separation criteria of less than 10 NM much like is used for cooperative aircraft flying under IFR today.

# 8. Reference Documents

## *8.1 Standards*

- ICAO Circ 328 – *Unmanned Aircraft Systems (UAS)*
- Annex 2 — *Rules of the Air* proposal for amendment
- U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*

## *8.2 Procedures*

TBD

### *8.3 Guidance Material*

EUROCAE Document (under development)

# BLOCK 2

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# Module N° B2-70: Advanced Wake Turbulence Separation (Time-based)

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | **KPA-02 Capacity**; | |
| **Domain / Flight Phases** | Aerodrome | |
| **Applicability Considerations** | 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. | |
| **Global Concept Component(s)** | CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-13 Aerodrome Design<br>GPI 14 Runway Operations | |
| **Main Dependencies** | Pre-requisite: B0 and B1-70 | |
| **Global Readiness Checklist** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

Refinement of the Air Navigation Service Provider (ANSP) aircraft-to-aircraft wake mitigation processes, procedures and standards to time-based assignment will allow increased runway capacity with the same or increased level of safety. Block 2 upgrade will be accomplished without any required changes to aircraft equipage or changes to aircraft performance requirements although full benefit from the upgrade will require, as in block 1, aircraft broadcasting their aircraft based real-time weather observations during their airport approach and departure operations to continually update the model of local conditions.. The upgrade is dependent on the block 1 establishment of wake turbulence characterization based on the wake generation and wake upset tolerance of individual aircraft types.

#### 1.1.1 Baseline

ANSP applied wake mitigation procedures and associated standards were developed over time, with the last comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved 6 category wake turbulence separation standards. Block 1 represented technology being applied to make available further runway capacity savings by enhancing the efficiency of wake turbulence separation standards and the ease by which they can be applied by the ANSP. In particular the expansion of the 6 category wake separation standards to a Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings), is expected to yield an average increased airport capacity of 4% above that which was obtained by the Block 0 upgrade to the ICAO 6 category wake separation standards. In addition Block 1 expanded the use of specialized ANSP wake mitigation separation procedures to more airports by using airport wind information (predicted and monitored) to adjust the needed wake mitigation separations between aircraft on approach.

### 1.1.2 Change brought by the module

Module B2–70 represents a shift to time-based application of the Block 1 expanded distance based wake separation standards and ANSP wake mitigation procedures upgrade. Block 1 represented technology being applied to make available further runway capacity savings by enhancing the efficiency of wake turbulence separation standards by expanding the 6 category wake separation standards to a Leader/Follower - Pair Wise Static matrix of aircraft type wake separation pairings (potentially 64 or more separate pairings). Automation supported the ANSP by providing the minimum distance to be applied by the ANSP between pairs of aircraft. That expanded matrix represented a less conservative, but albeit still conservative, conversion of essentially time based wake characteristics into a standard set of distances.

Block 1's goal was to reduce the number of operations in which an excessive wake spacing buffer reduced runway throughput. Block 2 uses the underlying criteria represented in the expanding re-categorization, the current winds, assigned speeds, and real time environmental conditions to dynamically assess the proper spacing between the aircraft to achieve wake separation. It couples that information with expect runway occupancy to establish a time spacing that provides a safe separation. These time-based separations are provided with support tools to the ANSP on their displays, and to the flight deck in the instances of cooperative separation which assumes already available flight deck tools for interval management. Further development of the Time-based separation will use Weather dependent separation (WDS) which develops the basic weather dependent concepts further and integrated with Time-Based Separation for approach. This concept utilises both wake decay and transport concepts (such as P-TBS and CROPS) into a single coherent concept, backed by advanced tools support and provides further landing rate improvements and resilience.

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

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

| | |
|---|---|
| *Capacity* | |
| *Efficiency* | |
| *Environment* | |
| *Predictability* | |
| *Safety* | |

| | |
|---|---|
| *CBA* | |

## 3. Necessary Procedures (Air & Ground)

### *Implement Leader/Follower - Pair Wise Time-based Separation Standards*

The change to the ICAO wake separation standards implemented in the Block 2 timeframe will change from a distance based separation that was expanded through the previous blocks from 3 to 60 or more to a tailored time-based minima.

Implementing Element 2 will not require any changes to air crew flight procedures.

## 4. Necessary System Capability

### *4.1 Avionics*

N/A

### *4.2 Ground System*

This new ANSP procedure will need automation support in providing the required time-based aircraft-to-aircraft wake separations to its air traffic controllers.

## 5. Human Performance

### *5.1 Human Factors Considerations*

TBD

### *5.2 Training and Qualification Requirements*

TBD

### *5.3 Others*

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

***5.1 Implement Leader/Follower - Pair Wise Time-based Separation Standards***

The product of this activity is a new procedure with supporting automaton requirements to establish time-based separation standards for high density and high throughput terminal areas. This will require an expansion of ICAO wake separation standards and supporting documentation. Once approved, ICAO's revised wake separation standards will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

None at this time

### *7.2 Planned or Ongoing Trials*

Currently being developed by SESAR WP 6.8.1

## 8. Reference Documents

### *8.1 Standards*

### *8.2 Procedures*

### *8.3 Guidance Materials*

ICAO Doc 9854 Global ATM Operational Concept, and ICAO Doc 9750 Global Air Navigation Plan
This module also incorporates R199Doc 9882

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# Module N° B2-75: Optimised Surface Routing and Safety Benefits (A-SMGCS Level 3-4, ATSA-SURF IA and SVS)

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-04 Efficiency, KPA-10 Safety | |
| **Domain / Flight Phases** | Aerodrome | |
| **Applicability Considerations** | Most applicable to large aerodromes with high demand, as the upgrades address issues surrounding queuing and management and complex aerodrome operations | |
| **Global Concept Component(s)** | AO - Aerodrome Operations<br>CM - Conflict Management<br>DCB - Demand Capacity Balancing<br>TS - Traffic Synchronisation | |
| **Global Plan Initiatives (GPI)** | GPI-14 Runway Operations<br>GPI-16 Decision Support Systems and Alerting Systems<br>GPI-17 Data Link Applications | |
| **Main Dependencies** | B1-75, Enhanced Surface Situational Awareness<br>Technical or operational relationship to: B2-80 (Remote Tower) | |
| **Global Readiness Checklist** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

This module is focused on improving the baseline case (completion of B1-75, Enhanced Surface Situational Awareness), by the introduction of new capabilities that enhance the coordination among ANSP, Airspace Users, and the Aerodrome Operator, and permit automated management of surface operations:

- Initial Surface Traffic Management (A-SMGCS Level 3)

- Enhanced Surface Traffic Management (A-SMGCS Level 4)

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

choose their own priorities for assigning specific flights to these taxi opportunities. This capability will have basic ability to incorporate any Air Traffic Flow Management Constraints to specific flights.

- Data Sharing – information about taxi times, queues, and delays is shared with other ANSP flight domains, and with external users (airspace users and airport operators).
- Improved Guidance by use of Aerodrome Ground Lighting – ground lighting systems on the aerodrome are enhanced to provide visual cues to aircraft operating on the surface.

These activities are intended to directly improve efficiency by maximizing runway use while minimizing taxi times, within the context of any higher level Air Traffic Flow Management strategy and available airport resources (e.g. gates, apron areas, stands, taxiways, etc.). This will result in reduced fuel burn, with associated lowering of environmental impacts.

Further, data sharing will improve the information available to Air Traffic Flow Management, leading to better coordination and decision making among ANSP and airspace users. A secondary impact of this element will be improved safety, as conformance to taxi clearance is monitored. Aircraft will receive taxi clearances electronically, to further reduce potential confusion about taxi routes. These capabilities also lessen the impact of reduced visibility conditions on the aerodrome operation.

### *1.3 Element 2: Enhanced Surface Traffic Management (A-SMGCS Level 4)*

This element of the block enhances capabilities from Element 1:

- Taxi Trajectories – automation builds a predicted trajectory for each aircraft including times along the taxi path. When this capability matures, taxi trajectories will be used to assist with deconflicting runway crossings. Conformance monitoring is enhanced to monitor against trajectory times in addition to paths, with prediction and resolution of taxi trajectory conflicts.
- Taxi Trajectory Guidance for Pilots – digital taxi clearances are parsed by the aircraft avionics to allow depiction of the taxi route on surface moving maps. Avionics may be further enhanced to provide visual and/or aural guidance cues for turns in the taxi route, as well as taxi speed guidance to meet surface trajectory times. This can be displayed on the instrument panel or on a Heads-Up Display.
- Synthetic Vision Systems – area navigation capability on the aircraft and detailed databases of aerodromes will allow for a computer-synthesized depiction of the forward visual view to be displayed in the cockpit. Integration with Enhanced Vision System will add integrity to this depiction. This capability reduces the impact that low visibility conditions have on the safety and efficiency of the surface operation. The depiction can be displayed on the instrument panel or on a Heads-Up Display.
- Flight-Specific Departure Schedule Management – ANSP and airspace users will collaboratively develop a flight-specific surface schedule. Automation assists in identifying appropriate departure times that consider any Air Traffic Flow Management actions. Other operational factors such as wake turbulence separation requirements will be considered by automation in sequencing aircraft for departures. Pushback and taxi operations will be managed to this schedule.
- Integration with Arrival and Departure Management – taxi schedules are built to account for arriving aircraft, and so that aircraft departures meet the objectives for system-wide Air Traffic Flow Management activities. Flight will be permitted to pushback with the intent to meet targeted departure times.

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

| | |
|---|---|
| *Access and Equity* | 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. |
| *Efficiency* | 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.<br>a. Reduced Taxi Out Times<br>i. Reduced fuel burn and other direct operating cost<br>ii. Associated reduced impact to environment<br>b. Reduced Start/Stop of during Taxi<br>iii. Reduced fuel burn and other direct operating cost<br>iv. Associated reduced impact to environment |
| *Flexibility* | a. Improved ability to re-sequence departing aircraft to meet changing conditions<br>b. Coordination with Air Traffic Flow Management<br>i. Improved ability to predict congestion (actual demand vs. capacity)<br>a. Improved application of Air Traffic Flow Management by trajectory<br>b. Improved Information to Air Traffic Flow Management<br>i. Improved ability to predict congestion (actual demand vs. capacity)<br>ii. Improved application of Air Traffic Flow Management Actions<br>c. Improved flexibility on the aerodrome surface by improving the ability to re-sequence departing aircraft to meet changing conditions |
| *Safety* | 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.<br>a. Reduced Taxi Non-Conformance<br>b. Reduced Taxi Clearance Communications Errors |

| | |
|---|---|
| *CBA* | 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. |

## 3 Necessary Procedures (Air & Ground)

Significant ANSP procedure changes for managing aerodrome surface operations will be required, including the creation of collaboration procedures and norms with airspace users and/or aerodrome operators for aggregate surface scheduling. In particular, managing surface operations by ANSP control of pushback times is potentially a significant change in aerodrome management policies at many locations. Specific procedures for each element and sub-element are required to effectively achieve the benefits of this module, and ensure safety, including procedures for ANSP use of Data Link Taxi Clearances and procedures for coordination with Air Traffic Flow Management.

Airspace users and/or aerodrome operators need to make significant changes to their procedures for managing surface operations, especially for the collaborative building of aggregate surface taxi schedules and the accommodation of ANSP control of pushback times.

Flight deck procedures for use and integration of Data Link Taxi Clearances are required.

## 4 Necessary System Capability

### 4.1 Avionics

The following aircraft technology is required:

1. Data Link Communications
2. Synthetic Vision System
3. Taxi Trajectory Guidance capability

### 4.2 Ground Systems

The following ANSP technology is required:

1. Initial and enhanced A-SMGCS / Surface Traffic Management Automation
2. Data sharing with Air Traffic Flow Management
3. Data Link Communications.

This element also requires an airspace user/aerodrome operator technology deployment in the form of an Enhanced A-SMGCS / Collaboration capability with ANSP Surface Traffic Management capability.

## 5 Human Performance

### 5.1 Human Factors Considerations

Since ground operations procedural changes for managing aerodrome surface operations will be required, including the creation of collaboration procedures and norms with airspace users and/or aerodrome operators for aggregate surface scheduling, human factors must be considered and demonstrated during the planning process. Human factors must also be considered in the context of workload and failure modes to ensure safety, including procedures for ANSP use of Data Link Taxi Clearances.

Human factors in the form of workload analysis must also be considered for airspace users and/or aerodrome operators when they make significant changes to their procedures for managing surface operations, especially for the collaborative building of aggregate surface taxi schedules and the accommodation of ANSP control of pushback times.

Additional studies must be completed as to the effects of changes in flight deck procedures for use and integration of Data Link Taxi Clearances.

### 5.2 Training and Qualification Requirements

Automation and procedural changes for aircrews, controllers, ramp operators, etc. will invoke necessary training for the new environment and to identify operational and automation issues before implementation. Scenarios will also have to be developed and trained that incorporate likely hood of occurrences of off nominal situations so the full capability of this module can be implemented.

# 6 Regulatory/Standardisation needs and Approval Plan (Air & Ground)

Standards for (a) Initial and Enhanced A-SMGCS / Surface Traffic Management Automation, (b) communication standards with Air Traffic Flow Management and Airspace User and/or Aerodrome Operators (aggregate collaboration on schedule, (integration of arrival, surface, and departure schedules), (c) Data Link Communications (d) Flight Deck Taxi Trajectory Guidance, and (e) Flight Deck Synthetic Vision Systems (RTCA SC-213/Eurocae WG-79).

# 7 Implementation and Demonstration Activities

## *7.1 Current Use*

ANSPs and commercial companies have developed initial capabilities in this area. These capabilities allow for data exchange of surface surveillance data between ANSPs, airspace users, and airport operators. Enhancements to operations are largely cantered on improvements that shared surface situational awareness provides.

## *7.2 Planned or Ongoing Trials*

### 7.2.1 Initial Surface Traffic Management (A-SMGCS Level 3)

Various ANSPs, research and government organizations and industry are working on prototype capabilities of Surface Traffic Management. These activities include Surface Traffic Management / Airport Collaborative Decision Making capabilities and concepts under evaluation at airports around the world (e.g. Memphis, Dallas-Fort Worth, Orlando, Brussels, Paris/Charles de Gaulle, Amsterdam, London/Heathrow, Munich, Zurich, and Frankfurt). Laboratory simulation experiments on more advanced capabilities such as Taxi Conformance Monitoring (MITRE) have been performed. European development is being accomplished via SESAR Work Program 6, Eurocontrol, and others. Deployment in the United States of initial capabilities is slated for the 2018 timeframe.

### 7.2.2 Enhanced Surface Traffic Management (A-SMGCS Level 4)

Collaborative Departure Scheduling is under research in the US and Europe, but has not yet undergone operational trials. Laboratory simulation experiments on more advanced capabilities such as Taxi Route Guidance (NASA) have been performed. Other areas such as management of aerodrome surface operations by trajectory are still under concept formulation.

# 8. Reference Documents

**8.1 Standards**

EUROCAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280

EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.

**8.2 Procedures**

**tbd**

**8.3 Guidance Material**

- ICAO Doc 9830 Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual
- FAA Advisory Circulars:

- AC120-28D Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout
- AC120-57A Surface Movement Guidance and Control System
- Manual of Air Traffic Services Data Link Applications (Doc 9694)

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Morgan, C.E., “A high-level description of Air Traffic Management Decision Support Tool Capabilities for NextGen Surface Operations”, MP100131, July 2010

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Truitt, T. R., & Muldoon, R. V. (2007). New electronic flight data interface designs for airport traffic control towers: Initial usability test (DOT/FAA/TC-07/16). Atlantic City, NJ: U.S. Department of Transportation, Federal Aviation Administration.

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Atkins, S., “Implication of Variability in Airport Surface Operations on 4D Trajectory Planning”, ICAS, AIAA-2008-8960, September 2008

Rappaport, D., et al, “Quantitative Analysis of Uncertainty in Airport Surface Operations”, ATIO, AIAA-2009-6987, September 2009 – Indicated that the overall effect (penalty) of airport reconfiguration was minimal. Suggests that the marginal benefit of improving taxi paths in these circumstances would be small.

Morgan, C., et al, “Mid-Term Surface Trajectory-Based Operations (STBO) Concepts of Use: Summary” MITRE Technical Report 100269V1, Sept. 2010

Morgan, C.E., “Surface Conformance Monitoring Concept of Use for the Mid- and Far- Term, Coordination Draft v1.0”, (Section 3) MITRE Technical Report 090248, August 2009

Brinton, C., et al, “Analysis of Taxi Conformance Monitoring Algorithms and Performance”, ICNS Conference, May 2007

Truit, T. et al, “Data Communications Segment 2 Airport Traffic Control Tower Human in the Loop Simulation”, DOT/FAA/TC-10/05July 2010

Hopff, P., “D-TAXI Trials at Brussels Airport”, Eurocontrol CASCADE Workshop, Toulouse April 2006.

NASA CTO-5, ATMSDI Surface Management System, Final Life-Cycle Benefits Assessment – June 2004.- Improved runway allocation provided single year benefits of $172.8 M / year if implemented at 52 airports – 92 m/year at 18 airports; Improved data for sector demand prediction (over ETMS) – 38.2$M /yr

Dan Howell, “Effect of Surface Surveillance Data Sharing on FedEx Operations at Memphis International Airport”, Air Traffic Control Quarterly, Vol. 13, No. 3, 2005 - 0.7 min reduction in taxi time for North Flow, 0.3 in South Flow; ROM – 0.5 min/flt – say 10-20K flts/day = 1.8-3.6 m min/yr ~100m$/yr

Brinton, C. “Collaborative Airport Surface Metering for Efficiency and Environmental Benefits” (Mosaic ATM?) - 96-193m$ in just fuel benefits

AIAA-2001-4360 – Using Surface Surveillance to Help Reduce Taxi Delays

Eurocontrol, “Airport CDM DMAN Evaluation at Brussels Airport Zaventem” v1.0, 2008.

Tuinstra, Eugene. And Klaus Haschke. “Generic Operational Concept for Pre-departure Runway Sequence Planning and Accurate Take-Off Performance: Enabled by DMAN interation with Airport CDM and A-SMGCS concepts.” Eurocontrol, 9 July 2009.

# Module N° B2-15: Linked AMAN/DMAN

| | | |
|---|---|---|
| **Summary** | Synchronised AMAN/DMAN will promote more agile and efficient en-route and terminal operations | |
| **Main Performance Impact** | KPA-02 Capacity; **KPA-04 Efficiency**; KPA-09 Predictability<br>KPA-06 Flexibility | |
| **Domain/ Flight Phases** | Aerodrome and Terminal | |
| **Applicability Considerations** | Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.<br>The implementation of this module is Least Complex.<br>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.<br>Infrastructure for RNAP/RNP routes need to be in place. | |
| **Global Concept Element(s)** | TS – Traffic Synchronization | |
| **Global Plan Initiative** | **GPI-6** Air Traffic Flow Management | |
| **Main Dependencies** | B1-15 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2025** |
| | Avionics Availability | **Est. 2025** |
| | Ground Systems Availability | **Est. 2025** |
| | Procedures Available | **Est. 2025** |
| | Operations Approvals | **Est. 2025** |

## 1. Narrative

### *1.1 General*

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

In Block 2 (2023), departure and arrival sequencing will be synchronised. Arrival and departure exact strains on the same aerodrome resources. Thus, the coupling of arrival and departure manager will harmonize and de-conflict the respective flows and enable more efficient runway utilization. ATM authorities can now coordinate arrival and departure activities and devise an arrival/departure sequence that avoids conflicts between the two. The synchronization of arrival and departure management allows ANSPs to configure arrival and departure procedures to maximize utilization of aerodrome and terminal airspace.

This synchronisation will foster greater runway throughput and airspace capacity. In addition, the integration enables dynamic sequencing for both arrival and departure. The ANSP can, based on runway configuration and demand, adjust departure and arrival flow by manipulation of meter fixes and such that airspace capacity is used efficiently. This joint sequencing will aid with ANSP’s demand and capacity balancing prerogatives and enable more efficient terminal and aerodrome airspace configuration.

Synchronisation of arrival and departure sequences relies upon operational consistency and information homogeneity. Flight information, such as speed, position, restrictions, and other relevant information, must be uniform and share across all ATC authorities. Information homogeneity and common procedures are essential in achieving the operational consistency between ATC authorities that is the stepping stone for departure and arrival synchronisation.

### 1.1.1 Baseline

Block 1 brought about the synchronisation of surface and departure management. Specifically, surface management and departure sequencing will be linked to further streamline departure operations. Surface and departure activities will be coordinated. Precise surface movement reduces runway occupancy time and improve conformance to assigned departure time. RNAV/RNP procedures usage in high density terminal domain is more prevalent. Greater usage of RNAV/RNP procedures optimises throughput and provides fuel-efficient routes for airspace users. Metering will also be extended into adjacent FIR airspace, ensure greater monitoring on conformance to Control Time of Arrivals. Extended metering will also assist in transitioning flights from en-route to terminal airspace.

### 1.1.2 Change brought by the module

In Block 2, arrival and departure sequencing will be synchronised. The primary benefits of such synchronisation are optimised allocation of airspace/aerodrome resources, resulting in greater runway and airspace throughput. Arrival and departure flow can be sequence to circumvent the negative impacts of natural phenomena, separation restrictions, and conflicts. This gives ATM greater latitude in coping with excess demand. Runway and airspace configuration can be dynamically adjusted to accommodate any change in the arrival/departure flow patterns. Integrated arrival and departure management ensure that aircrafts are optimally spaced to achieve the maximum throughput.

The synchronised information flow as the result of harmonisation between departure and arrival also foster greater common situation awareness for all stakeholders. Information transferred between all ATC authorities involved will be reconciled to provide a common operational picture. This reduces the complexity

### *1.2 Element 1: Arrival and Departure Synchronization*

Arrival and departure synchronization establishes a predictable and efficient stream of flights in the terminal and aerodrome airspace. The synchronization will optimize both terminal procedures and runway configuration to accommodate the maximum volume of aircrafts. Dynamic sequencing of arrival and departure flow will aid in the optimization of terminal procedures by avoiding or lessening the impact of relevant restrictions. The coupled arrival and departure sequence can be adjusted to accommodate the demand and terminal domain resource constraints.

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

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

| | |
|---|---|
| *Capacity* | Decrease in Miles-in-Trail (MIT) restrictions implies greater capacity in the terminal and aerodrome domain |
| *Efficiency* | Optimize utilization of terminal and runway resources. a. Optimize and coordinate arrival and departure traffic flows in the terminal and aerodrome domain |
| *Predictability* | Decrease uncertainties in aerodrome/terminal demand prediction |

| | |
|---|---|
| *Flexibility* | Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns |

| | |
|---|---|
| *CBA* | 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)[3] 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. |

## 3. Necessary Procedures (Air & Ground)

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

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

## 4. Necessary System Capability

### *4.1 Avionics*

No additional avionics beyond Block 0 is required for the implementation of this module.

### *4.2 Ground Systems*

Mechanism to share relevant information effectively and in a timely manner is essential to this element and also fosters greater common situational awareness between all users of the aerodrome and its surrounding airspace.

## 5. Human Performance

### *5.1 Human Factors Considerations*

ATM personnel responsibilities will not be affected

### *5.2 Training and Qualification Requirements*

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

[3] Exhitbit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

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

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

# 7. Implementation and Demonstration Activities

## *7.1 Planned or Ongoing Trials*

Linked AMAN/DMAN will be introduced as the next step following the integration of surface and departure management. The integration of arrival and departure management realizes the synchronization of arrival, departure, and surface operations.

# 8. Reference Documents

## *8.1 Standards*

## *8.2 Procedures*

## *8.3 Guidance Material*

European ATM Master Plan,

SESAR Definition Phase Deliverable 2 – The Performance Target,

SESAR Definition Phase Deliverable 3 – The ATM Target Concept,

SESEAR Definition Phase 5 – SESAR Master Plan

TBFM Business Case Analysis Report

NextGen Midterm Concept of Operations v.2.0

RTCA Trajectory Concept of Use

# Module N° B2-25 Improved Coordination through multi-centre Ground-Ground Integration: (FF-ICE/1 and Flight Object, SWIM)

| | | |
|---|---|---|
| **Summary** | FF-ICE supporting Trajectory based Operations through exchange and distribution of information for multicentre operations using Flight Object implementation and Interoperability (IOP) standards.<br><br>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 then two ATSUs. | |
| **Main Performance Impact** | KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, **KPA-07 Global Interoperability,** KPA-08 Participation by the ATM community KPA-10 Safety, | |
| **Operating Environment/Phases of Flight** | All flight phases and all types of ground stakeholders | |
| **Applicability Considerations** | Applicable to all ground stakeholders (ATS, Airports, Airspace Users) in an homogeneous areas, potentially global. | |
| **Global Concept Component(s)** | AUO –Airspace User Operations<br>AO – Airport Operations<br>DCB – Demand capacity Balancing<br>CM - Conflict management<br>IM - Information Management | |
| **Global Plan Initiatives (GPI)** | GPI-7 Dynamic and flexible route management<br>GPI-12 Functional integration of ground systems with airborne systems<br>GPI-16 Decision Support Systems | |
| **Pre-Requisites** | Successor of B1-25, B1-31 | |
| **Global Readiness Checklist** | | **Status (ready now or estimated date)** |
| | Standards Readiness | Est; 2018 |
| | Avionics Availability | No requirement |
| | Ground Systems Availability | Est; 2020 |
| | Procedures Available | Est. 2020 |
| | Operations Approvals | Est; 2020 |

## 1. Narrative

### *1.1 General*

#### 1.1.1 Baseline

The baseline for this module is coordination transfers and negotiation as described in B0-25 and B1-25 and the first step of FF-ICE/1 for ground application, during the planning phase before departure.

#### 1.1.2 Change brought by the module

Sharing of all the Flight and Flow information during Planning and Execution Flight Phase

### *1.2 Element:*

FF-ICE/1 will be extended for a complete use of FF-ICE after departure supporting Trajectory based Operations. The technical specification for FF-ICE will be implemented in the ground systems (ASP, AOC, Airport) using Flight Object implementation and IOP standard.

The module makes available a protocol to support exchange and distribution of information for multicentre operations.

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

The first implementations of SWIM (B1-31, B2-31) will facilitate flight information sharing.

### *1.3 Other remarks*

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

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

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

| | |
|---|---|
| *Capacity* | Reduced controller workload and increased data integrity and improved seamlessness at borders of ATSUs |
| *Efficiency* | Through more direct route and use of RTA to upstream centers.. |
| *Flexibility* | Better adaptation to user request change through facilitated information exchange |
| *Global Interoperability* | Easier facility of system connexion and wide exchange of the information among the actors |
| *Participation by the ATM community* | FF-ICE will facilitate the participation of all interested parties |
| *Safety* | More accurate and updated information |
| *Human performance* | Positive impact of more accurate information. |

| | |
|---|---|
| *CBA* | Balance between cost of ground system change and improved capacity/flight efficiency to be determined. |

## 3. Necessary Procedures (Air & Ground)

Need for new procedures for new set of applications towards Trajectory Based operation

## *4.* Necessary System Capability

### *4.1 Avionics*

Data communication will be used for exchange of trajectory information with the ground-system.

Only non-secured equipment like Electronic Flight Bag will have access to the ground SWIM environment.

### *4.2 Ground Systems*

ATM ground systems need to support IOP and SWIM concept.

Data communication infrastructure is required to support high speed ground-ground communication between ground systems and be connected to air-ground data-links.

## 5. Human Performance

### *5.1 Human Factors Considerations*

Positive impact of more accurate information.

### *5.2 Training and Qualification Requirements*

### *5.3 Others*

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

- Eurocae ED133 is available for Flight data Processing. For the time being it addresses only civil ATSU's FDP interoperability needs but it is foreseen that other Flight Information users needs will also be accomodated by this standard.
- Further standards are needed to support CDM applications and Flight information sharing and access to all ground stakeholders.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

### *7.2 Planned or Ongoing Activities*

In SESAR Project 10.2.5, Flight Object Interoperability (IOP) System Requirement & Validation using Eurocae ED133 first demonstration and validation activities are planned during 2012-2014 period and first developments in industrial systems are available from 2015.

It is anticipated that the initial implementation date in Europe between two ATSUs from two system providers and two ANSPs will occur between 2018 and 2020.

SESAR R&D projects on SWIM are in WP14 SWIM technical architecture and WP8 Information management.

## 8. Reference Documents

### *8.1 Standards*

- Eurocae ED133 Flight Object Interoperability Standard
- FF-ICE FIXM SARPs to be developed

### *8.2 Procedures*

### *8.3 Guidance Material*

- FF-ICE Concept Document

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# Module N° B2-31: Enabling Airborne Participation in collaborative ATM through SWIM

<table>
<tr><td>Summary</td><td colspan="2">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.</td></tr>
<tr><td>Timescale</td><td colspan="2">From 2023</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-01 Access & Equity, KPA-04 Efficiency, KPA-05 Environment, KPA-08 Participation by the ATM Community, KPA-09 Predictability, KPA-10 Safety</td></tr>
<tr><td>Domain / Flight Phases</td><td colspan="2">All phases of flight</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">long-term evolution potentially applicable to all environments</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">IM – Information Management</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-17 Implementation of data link applications<br>GPI-18 Electronic information services</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">Successor of: B1-30, B1-31, B1-105,</td></tr>
<tr><td rowspan="7">Global Readiness Checklist</td><td></td><td>Status (ready or date)</td></tr>
<tr><td>Standards Readiness</td><td>2023</td></tr>
<tr><td>Avionics Availability</td><td>2023</td></tr>
<tr><td>Infrastructure Availability</td><td>2023</td></tr>
<tr><td>Ground Automation Availability</td><td>2023</td></tr>
<tr><td>Procedures Available</td><td>2023</td></tr>
<tr><td>Operations Approvals</td><td>2023</td></tr>
</table>

## 1. Narrative

### *1.1 General*

The Global concept envisages that the aircraft is an integral part of the collaborative, information-rich ATM environment. This ultimately makes it a regular node of the SWIM processes and infrastructure, able to participate in the 4D trajectory management and collaborative processes. Enabling the aircraft to participate in SWIM is the availability of a low cost data link capability for strategic information exchange.

#### 1.1.1 Baseline

Modules B1-30 and B1-31 have created the ground SWIM infrastructure and the information reference model, and implemented processes and applications for ground users. Through datalinks such as WiMax , a high capacity data link exists for aircraft at the gate (end of pre-flight phase). Aviation, motivated first by non-ATM needs, has access to commercial satellite communication.

### 1.1.2 Change brought by the module

This module allows the aircraft to be fully connected as an information node in SWIM, enabling full participation in collaborative ATM processes with access to voluminous dynamic data including meteorology, initially for non-safety critical exchanges supported by commercial data links. The applications of this module are integrated into the processes and the information infrastructure which had evolved over the previous blocks.

The module can then evolve smoothly to the use of other technologies as they become available for the air-ground link when the aircraft is airborne. To enable the Collaborative ATM, and meteorological information exchange capabilities in this module, network access on the aircraft is required on the ground and in the air. However, since these capabilities are not safety-critical, the security and reliability requirements are lower than those of critical systems such as the VDL network, a commercial system utilizing cell-based or satellite based internet services could be used.

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

| | |
|---|---|
| *Access and Equity* | Access by the aircraft to the ATM information environment |
| *Efficiency* | Better exploitation of meteorological and other operational (e.g. airport situation) information to optimise the trajectory |
| *Environment* | Better exploitation of meteorological information to optimise the trajectory |
| *Participation by the ATM community* | The aircraft becomes an integral part of continuous collaboration and of the overall information pool. |
| *Predictability* | Anticipation of situations affecting the flight through the access to relevant information |
| *Safety* | Anticipation of potentially hazardous or safety bearing situations affecting the flight through the access to relevant information |

| | |
|---|---|
| *CBA* | The business case will be established in the relevant validation programmes. |
| *Human Performance* | 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.<br>The use of the applications during demanding flight conditions will need careful investigation.<br>Training will be required. |

## 3. Necessary Procedures (Air & Ground)

Procedures are to be defined. They will define the conditions of access to information and the use to supported applications depending on the characteristics of these and of the communication channels available, in particular safety, security and latency.

## 4. Necessary System Capability

### *4.1 Avionics*

The enabling technologies are under development. The most important one is the availability of a suitable combination of air-ground data links to support safety- or non-safety-critical applications.

### *4.2 Ground Systems*

The enabling technologies are under development.

# 5. Human Performance

## 5.1 Human Factors Considerations

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.

## 5.2 Training and Qualification Requirements

Training will be required for the reasons given in Section 5.1.

## 5.3 Others

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

Specifications are to be defined.

# 7. Implementation and Demonstration Activities

## 7.1 Current Use

- **None**

## 7.2 Planned or Ongoing Trials

- **Europe: D-AIM trials in 2009/10.** The Digital Aeronautical Information Management (D-AIM) project, a joint EUROCONTROL and LFV activity (with Jeppesen for the last year). It culminated in a series of a dozen of successful flight trials at Stockholm-Arlanda airport and around Stockholm TMA focusing on transmission of real-time originated NOTAMs & SIGMETs over data link, graphically depicted to the pilot on the Electronic Flight Bag (EFB) with moving map functionality. An integral element of the D-AIM project was the encoding of Airport Mapping data, shared to ground and air users over generic information services. The project was based on an open architecture based on global industry standards, with a description of the current and possible future architectures in combination with precise use-cases defining the work to be performed in the real world. LFV is progressing towards making some of the developed services operational. More information can be found on www.d-aim.aero .

- **US: FAA AAtS trials:** simulations, demonstrations and trials in the 2011-14 period, for both domestic and oceanic/remote areas global interoperability trials; the concept of use, architecture and technical requirements will be developed and tested. More information can be found on www.swim.gov .

# 8. Reference Documents

## 8.1 Standards

## 8.2 Procedures

## 8.3 Guidance Material

- FF-ICE Manual (under development)
- ICAO Global Concept

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# Module N° B2-35: Increased user involvement in the dynamic utilisation of the network

<table>
<tr><td>Summary</td><td colspan="2">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.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 Capacity; KPA-09 Predictability</td></tr>
<tr><td>Operating Environment/Phases of Flight</td><td colspan="2">Pre-flight phases</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Region or sub-region</td></tr>
<tr><td>Global Concept Component(s)</td><td colspan="2">DCB-Demand-Capacity Balancing<br>TS-Traffic Synchronisation<br>AOM-Airspace Organisation and Management<br>AUO-Airspace Users Operations</td></tr>
<tr><td>Global Plan Initiatives (GPI)</td><td colspan="2">GPI-6 Air traffic flow management<br>GPI-8 Collaborative airspace design and management</td></tr>
<tr><td>Pre-Requisites</td><td colspan="2">Successor of B1-35<br>Requires B1-30 and probably B2-25</td></tr>
<tr><td rowspan="6">Global Readiness Checklist</td><td></td><td>Status (ready now or estimated date)</td></tr>
<tr><td>Standards Readiness</td><td>Est. 2023</td></tr>
<tr><td>Avionics Availability</td><td>Est. 2023</td></tr>
<tr><td>Ground Systems Availability</td><td>Est. 2023</td></tr>
<tr><td>Procedures Available</td><td>Est. 2023</td></tr>
<tr><td>Operations Approvals</td><td>Est. 2023</td></tr>
</table>

## 1. Narrative

### *1.1 General*

#### 1.1.1 Baseline

The previous module, B1-35, has introduced an initial version UDPP, focused on the issues at an airport.

#### 1.1.2 Change brought by the module

This module further develops the CDM applications by which ATM will be able to offer/delegate to the users the optimisation of solutions to flow problems, in order to let the user community take care of competition and their own priorities in situation when the network or its nodes (airports, sector) does no longer provide actual capacity commensurate with the satisfaction of the schedules. This module also builds on SWIM for more complex situations.

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

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

| | |
|---|---|
| *Capacity* | Improved use of the available capacity in situations where it is constrained. |
| *Predictability* | The module offers airlines the possibility to have their priorities taken into account and optimise their operations in degraded situations. |

| | |
|---|---|
| *CBA* | To be established when the research on the module has progressed more significantly |

## 3. Necessary Procedures (Air & Ground)

Procedures to specify the conditions (in particular rules of participation, rights and duties, equity principles, etc) and notice for UDPP to be applicable. The process will need to be done in a way that does not conflict with or degrades the optimisation of the network done by ATFM.

## 4. Necessary System Capability

### *4.1 Avionics*

None in addition to that required for participation in SWIM where applicable.

### *4.2 Ground Systems*

Will be supported by SWIM environment technology and ground-ground integration, including with Airline operation systems.

Automated functions allowing negotiation among users and connection with ATFM systems.

## 5. Human Performance

### *5.1 Human Factors Considerations*

No significant issue identified. Nevertheless, the module will introduce additional factors in the decision making related to flight preparation and planning which will need to be understood by airline personnel.

### *5.2 Training and Qualification Requirements*

The new procedures will require training adapted to the collaborative nature of the interactions, in particular between ATFM and airline operations personnel.

### *5.3 Others*

Nil

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

Equity requirements will likely imply that the mechanisms underlying the process are transparent and verifiable. The procedures mentioned above will need be regulated.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

None at this time.

### *7.2 Planned or Ongoing Activities*

- **Europe**: SESAR work programme has just started to formulate the concept of UDPP, and will need to elaborate this module further before describing the trials for it**.**

## 8. Reference Documents

### *8.1 Standards*

TBD

### *8.2 Procedures*

TBD

### *8.3 Guidance Material*

TBD

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# Module N° B2-85 Airborne Separation (ASEP)

| | | |
|---|---|---|
| **Summary** | 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.<br><br>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. | |
| **Main Performance Impact** | KPA-02 Capacity, **KPA-03 Cost Effectiveness** KPA-04 Efficiency, KPA-05 Environment | |
| **Domain / Flight Phases** | En-route phase, oceanic, and approach, departure and arrival | |
| **Applicability Considerations** | 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. | |
| **Global Concept Component(s)** | CM- Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-16 Decision support systems and alerting systems | |
| **Pre-Requisites** | In-Trail-Procedure (ITP) B0-85 and Interval Management (IM) B1-85, | |
| **Global Readiness Checklist** | | **Status (ready or date)** |
| | 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."

### 1.1.1 Baseline

The baseline is provided by the first ASAS application described in the modules B0-86 and B1-85. These ASAS-ASEP operations will be the next step.

### 1.1.2 Change brought by the module

This module will introduce new modes of separation relying on aircraft capabilities including airborne surveillance supported by ADS-B and giving responsibility for separation to the pilot by delegation from the controller. This relies on the definition of new Airborne Separation Minima.

## *1.2 Element: ASEP*

**Airborne separation**: The flight crew ensures separation from designated aircraft as communicated in new clearances, which relieve the controller from the responsibility for separation between these aircraft. However, the controller retains responsibility for separation from aircraft that are not part of these clearances and from aircraft involved in ASEP and surrounding aircraft.

**Typical Airborne Separation applications include:**

- In-descent separation: the flight crews maintain a time-based horizontal separation behind designated aircraft.
- Level flight separation: the flight crews maintain a time or distance-based longitudinal separation behind designated aircraft.
- Lateral crossing and passing: the flight crews adjust the lateral flight path to ensure that horizontal separation with designated aircraft is larger than the applicable airborne separation minimum.
- Vertical crossing: the flight crews adjust the vertical flight path to ensure that vertical separation with designated aircraft is larger than the applicable airborne separation minimum.
- Paired Approaches in which the flight crews maintain separation on final approach to parallel runways
- In oceanic airspace many procedures are considered as improvement of In Trail Procedure (ITP) using new airborne separation minima
  - ASEP-ITF In Trail Follow
  - ASEP-ITP In Trail Procedure
  - ASEP-ITM In Merge

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

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

| | |
|---|---|
| *Capacity* | Increase by allowing reduced separation minima and potential reduction of ATCO workload |
| *Efficiency* | More optimum flight trajectories |
| *Environment* | Less fuel consumption due to more optimum flight trajectories |
| *Flexibility* | More flexibility to take in account change in constraint, weather situation |
| *Predictability* | Conflict resolution is optimised and potentially more standardized thanks to the airborne equipment performance standards. |
| *Safety* | To be demonstrated |

| | |
|---|---|
| *CBA* | To be determined by balancing cost of equipment and training and reduced penalties |

## 3. Necessary Procedures (Air & Ground)

ASAS-ASEP procedures need to be defined for PANS-ATM and PANS-OPS with clarifications of roles and responsibilities

# 4. Necessary System capability (Air & Ground)

## *4.1 Avionics*

For ASEP and airborne separation delegation: Air-Ground data-link and ADS-B Out and ADS-In airborne system associated to Airborne Separation Assistance Systems (ASAS). The ASAS is composed of 2 main functions i.e., airborne surveillance and conflict resolution.

## *4.2 Ground systems*

On the ground there is a need for specific tools to assess the aircraft capabilities and to support delegation function. This requires a full sharing of the trajectory information between all the actors. It may be necessary to tune STCA in a specific mode for this procedure (restricted to collision avoidance only).

# 5. Human Performance

## *5.1 Human Factors Considerations*

Change of role of controllers and pilots need to be carefully assessed and understood by both parties.

Specific training and qualification are required

## *5.2 Training and Qualification Requirements*

The pilot needs to be trained and qualified to assume the new role and responsibility and correct usage of the new procedures and avionics.

Automation support is needed both for the pilot and the controller which therefore will have to be trained to the new environment and to identify the aircraft/facilities which can use the services.

## *5.3 Others*

Liability issues are to be considered.

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

Change in PANS-OPS and PANS-ATM are required. Determination of applicable separation minima is necessary.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

None at this time.

## *7.2 Planned or Ongoing Trials*

**European projects**

**ASSTAR (2005-2007) initiated the work on ASEP and SSEP applications in Europe which has been pursued by SESAR projects as follows:**

**SESAR Project 04.07.04.b ASAS-ASEP Oceanic Applications**

"The Airborne Separation In Trail Follow (ASEP-ITF) and In Trail Merge (ASEP-ITM) applications have been designed for use in oceanic and other non-radar airspace.

ASEP-ITF transfers responsibility for separation between the ITF Aircraft and a Reference Aircraft from the controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high accuracy and integrity requirements on the avionics (both the ITF and Reference Aircraft positioning, airborne surveillance and ASEP-ITF ASAS logic). ASEP-ITF is intended as a means of improving vertical flexibility, allowing aircraft to make a level change where current procedural separation standards will not allow it, by enabling level changes to the flight level of a Reference Aircraft which is operating at a different flight level, but on the same identical track.

ASEP-ITM transfers responsibility for separation between the ITM Aircraft and a Reference Aircraft from the controller to the flight crew for the period of the manoeuvre. This transfer of responsibility will place high accuracy and integrity requirements on the avionics (both the ITM and Reference Aircraft positioning, airborne surveillance and ASEP-ITM ASAS logic). ASEP-ITM is intended as a means of improving lateral flexibility, allowing aircraft to change their routing where current procedural separation standards will not allow it, by enabling a lateral manoeuvre to follow, and then maintain, a minimum interval behind a Reference Aircraft which is operating at a same direction flight level.

Both applications will require the crew to use airborne surveillance information provided on the flight deck to identify the potential opportunity to use the applications and to maintain a reduced separation from the Reference aircraft during the manoeuvres."

**SESAR Project 04.07.06 En Route Trajectory and Separation Management – ASAS Separation (Cooperative Separation)**

The main objective of this project is to assess the introduction of ASAS separation application in the SESAR context (taking into account all platforms, including military and UAS). The project will be focused on the possibility to delegate in specific and defined conditions the responsibility for traffic separation tasks to the flight deck of suitable equipped aircraft.

# 8. Reference Documents

## *8.1 Standards*

To be developed

## *8.2 Procedures*

To be developed

## *8.3 Guidance material*

- ICAO Doc 9854 – Global ATM Operational Concept
- ICAO ANConf/11-IP5 draft ASAS Circular (2003)
- FAA/EUROCONTROL ACTION PLAN 23 – D3 -The Operational Role of Airborne Surveillance in Separating Traffic (November 2008)
- FAA/EUROCONTROL ACTION PLAN 23 – D4 –ASAS application elements and avionics supporting functions (2010)

# Module N° B2-101: New Collision Avoidance System

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity; **KPA-10 Safety;** | |
| **Operating Environment/Phases of Flight** | All airspaces. | |
| **Applicability Considerations** | | |
| **Global Concept Component(s)** | CM - Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI- 2 Reduced vertical separation minima, GPI- 9 Situational awareness, GPI-16 Decision support system and alerting systems | |
| **Pre-Requisites** | | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date). |
| | Standards Readiness | Est. 2023 |
| | Avionics Availability | Est. 2023 |
| | Infrastructure Availability | N/A |
| | Ground Automation Availability | √ |
| | Procedures Available | √ |
| | Operations Approvals | √ |

## 1. Narrative

### *1.1 General*

The existing airborne collision avoidance system – ACAS II has been very effective in mitigating the risk of mid-air collisions. Safety studies indicate that ACAS II reduces risk of mid-air collisions by 75 – 95% in encounters with aircraft that are equipped with either a transponder (only) or ACAS II respectively. In order to achieve this high level of safety, however, the alerting criteria used by ACAS II often overlap with the horizontal and vertical separation associated with many safe and legal airspace procedures. ACAS II monitoring data from the U.S. indicate that as many as 90% of observed Resolution Advisories (RAs) are due to the interaction between ACAS II alerting criteria and normal ATC separation procedures (e.g., 500 feet IFR/VFR separation, visual parallel approach procedures, level-off with a high vertical rate 1,000 feet above/below IFR traffic, or VFR traffic pattern procedures). In order to achieve intended efficiencies in the future airspace, a reduction in collision avoidance alerting thresholds may be necessary in order to further reduce separation while minimizing “nuisance alerts”. Initial examination of NextGen procedures such as Closely Spaced Parallel Operations (CSPO) or use of 3 nautical mile en-route ATC separation indicate that existing ACAS performance is likely not sufficient to support these future airspace procedures. As a result, a new approach to airborne collision avoidance is necessary.

### 1.1.1 Baseline

Implementation of an improved airborne collision avoidance system must minimize “nuisance alerts” while maintaining existing levels of safety. Additionally, this new system must be able to more quickly adapt to changes in airspace procedures and the environment.

### 1.1.2 Change brought by the module

Implementation of a new airborne collision avoidance system will enable more efficient operations and future airspace procedures while complying with safety regulations. The new airborne collision avoidance systems will accurately discriminating between necessary alerts and “nuisance alerts” across the expected horizontal and vertical separation projected in future airspace procedures. Improved differentiation leads to reduction in ATC personnel workload, as ATC personnel spent exert less time to respond to “nuisance alerts”.

These procedures facilitate the optimized utilization of constrained airspace, while maintain safety standards. The revision of horizontal and vertical separation enables grid-locked areas to accommodate more aircrafts in all flight domains. Augmented ACAS will facilitate Closely Spaced Parallel Operations, increasing terminal and aerodrome throughput. The new ACAS will also increase capacity of the en-route domain via the implementation of 3 nautical mile separation standards.

The implementation of this module depends on the on-going effort to develop a successor to the current TCAS technology. This successor should be capable of accommodating reduced separation standards and other new airspace procedures.

### 1.1.3 Other remarks

The U.S. Federal Aviation Administration (FAA) has funded research and development of a new approach to airborne collision avoidance for the past 3 years. This new approach takes advantage of recent advances in dynamic programming and other computer science techniques to generate alerts using an off-line optimization of resolution advisories. This approach uses extensive actual aircraft data to generate a highly accurate dynamic model of aircraft behaviour and sensor performance. Based on a predetermined cost function and using advance computational techniques, this approach generates an optimized table of optimal actions based on information regarding intruder state information. This approach significantly reduces logic development time and effort by focusing developmental activities on developing the optimization process and not on iterative changes to pseudo-code.

### 1.2 *Element*: Improve differentiation between legitimate and “nuisance” alerts

To facilitate future airspace procedures, such as Closely Spaced Parallel Operations (CSPO) and 3 nautical mile separation, the current Resolution Advisory (RA) rate accuracy is inadequate for such procedures. New airborne collision avoidance system will leverage recent advancements in computer science to achieve the desired RA rate accuracy. In addition, alerting criteria and procedures will be revisited for the new airborne collision avoidance system.

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

Key performance metrics include Probability of a Near Mid-Air Collision (p(NMAC), RA alert rate and operational acceptability. Computation of these metrics is conducted assuming both the future system as well as in conjunction with existing ACAS and operational environment.

P(NMAC) – Since ACAS is a safety-critical system, the key performance metric is the probability of a near mid-air collision. This probability is computed using Monte Carlo simulation and has historically been used in the development and evaluation of ACAS II. This probability may be expressed by itself, or may use risk ratio to express the change in risk associated with implementation of system changes when compared to the existing system.

Resolution Advisory (RA) rate – The future collision avoidance system must minimize nuisance alerts to enable reduced separation; RA rate is another key performance metric. The RA rate is assessed using Monte Carlo simulation. These simulations are conducted using encounter models and airspace procedures representative of the current and/or future environment. The observed RA rate may be compared either against the existing system or against an objective standard.

State can use the following metrics to gauge the performance of this module.

| | |
|---|---|
| *Capacity* | Reduced use of the 1030/1090 MHz spectrum |
| *Safety* | a. Improve Resolution Advisory (RA) rate accuracy to support future airspace procedures, such as new separation standards.<br>i. Resolution Advisory rate<br>ii. Nuisance alerts rate<br><br>b. Reduction in the probability of near mid-air collision<br>i. Probability of Near Mid-Air Collision – P(NMAC) |

| | |
|---|---|
| CBA | |

## 3. Necessary Procedures (Air & Ground)

Necessary operational procedures for future ACAS are contained in PANS-OPS (ICAO Doc. 8168) and PANS-ATM (Doc 4444). Future ACAS capabilities should support the implementation of these procedures.

## 4. Necessary System Capability

### *4.1 Avionics*

Improved algorithm and computational technique is needed to increase the accuracy of the RA rates and better differentiate "nuisance" and legitimate alerts. The necessary technical issues and requirements can be found in ICAO Annex 6, Part I, and ACAS Manual (ICAO Doc 9863).

### *4.2 Ground Systems*

NIL

## 5. Human Performance

### *5.1 Human Factors Considerations*

TBD

### *5.2 Training and Qualification Requirements*

TBD

### *5.3 Others*

TBD

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

ICAO Annex 6, Part I, Part II, and Annex 10, Vol. 4 specified the international standards for ACAS equipage and procedures.

# 7. Implementation and Demonstration Activities

## 7.1 *Current Use*

TCAS is currently required for all aircrafts in the NAS. Level of equipage is dependent on the Max. Take Off Weight (MTOW) of the aircraft.

ICAO ANNEX 6 requires ACAS II for certain categories of aircraft. Currently TCAS II Version 7 is the minimum equipment specification which complies with the ACAS II standard. Some airspaces will require TCAS II Version 7.1 equipment form 2015.

## *7.2 Planned or Ongoing Activities*

TBD

# 8. Reference Documents

## *8.1 Standards*

RTCA DO-298 *Safety Analysis of Proposed Change to TCAS RA Reversal Logic.*

## *8.2 Procedures*

## *8.3 Guidance Material*

M. J. Kochenderfer and J. P. Chryssanthacopoulos, "*Robust airborne collision avoidance through dynamic programming*," Massachusetts Institute of Technology, Lincoln Laboratory, Project Report ATC-371, 2010.

# Module N° B2-05: Optimised Arrivals in Dense Airspace

| | | |
|---|---|---|
| **Summary** | 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 | |
| **Main Performance Impact** | **KPA-04 Efficiency**; KPA-05 Environment. | |
| **Operating Environemnt/Phases of Flight** | En-route, Terminal Area (Landings), Descent | |
| **Applicability Considerations** | Global, High Density Airspace (based on US FAA Procedures) | |
| **Global Concept Component(s)** | Airspace Organization and Management (AOM)<br>Airspace User Operations (AUO)<br>Traffic synchronization (TS) | |
| **Global Plan Initiatives (GPI)** | GPI-5 RNAV and RNP (Performance-based navigation)<br>GPI-9 Situational Awareness<br>GPI-11 RNP and RNAV SIDs and STARs | |
| **Pre-Requisites** | B0-05, B1-05 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | √ |
| | Avionics Availability | 2023 |
| | Ground Systems Availability | 2023 |
| | Procedures Available | 2023 |
| | Operations Approvals | 2023 |

## 1. Narrative

### *1.1 General*

Optimised Arrivals in Dense Airspace integrates capabilities that will provide improved use continuously descending arrivals in highest congested airspace. Key aspects of Optimised Profiles in Dense Airspace are:

- Arrival procedures which allow the aircraft to fly a “best economy descent” from en-route airspace to final approach.
- Limited or no throttle is applied throughout the descent, with momentary level-offs being used to slow an aircraft as required by airspace restrictions.
- Flow management automation that allows air traffic control to manage aircraft flying Optimised arrivals with crossing, departing, and other arriving traffic.
- Cockpit automation that allows aircraft to freely choose top-of-descent and descent profile based on aircraft state and weather conditions.
- En-route and terminal controllers rely on automation to identify conflicts and eventually propose resolutions.
- Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of navigational aids, enabling the flexibility of point-to-point aircraft operations.

- Required Navigation Performance (RNP) operations introduce the requirement for onboard performance monitoring and altering. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor its achieved navigation performance for a specific operation, and inform the air crew if the operational requirement is being met.
- The basis for the operation is an accurate three-dimensional trajectory that is shared among aviation system users. This provides accurate latitude, longitude, and altitude information to airspace users.
- Consistent and up-to-date information describing flights and air traffic flows are available system-wide, supporting both user and service provider operations.

### 1.1.1 Baseline

The baseline for this block is Improved Flight Descent Profile and Complexity Management enabled by blocks B0-5 and B3-10. Optimised Arrivals are a component of Trajectory-Based Operations (TBO) initiatives. Decision support capabilities are available that are integrated to assist aircraft crew and air traffic separation providers in making better decisions and optimizing the arrival profile. Consistent 3D trajectory information is available to users to inform ATM decision making.

### 1.1.2 Change brought by the module

This block provides extensions to the baseline, with emphasis on economic descents in airspace with dense traffic levels. Benefits of these Trajectory Based Operations include fuel savings and noise and emission reduction by keeping aircraft at a higher altitude and at lower thrust levels than traditional step-down approaches. Simplifying routes using Optimised Arrivals may also reduce radio transmissions between aircraft crew and controllers.

Benefits of these operations in dense airspace include achieving target traffic and throughput levels while also enabling fuel savings and noise reduction. A traditional assumption is that the use of Optimised Arrivals will reduce throughput in dense airspace, or may not be achievable at all due to complexities created in sequencing Optimised arrivals with non-Optimised arrivals, departures, and crossing traffic.

The aircraft's ability to accurately fly an Optimised Arrival, coupled with the state and intent information sent form the aircraft to ATC automation, will increase accuracy of trajectory modelling and problem prediction.

### 1.1.3 Other

This module continues the evolution in RNAV and RNP procedure design in dense airspace, and the evolution of automation used to aid in decision support for both air crews and Air Traffic Control.

## 1.1 *Element 1:* Accurate Trajectory Modelling

This element is focused on obtaining the most accurate trajectory model for use by all automation systems. This includes accurate position information, clearance information, and the use of automated resolutions that reduce controller workload.

## *1.2 Element 2: Advanced Aircraft Capabilities*

This element will focus on cockpit capabilities that enable optimal trajectory selection and the ability to fly point-to-point RNAV and RNP procedures. This element will also examine cockpit automation that enables the aircraft to self-separate and avoid potential conflicts. This element will focus on globally-harmonized standards development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

## *1.3 Element 3: Traffic Flow Management and Time-Based Metering*

This element will harmonize the Traffic Flow Management automation which continuously predicts the demand and capacity of all system resources, and will identify when the congestion risk for any resource (airport or airspace) is predicted to exceed an acceptable risk. Traffic Management will take action in the form of just in time reroutes and metering times to congested resources. The problem resolution element will create a solution that meets all system constraints.

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

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

| | |
|---|---|
| *Capacity* | Better use of terminal airspace. High levels of traffic can be accommodates while still allowing the use of best economy descents that save fuel, emissions, and noise. Capacity will be enhanced by improved ability to plan for flows in and out of the airport. |
| *Efficiency* | Users will fly more fuel and noise efficient arrivals and descent profiles. Time in flight may also be reduced to automation that enhances decision making and selection of a preferred trajectory. |
| *Flexibility* | Users will be able to select arrival trajectory that best accommodates aircraft according to traffic conditions, weather conditions, and aircraft state. |
| *Safety* | Economical descents used without sacrificing safety due to enhanced airspace management and automation to aid in aircraft separation. |

| | |
|---|---|
| *CBA* | The major qualitative business case elements of this module are as follows:<br>• Capacity: Additional flights can be accommodated in terminal airspace because of reduced controller workload and better trajectory modelling/planning.<br>• Efficiency: Users will fly more fuel and noise efficient arrival descent profiles.<br>• Safety: Economic descents flown without sacrificing safety.<br>• Flexibility: Users will have greater flexibility in selecting the flight trajectory that best meets their needs. |

## 3. Necessary Procedures (Air & Ground)

For strategic actions, the necessary procedures basically exist for Air Navigation Service Providers (ANSPs) and users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation. The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and will necessitate procedure development, including the roles of ANSPs. International standards for information exchange between systems to support these operations need to be developed. This includes development of global standards for the exchange of trajectory information between ground and air.

## 4. Necessary System Capability

### *4.1 Avionics*

The continued development of automation for both the cockpit and ANSPs is needed to aid in trajectory modelling and required separation decision making. Aircraft-based capabilities, such as ADS-B/CDTI exist, but applications are still being developed to support the objectives of this module.

### *4.2 Ground Systems*

The continued development of automation for both the cockpit and ANSPs is needed to aid in trajectory modelling and required separation decision making. In addition, development of technology that provides mitigation strategies for conflicts or potential conflicts will also aid in enabling Optimised profiles in dense airspace.

# 5. Human Performance

## *5.1 Human Factors Considerations*

TBD

## *5.2 Training and Qualification Requirements*

TBD

## *5.3 Others*

TBD

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

This module requires:

- Development of global standards for trajectory information exchange.
- Standardisation of procedure design guidance
- Standardisation of ATC/Pilot phraseology, such as the use of a “Descend Via” clearance when utilizing an Optimised Arrival

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

Optimised Arrivals are currently being used at the following U.S. airports in dense airspaces:

- Los Angeles International Airport (LAX)
- Phoenix Sky Harbor International Airport (PHX)
- Atlanta Hartsfield International Airport (ATL)
- Las Vegas International Airport (LAS)

## *7.2 Planned or Ongoing Trials*

No global demonstration trials are currently planned for this module. There is a need to develop a trial plan as part of the collaboration on this module.

# 8. Reference Documents

## *8.1 Standards*

## *8.2 Procedures*

## *8.3 Guidance Material*

ICAO Doc 9331, Continuous Descent Operations (CDO) Manual

# Module N° B2-90: Remotely Piloted Aircraft (RPA) Integration in Traffic

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-01 Access & Equity, KPA-10 Safety | |
| **Domain/Flight Phases** | En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing) | |
| **Applicability Considerations** | Applies to all RPAS operating in controlled airspace and at aerodromes. Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those able to meet minimum certification and equipment requirements. | |
| **Global Concept Components** | AOM - Airspace Organization and Management<br>CM - Conflict Management<br>AUO - Airspace User Operations | |
| **Global Plan Initiatives (GPI)** | GPI-9, Situational awareness<br>GPI-12, Functional integration of ground systems with airborne systems<br>GPI-17, Data link applications | |
| **Main Dependencies** | Preceded by B1-90 | |
| **Global Readiness Checklist** | | **Status** (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 |

## 1. Narrative

### *1.3 General*

Based on Block 1, basic RPA procedures, Block 2 includes the procedures and technology that are possible in the block 2 timeframe. As discussed below.

| Block 2 | Class B and C | Class A Airspace (Other than High Seas) | High Seas (Class A Airspace) | Class D, E, F, and G |
|---|---|---|---|---|
| **Authorization** | Strict compliance with the provisions of the authorization is required | | | Operations not permitted, unless by waiver or authorization |
| **C2 Link Failure Procedures** | Will follow standardized procedures. A special purpose transponder code will be established. | | Will follow standardized procedures. | |
| **Communications** | Continuous two-way communications as required for the airspace. UAS will squawk 7600 in case of loss of communications. | | Continuous two-way communications will be maintained directly or via a service provider (e.g. ARINC or SETA) depending on location and operation. | |

| | | | |
|---|---|---|---|
| **Separation Standards** | New separation standards may be required | Separation criteria will be analysed and special separation criteria might be developed. | |
| **ATC Instructions** | RPAS will comply with ATC instructions as required | | |
| **RPA Observers** | As required for the operation | | |
| **Medical** | Remote pilots shall have an appropriate medical certificate | | |
| **Presence of Other Aircraft** | RPAS shall not increase safety risk to the air navigation system | | |
| **Visual Separation** | Visual separation may be permitted. | TBD | |
| **Responsibility of Remote Pilot** | Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization | | |
| **Populated Areas** | Restrictions to be determined by the State. | | |
| **ATC Services** | Consistent with Annex 11, | | |
| **Flight Plan** | RPAS operations, except VLOS, shall be conducted in accordance with IFR. Flight plans shall be filed. | | |
| **Meteorological Conditions** | Restrictions to be determined by the State | | |
| **Transponder** | Shall have and use an operating mode C/S transponder | | |
| **Safety** | Identify the hazards and mitigate the safety risks; adhere to the authorization | | |
| **NOTAMs** | NOTAM requirements, if any, to be determined by the State | | |
| **Certification** | TBD | | |

### 1.3.1 Baseline

### 1.3.2 Changes brought by the module

The projected changes during this time frame include:

- **<u>Access to most airspace for select airframes without specific airspace constraints:</u>** As aircraft certification (based on an established safety case for a particular RPA system – airframe, link, and RPS) is developed and procedures are defined, airspace constraints will gradually be lifted and specific RPAs will be permitted to fly in more situations. In the Block 2 timeframe, this will start with a very small number of RPAs, but will be permitted to grow as the RPA proves it can meet standards, and certification and procedures are developed. This access will be based on the improvements to the RPA, the developed technology, (GBDAA, ADS-B, and Specific C2 link failure squawk) and improved ATM procedures.
- **<u>RPAS certification procedures</u>** Using Minimal Aircraft System Performance Specification (MASPS) developed by standards committees or adopted by ICAO, material solutions will be developed for integration into RPAS. As these solutions are integrated into selected RPAS, the RPAS will go through the process of being certified airworthy. Airworthiness and certification are based on a well-established airworthiness design standards. Therefore the following RPA related issues will have to be addressed:
    - Procedures Standards and Recommended Practices for all RPA classes
    - Procedures and standards for Ground Control Stations (RPS),
    - Provisions for C2 links
    - Possible rule changes to set forth a type standard for various RPA
    - Modification of type design (or restricted category) standards to account for unique RPA features (e.g., removal of windscreens, crashworthiness standards, control handoff from one RPS to another, etc.)
- **<u>RPA procedures defined</u>**: Procedures will be developed to permit selected RPA (proven airworthy) to fly in non-segregated airspace with manned aircraft. Training for pilots and ATC personal must be developed to accommodate these RPAS.
    - **<u>New special purpose transponder code for lost link</u>**: A new transponder code will be developed so that the ATC automation can differentiate RPA lost C2 links from loss of two-way radio communications in any

aircraft. Because transponder codes cannot be received over the high seas, RPA will broadcast position to nearby aircraft via ADS-B. If ADS-C is mandated for high seas RPA, lost link position may be tracked by ATC if that electronic link remains intact.

- o **Standardized lost link procedures**
- o **Revised separation criteria and/or handling procedures (i.e. moving airspace)**

- **ADS-B on most RPA classes**: IT is envisioned that ADS-B will be included on most new RPA's being built during this time period and a retrofit program should be established.
- **Detect and Avoid technologies** will be improved and certified to support RPAs and operational improvements. Ground Based Detect and Avoid (GBDAA) will be certified and approved for more pieces of airspace. Other approaches to consider include an onboard (airborne) detect and avoid solution (ABDAA). ABDAA efforts are currently focused on developing the capability to perform both self-separation and collision avoidance onboard the aircraft that ensure an appropriate level of safety even in the event of lost command and control links. The initial capability will provide an ability to collect and analyze valuable data for developing a robust airborne DAA system.
- **Protected spectrum and security**[4] this necessitates the use of designated frequency bands, i.e. those reserved for aeronautical safety and regularity of flight under Aeronautical Mobile (route) Service (AM(R)S), Aeronautical Mobile Satellite (route) Service (AMS(R)S), Aeronautical Radio Navigation Service (ARNS) and Aeronautical Radio Navigation Satellite Service (ARNSS) allocations as defined in the ITU Radio Regulations. It is essential that any communications between the GCS and RPA for C2 meet the performance requirement applicable for that airspace and/or operation, as determined by the appropriate authority. SATCOM links may require a backup.

### *1.4 Elements*

There is only one element for this module, RPA integration into traffic, (evolution of basis procedures). All of the improvement listed above relate to the integration of RPAS's into traffic.

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

| | |
|---|---|
| *Capacity* | Could be impacted due to new separation standards, if applicable<br><br>Metric: sector capacity |
| *Efficiency* | Access to airspace by a new category of users. Metric: volume of RPA traffic |
| *Environment* | Increased by standardizing the integration of RPA's with manned aircraft. Procedures for integration will become implemented and become routine.<br><br>Metric: volume of RPA traffic |
| *Predictability* | The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States.<br><br>Metric: volume of interstate RPA traffic |
| *Safety* | Increased situational awareness; controlled use of aircraft<br><br>Metric: incident occurrences |

| | |
|---|---|
| *CBA* | The business case is directly related to the economic value of the aviation applications supported by RPAS. |

## 3. Necessary Procedures (Air & Ground)

Improved air traffic management (ATM) procedures will need to be in place to allow the access of RPA's into the non-segregated airspace. Specifically:

- ATM provisions need to be amended to accommodate the RPA taking into account the unique operational characteristics of each RPA type as well as their automation and non-traditional IFR/VFR capabilities,
- Air navigation service providers will need to review emergency and contingency procedures to take account of unique RPA failure modes such as a lost link, to include standardized lost link procedures, and the new special

[4] ICAO Cir 328 An/190 Unmanned Aircraft Systems (UAS)

- purpose transponder code for lost link. Also consider procedures that may be necessary if the RPA is using an alternate control link that results in excessive delay in responding to RPA pilot inputs,
- Terminal area will need to improve their procedures to allow for the increased volume of RPA activity,
- Ground operations will need to be modified to accommodate the increased activity of RPA's as well.

Improved RPA certification procedures will need to be developed, as well as standardizing the lost link procedures. As ABDAA algorithms are developed, associated RPA operations procedures will need to be developed.

# 4. Necessary System Capability (Air & Ground)

## *4.1 Avionics*

- ADS-B on most RPA as well as all manned aircraft
- Preliminary development and testing of (ABDAA)

## *4.2 Ground Systems*

- GBDAA where applicable
- ATC automation will need to be able to respond to this new lost link code
- Automatic position reporting to ATC capability for lost link over high seas

# *5. Human Performance*

## *5.1 Human Factor Considerations*

The controller-pilot relationship is changing and will need to be investigated. Specific training for controllers, remote pilots and pilots will be required, in particular with respect to the new detect and avoid situations.

## *5.2 Training and Qualifications Requirements*

TBD

## *5.3 Others*

TBD

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

Standards are needed for the regulatory approval of the following.

- Lost link procedures and standards
- Specific special purpose transponder code for lost link
- Updated ATM procedures to allow for the integration of RPA's into en-route and terminal airspace
- Update airworthiness standards and procedures

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

None at this time. -

## *7.2 Planned or On Going Trials*

**Europe**

- So far all strategies are aimed at full integration within the timeframe of Block 2. SESAR will address this. ADS-B and Satcom are on the agenda
- Integrated RPA/manned Airports operations
- Separation and airspace safety panel (SASP) will make determination on separation standards that will be applicable

## *8 Reference Documents*


- ICAO Circ 328 – *Unmanned Aircraft Systems (UAS)*
- Annex 2 — *Rules of the Air* proposal for amendment
- U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*
- EUROCAE Document (under development)

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# BLOCK 3

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# Module N° B3-15: Integration AMAN/DMAN/SMAN

<table>
<tr><td>Summary</td><td colspan="2">This module includes a brief description of integrated arrival, en-route, surface, and departure management.</td></tr>
<tr><td>Main Performance Impact</td><td colspan="2">KPA-02 Capacity; KPA-04 Efficiency; KPA-09 Predictability<br>KPA-06 Flexibility</td></tr>
<tr><td>Domain/ Flight Phases</td><td colspan="2">Aerodrome and Terminal</td></tr>
<tr><td>Applicability Considerations</td><td colspan="2">Runways and Terminal Manoeuvring Area in major hubs and metropolitan areas will be most in need of these improvements.<br>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 RNAP/RNP routes need to be in place.</td></tr>
<tr><td>Global Concept Element(s)</td><td colspan="2">TS – Traffic Synchronization</td></tr>
<tr><td>Global Plan Initiative</td><td colspan="2">GPI-6 Air Traffic Flow Management</td></tr>
<tr><td>Main Dependencies</td><td colspan="2">B2-15</td></tr>
<tr><td rowspan="5">Global Readiness Checklist</td><td>Standards Readiness</td><td>Status (ready now or estimated date)</td></tr>
<tr><td>Avionics Availability</td><td>Est. 2025+</td></tr>
<tr><td>Ground Systems Availability</td><td>Est. 2025+</td></tr>
<tr><td>Procedures Available</td><td>Est. 2025+</td></tr>
<tr><td>Operations Approval</td><td>Est. 2025+</td></tr>
</table>

## 1. Narrative

### *1.1 General*

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

Synchronization of all flight phases represents the full integration of all control loops. An optimized time profile for flights can be derived, and use as a mean to manage demand and capacity and optimally space aircrafts. Optimized time profile describes the time component of the 4D trajectory. 4-D trajectory management enables airspace users and ATC authorities to negotiate conflict-free trajectories that best suits various stakeholders' operational objectives. Moreover, all stakeholders will share a coherent and consistent view of the trajectories from gate to gate. Strategic flow adjustments can be made to the trajectory based on demand and capacity balancing, along with tactical changes, can be managed timely and effectively. The synchronization and the use of 4-D trajectories will promote superior predictability and reduce uncertainty between the planned and executed trajectory.

Traffic synchronization also implies that information is synchronized across flight phases. Coordination is needed between ATC authorities for information synchronization. This coordination requires information homogeneity – the information that is shared must be of the desired quality and is consistent in content and format. Information such as position, speed, Controlled Time of Arrival (CTAs), Scheduled Time of Arrival (STAs), aircraft weight, and relevant ATM decisions must satisfy the quality requirements of each ATC authorities. In addition to uniformed quality and format, a common information exchange scheme will be implemented to ensure the unhindered information flows between adjacent ATC authorities.

### 1.1.1 Baseline

Block 2 brought about the synchronisation of arrival and departure management. Arrival and departure sequencing will be linked to further augment airspace capacity and efficient terminal and aerodrome airspace design. This is realized by integrating the terminal with en-route airspace in high density areas and adjusting the arrival/departure sequence to ensure that they are both free from conflicts. In addition, this harmonization will also serve to reduce idle time at the gates and ground delays.

Arrival and departure synchronization advocate the expansion of terminal separation standards of 3 nautical miles to adjacent en-route airspace. Less stringent MIT restrictions implies more flights can be accommodated in a congested airspace. Furthermore, the expansion allows ATC authorities to optimize the sequencing of incoming traffic and increase throughput in high demand aerodromes.

Electronic coordination of departure operation between ATC authorities, such as coordination of departure flow with relevant ATC authorities, will promote more agile and efficient operations. Automated distribution of relevant information has the added benefit of reduced workloads at the respective ATC authorities.

### 1.1.2 Change brought by the module

In block 3, traffic synchronization will be realized.. The integration of surface, arrival, and departure management lead to optimized flow management and efficient utilization of airspace..

Traffic synchronization will bring about 4-D control of flights. A full time profile facilitates the execution of 4D trajectory control. A flight will be given to time profile to adhere to. Time profile enables ATM to optimize airspace throughput. The time profile also serves to provide greater predictability and mitigate uncertainty in demand and capacity predictions. Greater predictability enables better planning and enhances operational efficiency. In addition to predictability, synchronization and 4D trajectory management facilitate greater flexibility. Airspace users and ATC authorities can negotiate trajectories to avert conflicts and other hindering factors. These trajectories will be conflict free, and will both meet the business objectives (e.g. fuel efficient routes) of the airspace users and conform to ATM decisions. Traffic synchronization allows for the strategic and tactical management of traffic flows.

In addition to predictability, the implementation of time traffic synchronization will advance information homogeneity, leading to greater common situational awareness and rapid collaborative ATM decision making across multitude of ATC facilities. Information homogeneity across all flight phases presents both the airspace users and ATM with consistent, accurate, timely, and relevant information. Furthermore, information homogeneity reduces the complexity of ATM operations. As the need for reconciliation of discrepancy in various aspects of ATM operations is lessen.

## *1.2 Element 1: Full Traffic Synchronization*

The synchronization of en-route, arrival, departure, and surface represents the establishment and maintenance of a safe, efficient, and orderly flow of air traffic. Conflict management, demand and capacity, and synchronization will be fully integrated. Traffic synchronization will encompasses all physical phases of a flight. It will serve as a tool to manage traffic flows both tactically and strategically. Traffic synchronization will utilize a combination automation, procedures, and airspace modification to optimize throughputs in all domains – surface, departure, arrival, and en-route.

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

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

| | |
|---|---|
| *Capacity* | Mitigate impacts of various restrictions and conflicts and allow a greater throughput |
| *Efficiency* | Optimize and coordinate arrival, departure, and surface traffic flows in the terminal and aerodrome domain. |
| *Predictability* | Optimized Time Profile and greater ATM decision compliance<br>Gate-to-Gate 4D trajectory will mitigate uncertainties in demand prediction across all domains and enables better planning through all airspace. |
| *Flexibility* | Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns |

| | |
|---|---|
| *CBA* | 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. |

## 3. Necessary Procedures (Air & Ground)

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

## 4. Necessary System Capability

### *4.1 Avionics*

Full Traffic Synchronization will require the aircraft to be capable of exchanging information regarding the 4D Trajectory Profile, and be able to adhere to an agreed 4D Trajectory.

### *4.2 Ground Systems*

Traffic synchronization may require sequencing and optimization automation systems upgrades. These upgrades should support time based management, integrated sequencing, and augmented surveillance capabilities.

## 5. Human Performance

### *5.1 Human Factors Considerations*

Analysis should be completed to determine if any changes to the Computer Human Interface are needed to enable ATM Personnel to best manage the 4D Trajectory Profiles.

### *5.2 Training and Qualification Requirements*

Automation support is needed for Air Traffic Management in airspace with high demands. Thus, training is needed for ATM personnel. ATM personnel responsibilities will not be affected

### *5.3 Others*

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

Full traffic synchronization will entail policies on information sharing, roles and responsibilities of all actors in 4-D trajectory management, and mutual understanding/acceptance of new operational procedures. A framework, similar to should be establish to serve as a forum for all stakeholders to discuss relevant issues and concerns.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

TBD

### *7.2 Planned or Ongoing Trials*

TBD

## 8. Reference Documents

### *8.1 Standards*

### *8.2 Procedures*

### *8.3 Guidance Material*

European ATM Master Plan,

SESAR Definition Phase Deliverable 2 – The Performance Target,

SESAR Definition Phase Deliverable 3 – The ATM Target Concept,

SESEAR Definition Phase 5 – SESAR Master Plan

TBFM Business Case Analysis Report

NextGen Midterm Concept of Operations v.2.0

RTCA Trajectory Concept of Use

# Module N° B3-25 Improved Operational Performance through the introduction of Full FF-ICE

| | | |
|---|---|---|
| **Summary** | All data for all relevant Flights systematically shared between the air and ground systems using SWIM in support of collaborative ATM and Trajectory Based Operations. | |
| **Main Performance Impact** | KPA-02 Capacity, KPA-04 Efficiency KPA-06 Flexibility, **KPA-07 Global Interoperability,** KPA-08 Participation by the ATM community, KPA-10 Safety, | |
| **Operating Environment/Phases of Flight** | All phases of flight from initial planning to post-flight | |
| **Applicability Considerations** | Air and ground | |
| **Global Concept Component(s)** | IM-information management | |
| **Global Plan Initiatives (GPI)** | GPI-7 Dynamic and flexible route management<br>GPI-12 Functional integration of ground systems with airborne systems<br>GPI-16 Decision Support Systems | |
| **Pre-Requisites** | B1-30, B2-25, B2-31 | |
| **Global Readiness Checklist** | | **Status (ready now or estimated date)** |
| | Standards Readiness | Est 2023 |
| | Avionics Availability | Est 2025 |
| | Ground Systems Availability | Est 2025 |
| | Procedures Available | Est 2025 |
| | Operations Approvals | Est 2025 |

# 1. Narrative

**Refer to ICAO Draft Brochure**: FLIGHT & FLOW INFORMATION FOR A COLLABORATIVE ENVIRONMENT (FF-ICE) A Concept to Support Future ATM systems

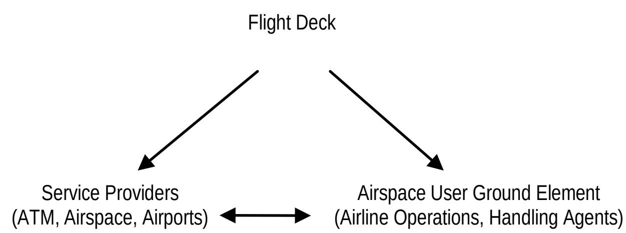
The Role of FF-ICE

As a product of the ICAO Global ATM Concept, FF-ICE defines information requirements for flight planning, flow management and trajectory management and aims to be a cornerstone of the performance-based air navigation system. Flight information and associated trajectories are principal mechanisms by which ATM service delivery will meet operational requirements.

FF-ICE will have global applicability and will support all members of the ATM community to achieve strategic, pre-tactical and tactical performance management.
FF-ICE emphasises the need for information sharing to enable significant benefits.

The exchange of flight/flow information will assist the construction of the best possible integrated picture of the past, present and future ATM situation. This exchange of information enables improved decision making by the ATM actors involved in the entire duration of a flight, i.e. gate-to-gate, facilitating management of the full 4-D trajectory.
FF-ICE ensures that definitions of data elements are globally standardised and provides the mechanisms for their exchange. Thus, with appropriate information management a Collaborative Decision Making environment is created enabling the sharing of appropriate data across a wider set of participants resulting in greater coordination of the ATM community, situational awareness and the achievement of global performance targets.

The future collaborative and dynamic flight information process will involve the full spectrum of ATM Community members as envisaged in the ATM Global Operational Concept. The cornerstone of future air traffic management is the interaction between these various parties and FF-ICE allows dynamic exchange of information.




The Global ATM concept, implemented through regional programmes such as SESAR (Single European Sky ATM Research) in Europe, NextGen (Next Generation Air Transportation System) in North America and CARATS (Collaborative Action for Renovation of Air Traffic Systems) in Japan, foresees Air Traffic Control becoming traffic management by trajectory. The roles of the parties illustrated above will evolve to support the requirements of this concept which will:

- Entail systematic sharing of aircraft trajectory data between actors in the ATM process
- Ensure that all actors have a common view of a flight and have access to the most accurate data available
- Allow operations respecting the airspace users' individual business cases

The Need for Change

The Global ATM Concept envisages an integrated, harmonised and globally interoperable system for all users in all phases of flight. The aim is to increase user flexibility and maximise operating efficiencies while increasing system capacity and improving safety levels in the future ATM system. The current system, including the flight planning process, has many limitations. FF-ICE helps to address these limitations and establishes the environment to enable improvements such as:

- Reduced reliance on voice radio communications for air/ground links
- Increased collaborative planning amongst ATM actors
- Providing facilities for real time information exchange
- Maximising benefits of advanced equipment and encouraging deployment of improved air and/or ground systems

### *1.1 General*

#### 1.1.1 Baseline

FF-ICE step 1 is implemented and initial SWIM applications are available on the ground. Flight-Object has been deployed as basis of the new FDP systems.

#### 1.1.2 Change brought by the module

New way to exchange trajectory data to provide better ATM services to airspace users.

Flight-object will be implemented in the ground systems and will support the flight information and trajectory sharing through SWIM during all phases of flight between air and ground. All messages between air and ground systems will use XML format to facilitate development and evolution.

### 1.2 Element:

The main challenge is to implement FF-ICE in airborne systems and use SWIM for airborne access to ATM information.

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

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

| | |
|---|---|
| *Cost Effectiveness* | Standard information will reduce cost of system development |
| *Efficiency* | Better knowledge of trajectory information will allow more optimum flight profile. |
| *Environment* | Y |
| *Global Interoperability* | Global interoperability is facilitated by easier connection of all stakeholders |
| *Participation by the ATM community* | Participation of all stakeholders is facilitated through real-time data sharing |
| *Predictability* | The sharing of information between aircraft and ground systems will enhance the predictability |
| *Safety* | System wide data sharing will allow early detection of inconsistencies and updated information which will improve situation awareness.. |

| | |
|---|---|
| *CBA* | To be demonstrated by the balance of cost of system change with other performance improvement. |

## 3. Necessary Procedures (Air & Ground)

Publish and subscribe mechanisms will allow real-time sharing of the Flight Information for concerned and authorized actors.

The use of these data will be mainly for decision making tools and further automation.

## *4.* Necessary System Capability

### *4.1 Avionics*

Connection of the Flight Deck systems to the ground systems through a high speed data communication system.

Necessary distributed applications to manage the new services

### *4.2 Ground Systems*

There is a need for full secure and high throughput ground-ground and air-ground communications networks supporting SWIM access for exchange of Flight and Flow information from planning phase to post-Flight phase

Necessarily distributed applications to manage the new services

## 5. Human Performance

### *5.1 Human Factors Considerations*

This technological evolution does not affect directly the pilots or controllers and could be transparent. (System to system exchange, more accurate and updated data)

### *5.2 Training and Qualification Requirements*

Training of pilot, controller to use the new services associated to decision support tools through new procedures.

### *5.3 Others*

Not Applicable ?

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

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

### *7.2 Planned or Ongoing Activities*

Full-FF-ICE could be considered as the ultimate goal of the Trajectory Based Operations and it is part of NextGen and SESAR R&D plan.

List of SESAR Projects: WP14 and WP8.

## 8. Reference Documents

### *8.1 Standards*

### *8.2 Procedures*

### *8.3 Guidance Material*

6. FF-ICE concept document
7. Trajectory Based Operations documents

# Module N° B3-10: Traffic Complexity Management

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | **KPA-02 Capacity**; KPA-04 Efficiency; KPA-06 Flexibility; KPA-09 Predictability | |
| **Operating Environment/Phases of Flight** | Pre-flight and in-flight | |
| **Applicability Considerations** | Regional or sub-regional. Benefits are only significant over a certain geographical size and assume that it is possible to know and control/optimise relevant parameters. Benefits mainly useful in the higher density airspace | |
| **Global Concept Component(s)** | AOM – Airspace Organisation and Management<br>TS – Traffic Synchronisation<br>DCB – Demand & Capacity Balancing | |
| **Global Plan Initiatives (GPI)** | GPI-6 Air traffic flow management<br>GPI-8 Collaborative airspace design and management | |
| **Pre-Requisites** | Successor of: B1-10, B2-35<br>Parallel progress with: B3-5, B3-15, B3-25, B3-85 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Est. 2028** |
| | Avionics Availability | **Est. 2028** |
| | Ground Systems Availability | **Est. 2028** |
| | Procedures Available | **Est. 2028** |
| | Operations Approvals | **Est. 2028** |

## 1. Narrative

### *1.1 General*

While Trajectory-based Operations are the long-term evolution of the management of an individual trajectory, a number of events and phenomena affect traffic flows due to physical limitations, economic reasons or particular events and conditions. The long-term evolution of their management is addressed in this module in relation with traffic densities higher than the present ones, and/or with a view to improve the solutions applied so far and provide optimised services while working closer to the system limits. This is referred to as “managing complexity”.

The module integrates various ATM components to generate its extra performance benefits and will introduce further refinements in DCB, TS and AOM processes (and possibly SDM, AUO and AO) to exploit the more accurate and rich information environment expected from TBO, SWIM and other longer term evolutions.

This is an area of active research, where innovative solutions are probably as important as the understanding of the uncertainties inherent to ATM and of the air transport mechanisms and behaviours to which ATM performance is sensitive to.

### 1.1.1 Baseline

Prior to this module, most of the ingredients of the Global ATM Concept will have been progressively put in place, but not yet completely pending the dissemination of a certain number of capabilities and enablers, and also not fully integrated. There remains room to achieve performance gains by addressing the issues that the lack of optimised integration will raise.

### 1.1.2 Change brought by the module

The module provides for the optimisation of the traffic flows and air navigation resources usage. It addresses the complexity within ATM due to the combination of higher traffic densities, more accurate information on trajectories and their surrounding environment, closely interacting processes and systems, and the quest for greater levels of performance.

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

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

| | |
|---|---|
| *Capacity* | Increase and optimised usage of system capacity. |
| *Efficiency* | Optimisation of the overall network efficiency. |
| *Flexibility* | Accommodation of change requests. |
| *Predictability* | Minimise the impact of uncertainties and unplanned events on the smooth running of the ATM system. |

| | |
|---|---|
| *CBA* | To be established as part of the research related to the module. |

## 3. Necessary Procedures (Air & Ground)

To be defined.

## 4. Necessary System Capability

The module will exploit technology then available, in particular SWIM and TBO which will provide the accurate information on the flights and their environment. It will also likely rely on automation tools.

### *4.1 Avionics*

None in addition to that required for participation in SWIM and/or TBO operations.

### *4.2 Ground Systems*

Intensive use of automated functions and sophisticated algorithms to exploit information.

## 5. Human Performance

### *5.1 Human Factors Considerations*

The high degree of integration of the traffic information and the optimisation of the processes will likely require high levels of automation and the development of specific interfaces for the human operators.

### *5.2 Training and Qualification Requirements*

Training requirements will be high, not only prior to entry into service but also as a regular maintenance of the skills.

### *5.3 Others*

Nil

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

To be defined.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

None at this time.

## *7.2 Planned or Ongoing Activities*

- **Europe:** the SESAR programme has established a research network on "complexity" together with research projects addressing some of the relevant issues.
- **US:** research is being conducted at NASA and Universities.

No live trials in the foreseeable future.

# 8. Reference Documents

## *8.1 Standards*

TBD

## *8.2 Procedures*

TBD

## *8.3 Guidance Material*

TBD

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# Module N° B3-105: Better Operational Decisions through Integrated Weather Information (Near-term and Immediate Service)

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity; KPA-04 Efficiency; KPA-09 Predictability, KPA-10 Safety | |
| **Operating Environment/Phase of Flight** | All | |
| **Applicability Considerations** | 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. | |
| **Global Concept Component(s)** | AOM- Airport Operations and Management<br>DCB -Demand and Capacity Balancing<br>AO -Aerodrome Operations<br>TM-Traffic Synchronization<br>CM -Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9: Situational Awareness<br>GPI-15: Match IMC and VMC Operating Capacity<br>GPI-19: Meteorological Systems | |
| **Pre-Requisites** | Successor to B1-105 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | Est 2023 |
| | Avionics Availability | Est 2023 |
| | Infrastructure Availability | **Est 2023** |
| | Ground Automation Availability | Est 2023 |
| | Procedures Available | Est 2023 |
| | Operations Approvals | Est 2023 |

# 1. Narrative

## 1.1 General

This module is focused on developing advanced concepts and necessary technologies to enhance global ATM decision making in the face of adverse weather. The major components include a consistent, integrated set of meteorological information available to all users and ANSPs, advanced decision support tools that utilize the information to assess the potential operational impacts of the weather situation and decision support tools that develop candidate mitigation strategies for dealing with the impacts.

The capabilities discussed in this module will primarily benefit in-flight operations and weather avoidance in the en-route, terminal and aerodrome domains. But, this module will also extend initial pre-flight and flow planning capabilities realized in module B1-105. These negotiation capabilities will be globally interoperable to allow for seamless planning of trajectories for international flights.

### 1.1.1 Baseline

The baseline for this module is the initial, enhanced weather decision making capabilities enabled by module B1-105. Decision support capabilities are available, and integrated with weather information, to assist ANSPs and users to make better decisions in the strategic timeframe (40 minutes and out). A consistent, integrated weather information base is available to all ANSPs and users, to inform ATM decision making.

### 1.1.2 Change brought by the module

This module provides extensions to this baseline, with emphasis on the tactical (0-420 minute) timeframe, and greater use of aircraft-based capabilities for weather awareness and avoidance. A major focus is on the provision of enhanced automation capabilities (building on B1-105) for developing characterizations of potential weather impacted airspace, and for using those characterizations to determine impact on ATM operations and individual flights.

## 1.2 Element 1: Enhanced Weather Information

This element is focused on the development of enhanced weather information for integration into ATM decision making. The scope of weather information to be considered includes observations and forecasts of the full range of aviation-relevant phenomena, including convection, turbulence, volcanic ash, low-level wind shear, ceiling and visibility, wake turbulence, etc. This also includes an emphasis on increasing the availability of characterizations of potentially weather constrained airspace which may be directly integrated into ANSP and user decision making. This element also focuses on the development or revision of global standards for weather information content and format, given the migration to 4-D representations of weather information, versus current text and graphics.

## 1.3 Element 2: Weather-Integrated Decision Support Tools

This element continues the evolution to the utilization of ATM decision support tools, used by ANSPs and users, which directly integrate the above weather information into their processing. Based on experiences gained from development and deployment of initial capabilities as part of module B1-105, extensions are developed to generate more efficient and operationally acceptable weather mitigation solutions. This element also develops direct automation-to-automation negotiation capabilities (both ground-based and aircraft-based) to streamline the development of mutually acceptable ATM decisions.

## 1.4 Element 3: Cockpit Weather Capabilities

This element will focus on aircraft-based capabilities that will assist pilots with weather avoidance, and thus enhance safety. Capabilities such as ADS-B In, air-to-air information exchange, and integration of weather into cockpit-based automation tools are considered. In addition, increased availability of aircraft-based weather observations will further enhance situational awareness, and help to improve weather forecasting. This element must focus on globally-harmonized standards development for weather information exchange to support these capabilities.

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

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

| | |
|---|---|
| *Capacity* | 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.<br><br>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. |
| *Efficiency* | 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. |
| *Safety* | Increased weather situational awareness by pilots, and ANSPs, enables avoidance of hazardous conditions. |

| | |
|---|---|
| *CBA* | The business case is still to be determined as part of the development of this module, which is in the research phase. |

## 3. Necessary Procedures (Air & Ground)

The necessary procedures basically exist for ANSPs and users to collaborate on weather-related decisions. Extensions to those procedures will be developed to reflect the use of enhanced weather observation and forecast information, plus the use of characterizations of potential weather-impacted airspace. International standards for information exchange between systems to support these improved ATM operations must be developed. This includes development of global standards for the delivery of weather information to aircraft.

The use of ADS-B/CDTI and other cockpit capabilities to support weather avoidance by pilots will necessitate procedure development, including the roles of ANSPs. International standards for weather information exchange between ground-based and aircraft-based systems to support these operations must be developed. This includes development of global standards for the delivery of weather information to aircraft.

## 4. Necessary System Capability

### 4.1 Avionics

This module has a significant dependency on advanced aircraft capabilities being widely available. Although aircraft-based capabilities such as ADS-B/CDTI and EFBs exist, the level of equipage is still evolving, and applications are still being developed to support the objectives of this module. Also, integration of advanced weather information into aircraft-based decision support tools will be needed. Increased levels of aircraft equipage with weather sensors (e.g. turbulence, humidity, winds) will be necessary to ensure tactical weather situational awareness for all aircraft in an area of interest..

### 4.2 Ground Systems

For this longer-term module, the needed ground-system technology is still in development. Research is on-going into decision support tools that ingest weather information directly, and support the automated development of candidate mitigation strategies. For example, conflict resolution tools will be integrated with weather information to ensure aircraft are not inadvertently routed into adverse weather. Work is also needed to ensure a globally harmonized, common weather information base that is available to all ANSPs and users for decision making. Also, integration of ground-based and aircraft-based automation capabilities, including exchange of digital weather information, is needed to support tactical weather avoidance decision making.

# 5. Human Performance

## 5.1 Human Factors Considerations

This module may necessitate changes in how service providers and users deal with tactical weather situations. While pilots will continue to be responsible for the safe operation of their aircraft in adverse weather, the roles and responsibilities of controllers (informed by conflict resolution tools) must also be considered, in order to achieve safe and efficient approaches to weather avoidance. Also, the realization of a “common view” of the weather situation between service providers, flight operational and pilots will require trust in a single, common information base of weather.

## 5.2 Training and Qualification Requirements

Automation support, integrated with weather information is needed for flight operations, pilots and service providers. Training in the concepts behind the automation capabilities will be necessary to enable the effective integration of the tools into operations. Also, enhanced procedures for collaboration on tactical weather avoidance will need to be developed and training provided, again to ensure effective operational use.

# 6 Regulatory/Standardisation needs and Approval Plan (Air & Ground)

This module requires the following:

Development of global standards for weather information exchange, with emphasis on exchange of 4-D (X, Y, Z, and T [time]) gridded weather information.

Regulatory agreement on what constitutes required weather information in the age of digital exchange, versus text and graphics.

Certification decisions on aircraft-based weather display and dissemination. Dissemination includes air-to-ground for aircraft based observations (e.g. turbulence and humidity), as well as possible air-to-air exchange of those observations (e.g. turbulence information to nearby aircraft) via ADS-B.

Certification decisions on aircraft-based weather display and dissemination. Dissemination includes air-to-ground for aircraft based observations (e.g. turbulence and humidity), as well as possible air-to-air exchange of those observations (e.g. turbulence information to nearby aircraft) via ADS-B.

# 7. Implementation and Demonstration Activities

## *7.1 Current Use*

Many countries and the user community have been utilizing a Collaborative Decision Making (CDM) process for developing coordinated strategies for dealing with adverse weather. These efforts have included the application of enhanced weather forecast information, as it is developed. In addition, the FAA and the National Weather Service are continuing research on aviation-related weather forecasts, at all decision time horizons. Initial demonstrations of these candidate products are showing promise in enhancing the quality of weather information upon which ATM decisions can be made, by ANSPs and users.

Since this module is in the category of Long Term Issues, there are limited examples of current operational use. In the U.S. experience with the use of FIS-B, and the Alaska Capstone effort, has shown a significant safety benefit, with increased cockpit weather display capabilities. Also, for General Aviation aircraft, private vendors are making weather information available in the cockpit, as optional services. The FAA is conducting research on ADS-B In applications that relate to weather avoidance via cockpit functionality. In Europe, FIS-B-like capabilities are being deployed currently in Sweden and Russia that provide for enhanced weather information availability to pilots. (Suggest ICAO amplify on this addition, as appropriate) Such U.S. and European research efforts will help to inform the work to be done under this module.

### *7.2 Planned or Ongoing Activities*

No global demonstration trials are currently planned for this module. There is a need to develop such a plan as part of the collaboration process, and as an extension of other modules.

## 8. Reference Documents

### 8.1 Standards

World Meteorological Organization standards for weather information content and format. Others TBD; to be developed as part of this research

#### 8.2 Procedures

To be developed

#### 8.3 Guidance material

To be developed.

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# Module N° B3-85: Airborne Self-Separation (SSEP):

| | | |
|---|---|---|
| **Summary** | 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<br>The flight crew ensures separation of their aircraft from all surrounding suitably equipped traffic. The controller has no responsibility for separation. | |
| **Main Performance Impact** | KPA-02 Capacity, **KPA-03 Cost Effectiveness** KPA-04 Efficiency, KPA-05 Environment | |
| **Domain / Flight Phases** | En-route phase, oceanic | |
| **Applicability Considerations** | 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 equipage roles and responsibilities (procedure and training). First area for SSEP application is in low density areas. | |
| **Global Concept Component(s)** | CM- Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-16 Decision support systems and alerting systems | |
| **Main Dependencies** | In-Trail-Procedure (ITP) B0-86 and Interval Management (IM) B1-85 and Airborne Separation B2-85 | |
| **Global Readiness Checklist** | | **Status (ready or date)** |
| | Standards Readiness | Est. 2028 |
| | Avionics Availability | Est. 2028 |
| | Ground Systems Availability | Est. 2028 |
| | Procedures Available | Est. 2028 |
| | Operations Approvals | Est. 2028 |

## 1. Narrative

### *1.1 General*

Airborne separation is described in the Global ATM Operational concept (ICAO Doc 9854) "

"**Self-Separation**

Self-separation is the situation where the airspace user is the separator for its activity in respect of one or more hazards.

Full self-separation is the situation where the airspace user is the separator for its activity in respect of all hazards. In this case, no separation provision service will be involved; however, other ATM services, including strategic conflict management services, may be used.

### 1.1.1 Baseline

The baseline is provided by the first ASAS application described in the module B0-86 In-Trail Procedures, B1-85 ASAS-ASPA interval management and B2-85 Airborne separation by temporary delegation. These ASAS- SSEP operations will be the next step, giving more autonomy to the equipped aircraft.

### 1.1.2 Change brought by the module

This module will introduce self-separation relying on aircraft capabilities including airborne surveillance supported by ADS-B and giving responsibility for separation to the pilot in designated airspace.

### *1.2 Element: SSEP*

**Airborne self-separation**: The flight crew ensures separation of their aircraft from all surrounding traffic. The controller has no responsibility for separation. First applications are in Oceanic airspace and low density airspace.

**Typical Airborne Self-separation applications include:**

- Airborne Self-separation in ATC-controlled airspace.
- Airborne Self-separation in segregated en-route airspace.
- Airborne Self-separation in mixed-equipage en-route airspace.
- SSEP – FFT Free Flight on an Oceanic Track

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

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

| | |
|---|---|
| *Access and Equity* | Only suitably equipped aircraft can access the designated airspace |
| *Capacity* | 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. |
| *Efficiency* | More optimum flight trajectories |
| *Environment* | Less fuel consumption due to more optimum flight trajectories |
| *Flexibility* | More flexibility to take in account change in constraint, weather situation |
| *Global Interoperability* | The airborne systems must be standardized to ensure air-air compatibility. |
| *Participation by the ATM community* | Increased role of the pilot |
| *Safety* | To be demonstrated |

| | |
|---|---|
| *CBA* | To be determined by balancing cost of equipment and training and reduced penalties |

## 3. Necessary Procedures (Air & Ground)

ASAS- SSEP procedures need to be defined for PANS-ATM and PANS-OPS with the need to determine applicable separation minima. Operational procedures to enter and exit the designated airspace must be defined.

# 4. Necessary System capability (Air & Ground)

## 4.1 Avionics

For self-separation (SSEP) the main capabilities are on ASAS. The ASAS is composed of 3 main functions, i.e., airborne surveillance, conflict detection and conflict resolution.

## 4.2 Ground systems

For self-separation in a mixed airspace where a mix of equipped and non-equipped is authorized, on ground there is a need for specific tools to assess the aircraft capabilities, to support and to monitor the execution of separation by self-separating aircraft, while managing the separation of the others aircraft. This requires a full sharing of the trajectory information between all the actors.

For self-separation in a segregated airspace, there is a need to check that the predicted density allows this mode of mitigations and that the aircraft are authorized to fly through this airspace. Specific tools could be necessary to manage the transfer from self-separation airspace to conventional airspace.

# 5. Human Performance

## 5.1 Human Factors Considerations

Change of role of controllers and pilots need to be carefully assessed

Specific training and qualification are required

## 5.2 Training and Qualification Requirements

The pilot need to be trained and qualified to assume the new role and responsibility and correct usage of the new procedures and avionics.

Automation support is needed for the pilot and the controller which therefore will have to be trained to the new environment and to identify the aircraft/facilities which can use the services in mixed mode environments.

## 5.3 Others

Liability issues are to be considered

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

Change in PANS-OPS and PANS-ATM are required

# 7. Implementation and Demonstration Activities

## 7.1 Current Use

None at this time.

## 7.2 Planned or Ongoing Trials

**European project**

**ASSTAR (2005-2007) initiated the work on ASEP and SSEP applications in Europe which has been pursued by SESAR projects as follows:**

**SESAR Project 04.07.05 Self Separation in Mixed Mode Environment**
One goal of the ASAS development path is to enable self separation (SSEP) in mixed mode operations. The intention is to allow self-separating flights and ANSP separated flights to operate in the same airspace. The project has 2 phases with following objectives:

1st phase: Assess compatibility between 4D-contract and ASEP applications as a step towards autonomous operations.

2nd phase: develop and validate the operating concept for the SSEP applications in mixed mode, i.e. together with conventional, new airborne mode (ASEP-C&P) and new ground modes.

The main objective is to validate the integration of 4D, ASAS, and conventional traffic in the separation management task. The focus will be the interaction of conventional and new separation modes and the consequences for capacity, efficiency, safety, and predictability. Moreover, relations between safety and capacity will be studied aiming at decreasing the number of critical incidents despite increasing traffic.

# 8. Reference Documents

## *8.1 Standards*

To be developed

## *8.2 Procedures*

To be developed

## *8.3 Guidance materials*

- ICAO Doc 9854 – Global ATM Operational Concept
- ICAO ANConf/11-IP5 draft ASAS Circular (2003)
- FAA/EUROCONTROL ACTION PLAN 23 – D3 -The Operational Role of Airborne Surveillance in Separating Traffic (November 2008)
- FAA/EUROCONTROL ACTION PLAN 23 – D4 –ASAS application elements and avionics supporting functions (2010)

# Module N° B3-05: Full 4D Trajectory-based Operations

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-02 Capacity; **KPA-04 Efficiency**; KPA-05 Environment; KPA-10 Safety; | |
| **Domain / Flight Phases** | En-route/Cruise, Terminal Area, Traffic Flow Management, Descent | |
| **Applicability Considerations** | Applicable to air traffic flow planning, en-route operations, terminal operations (arrival/departure), and arrival operations. Benefits accrue to both flows and individual aircraft. Aircraft equipage is assumed in the areas of: ADS-B In/CDTI; data communication and advanced navigation capabilities. 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. | |
| **Global Concept Component(s)** | AOM - Airspace Organization and Management<br>DCB - Demand and Capacity Balancing<br>AUO - Airspace User Operations<br>TS - Traffic synchronization<br>CM - Conflict management | |
| **Global Plan Initiatives (GPI)** | GPI-5- RNAV/RNP (Perf. Based Nav)<br>GPI-11- RNP and RNAV SIDs and STARs<br>GPI-16- Decision Support Systems and Alerting Systems | |
| **Main Dependencies** | B0-40, B1-10, B1-25, B1-40, | |
| **Global Readiness Checklist** | | **Status** (indicate ready with a tick or input date) |
| | Standards Readiness | 2025 |
| | Avionics Availability | 2028 |
| | Ground Systems Availability | 2028 |
| | Procedures Available | 2028 |
| | Operations Approvals | 2028 |

## 1. Narrative

### *1.1 General*

This module implements 4D trajectory based operations that uses the capabilities of aircraft Flight Management Systems to optimise aircraft flight trajectories in four dimensions. Full TBO integrates advanced capabilities that will provide vastly improved surveillance, navigation, data communications, and automation for ground and airborne systems with changes in service provider roles and responsibilities.

### 1.1.1 Baseline

This module 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. It continues the evolution in procedures and automation capabilities, both ground-based and aircraft-based, for using accurate trajectories to benefits the system. Optimised arrivals in dense airspace were previously enabled. Decision support capabilities are available that are integrated to assist ANSPs and users to make better decisions in arrival profile optimisation. A consistent, integrated information base is available to all ANSPs and users to inform ATM decision making.

### 1.1.2 Change brought by the module

In future en route airspace, mixed levels of aircraft performance and air crew authorizations are expected. High-performance aircraft will be capable of flying RNAV routes, accurately conforming to their route of flight, supporting data communications, communicating requests and aircraft state and intent information electronically with the ATC automation, and receiving clearances and other messages electronically from the ATC automation.

Some en route airspace will be designated for high-performance aircraft only, allowing the air traffic control (ATC) system to engage operations that fully leverage the capabilities of those aircraft. Aircraft will communicate state and intent information to the ATC automation and closely follow their intended routes of flight. As a result, the automated problem prediction and resolution capabilities will be able to maximize user benefits by supporting user-preferred flight plans, minimizing changes to those plans as aircraft traverse the NAS, and improving services provided.

The controller's primary responsibilities will be to respond to problems predicted by the ATC automation, and to maintain accurate flight information in the ATC automation. Predicted problems will include:

- Aircraft to aircraft conflicts
- Aircraft to special use or other types of restricted airspaces
- Aircraft to severe weather forecast areas
- Aircraft to metering constraint problems including miles in trail restrictions
- The aircraft's capability to accurately fly its cleared route of flight, coupled with the state and intent information sent from the aircraft to the ATC automation, will increase the accuracy of trajectory modeling and problem prediction. Key aspects of Full TBO are:
- The basis for all operations is an accurate four-dimensional trajectory that is shared among all of the aviation system users.
- Consistent and up-to-date information describing flights and air traffic flows are available system-wide, supporting both user and service provider operations.
- Data Communication is used between the ground and aircraft to improve the accuracy of trajectories, request changes in 4D trajectory, provide precise clearances to the flight, and exchange information without controller involvement.
- Area Navigation (RNAV) operations remove the requirement for routes to be defined by the location of navigational aids, enabling the flexibility of point-to-point aircraft operations.
- Required Navigation Performance (RNP) operations introduce the requirement for onboard performance monitoring and alerting. A critical characteristic of RNP operations is the ability of the aircraft navigation system to monitor its achieved navigation performance for a specific operation, and inform the air crew if the operational requirement is being met.
- En route controllers rely on automation to identify conflicts and propose resolutions allowing them to focus on providing improved services to the users.
- The ability of cockpit automation to fly the aircraft more precisely and predictably reduces routine tasks of controllers.

- Performance-based services that require minimum flight performance levels are provided in designated airspace.
- Flow management automation will propose incremental congestion resolutions that will maintain congestion risk at an acceptable level, using flight-specific alternative intent options to the extent possible. Flight operation centers (FOC) will dynamically re-calculate and furnish the flight crew and flow management updated intent options and priority of the options as conditions change.
- Time-based flow management that coordinates arrival flows for high traffic airports.

### *1.2 Element 1: Advance Aircraft Capabilities*

This element focuses on aircraft-based capabilities that assists pilots with weather and other aircraft avoidance, and thus enhance safety. Such capabilities as ADS-B In, air-to-air information exchange, and integration of weather into cockpit-based automation tools. This element also focuses on globally-harmonized standards development for trajectory data exchange between the ground and aircraft avionics systems such as the FMS.

### *1.3 Element 2: Problem Detection and Resolution*

This element will continue the evolution to the use of ATM decision support tools, by ANSPs and users, which provide manoeuvres for flying the most economical descent profiles. Based on experiences gained from development and deployment of initial capabilities, extensions will be developed to generate more efficient and operationally acceptable arrival profile solutions. This element will also explore direct automation-to-automation negotiation capabilities to streamline the development of mutually acceptable ATM solutions. This element is will also focus on getting the most accurate trajectory model in the system for use by all automation functions. This entails putting every clearance given to the aircraft into the automation, using automation generated resolutions to make it easier for the controllers to enter the clearance, and receiving flight specific data from the aircraft to include in the trajectory calculation and any resolution options.

### *1.4 Element 3: Traffic Flow Management and Time-Based Metering*

This element will harmonize the Traffic Flow Management automation which continuously predicts the demand and capacity of all system resources, and will identify when the congestion risk for any resource (airport or airspace) is predicted to exceed an acceptable risk. Information from FOCs or flight crews indicates intent options and preferences, so that user reactions and adjustments to the 4DT to address constraints such as weather are accounted before the ANSP would take action. Traffic Management will take action in the form of just in time reroutes and metering times to congested resources. The problem resolution element will create a manoeuvre that meets all system constraints.

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

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

| | |
|---|---|
| *Capacity* | 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.<br>i. Applied horizontal separation |
| *Efficiency* | Harmonized avionics standards<br>a. cost savings and environmental benefits through reduced fuel burn<br>i. Level flight time<br>ii. Level distance time<br>iii. Fuel burn<br>a. Users will be better able to plan and receive their preferred trajectory<br>i. Number of user-preferred profiles that can be accommodated |

| | |
|---|---|
| *Environment* | a. Users will be better able to plan and receive their preferred trajectory<br>i. Number of user-preferred profiles that can be accommodated<br>a. Cost savings and environmental benefits through reduced fuel burn<br>i. Level flight time<br>ii. Level distance time<br>ii. Fuel burn |
| *Safety* | a. Increased flight crew situational awareness<br>b. Reduction of conflicts between aircraft and more lead time in resolving those conflicts that exist.<br>c. Number of incident occurrences |

| | |
|---|---|
| *CBA* | 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. |

## 3. Necessary Procedures (Air & Ground)

The use of ADS-B/CDTI and other cockpit capabilities to support aircraft avoidance is still a research topic and will necessitate procedures development, including the roles of ANSPs.

For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation.

For strategic actions, the necessary procedures basically exist for ANSPs and users to collaborate on flight path decisions. Extensions to those procedures will need to be developed to reflect the use of increased decision support automation capabilities, including automation-to-automation negotiation.

## 4. Necessary System Capability (Air & Ground)

### *4.1 Avionics*

For this longer-term element, the needed technology is still in development. Aircraft-based capabilities, such as ADS-B/CDTI, exist, but applications are still being developed to support the objectives of this element.

### *4.2 Ground Systems*

For the longer-term element, the needed technology is still in development. For ground-based technology, research is on-going into decision support tools that produce fuel efficient resolutions, and support the automated development of candidate mitigation strategies. Work is also needed to incorporate data from aircraft systems into ground trajectory models to ensure the most accurate trajectory.

## 5. Human Performance

### *5.1 Human Factor Considerations*

TBD

### *5.2 Training and Qualifications Requirements*

TBD

### *5.3 Others*

TBD

## 6. Regulatory/Standardisation needs and Approval Plan (Air & Ground)

### *6.1 Element 1: Advance Aircraft Capabilities*

International standards for information exchange between systems to support these operations need to be developed. This includes development of global standards for the exchange of trajectory information between ground and air.

International standards for information exchange between systems to support these operations need to be developed. This includes development of global standards for the exchange of trajectory information between ground and air. Included in this is development of global standards for trajectory information exchange and certification decision on aircraft-based aircraft display and dissemination. Dissemination includes air-to-ground as well as air-to-air exchange of those observations via ADS-B.

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

Since this module is in the category of Long Term Issues, there are no examples of current operational use. Numerous entities are conducting research on ADS-B In applications that relate to aircraft avoidance via cockpit functionality. Such research efforts will help to inform the work to be done under this block.

### *7.2 Planned or Ongoing Trials*

#### 7.2.1 Element 1: Advance Aircraft Capabilities

No global demonstration trials are currently planned for this module. There is a need to develop such a plan as part of the collaboration on this module.

## 8. Reference Documents

- NextGen and SESAR Operational Concepts
- DOC4444 & Annex 10-V2
- Manual of Air Traffic Services Data Link Applications (Doc 9694)
- EUROCOAE/RTCA documents: ED100A/DO258A, ED122/DO306, ED120/DO290, ED154/DO305, ED110B/DO280
- EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements.

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# Module N° B3-90: Remotely Piloted Aircraft (RPA) Transparent Management

| | | |
|---|---|---|
| **Summary** | 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. | |
| **Main Performance Impact** | KPA-01 Access & Equity, KPA-02 Capacity; KPA-04 Efficiency; KPA-05 Environment, KPA-09 Predictability, KPA-10 Safety | |
| **Domain Flight Phases** | En-route, oceanic, terminal (arrival and departure), aerodrome (taxi, take-off and landing) | |
| **Applicability Considerations** | Applies to all RPAS operating in controlled airspace and at aerodromes. Requires good synchronisation of airborne and ground deployment to generate significant benefits, in particular to those able to meet minimum certification and equipment requirements. | |
| **Global Concept Component(s)** | AOM - Airspace Organization and Management<br>CM - Conflict Management<br>AUO - Airspace User Operations | |
| **Global Plan Initiatives (GPI)** | GPI-6, Air traffic flow management<br>GPI-9, Situational awareness<br>GPI-12, Functional integration of ground systems with airborne systems | |
| **Pre-Requisites** | B2-90 | |
| **Global Readiness Checklist** | | **Status** (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 |

## 1. Narrative

### *1.1 General*

Based on block 2 upgrades and procedures

#### 1.1.1 Baseline

The baseline contains procedures that accommodate and allow for the evolution of RPA's into the airspace. This includes the improvements addressed in Block 2-90, which are:

- Access to most airspace for select airframes without specific authorization or experimental aircraft waiver
- RPAS certification procedures
- New special purpose transponder code for lost link
- Standardized lost link procedures
- Revised separation criteria and/or handling procedures (i.e. moving airspace)
- ADS-B on most RPA classes
- Detect and Avoid technologies improvements
- Automatic position reporting to ATC capability for lost link over high seas

| Block 3 | 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) |
|---|---|---|---|---|
| **Authorization** | Strict compliance with standard regulations is required. | | | |
| **C2 Link Failure Procedures** | Shall follow standardized procedures. A special purpose transponder code will be established. | | Shall follow standardized procedures. Must broadcast or contract position reports to ATC | RPA must be equipped for Air born Detect and avoid in case a lost link is experienced during flight |
| **Communications** | Continuous two-way communications as required for the airspace. UAS will squawk 7600 in case of communications failure. | | Primary communications are via terrestrial data link; for lost communications RPA pilot will use telephonic communications.<br><br>RPA will be capable of air-to-air communications. | N/A |
| **Separation Standards** | New separation standards may be required | | Separation criteria will be analysed and special separation criteria might be developed. With ADS-B self-separation for passing manoeuvres at the same altitude will be permitted f | RPAS is responsible for maintaining safe separation |
| **ATC Instructions** | RPAS will comply with ATC instructions as required | | | N/A |
| **RPA Observers** | Not required if RPAS is equipped for GBSAA flight in a GBSAA approved area, or is equipped for ABSAA | Not required | | N/A |
| **Medical** | Remote pilots shall have an appropriate medical certificate | | | |
| **Presence of Other Aircraft** | RPA shall not increase safety risk to the air navigation system | | | |
| **Visual Separation** | Visual separation will be permitted if RPAS is equipped for GBDAA flight in a GBSAA approved area, or is equipped for ABDAA | | TBD | RPA must use GBDAA or ABDAA for separation at all times |
| **Responsibility of Remote Pilot** | Remote pilot is responsible for compliance with the rules of the air and adherence with the authorization | | | |
| **Populated Areas** | RPAS shall not conduct operations over populated areas | Operations over populated areas permitted if there is sufficient height to glide to an unpopulated area in an emergency | | RPAS shall not be conduct operations over populated areas |
| **ATC Services** | Consistent with Annex 11, Appendix 4 | | | N/A |
| **Flight Plan** | RPA operations will be conducted on an IFR or VFR flight plan. VFR flight plans will only be conducted if the RPAS is equipped for GBDAA flight in a GBDAA approved area, or is equipped for ABDAA. | | | |
| **Meteorological Conditions** | Restrictions to be determined by the State | | | |

| | | |
|---|---|---|
| **Transponder** | Shall have and use ADS-B | N/A |
| **Safety** | Identify the hazards and mitigate the safety risks; adhere to the authorization | |
| **NOTAMs** | NOTAM requirements, if any, to be determined by the State | |
| **Certification** | TBD | |

### 1.1.2 Changes brought by the module

- **Certification for RPA's flying in all classes of airspace:** Here the RPA operates in the non-segregated airspace just like any other aircraft. Certification has been defined based on standards, and the safety case has been proven for each aircraft type. The Air Traffic Management (ATM) procedures (identification of aircraft type, separation standards, and lost communications procedures are well defined in Block 3 to allow for this type of operations.
- **Reliable C2 link:** This improvement continues from the work done in block 2 and the procedures and standards will be fully vetted and certified during this block.
- **Certified autonomous response:** The ability to respond autonomously in any situation to provide both self-separation and collision avoidance maneuvers. This is needed to ensure safety even during a lost link event. The pilot can still have the ability to override the autonomous actions whenever the C2 link is operational.
- **Certified ABSAA algorithms:** During this block the procedures and standards for autonomous operations, based on an ABSAA solution and algorithm set, will be developed and certified.
- **Aerodrome procedures[5]:** During this block, RPA will be integrated into aerodrome operations. Consideration may have to be given to the creation of airports that would support RPA operations only. The unique characteristics of the RPA need to be considered, some of the areas to be considered are:
  - Applicability of aerodrome signs and markings for RPAs
  - Integration of RPA with manned aircraft operations on the maneuvering area of an aerodrome
  - Issues surrounding the ability of RPA to avoid collisions while maneuvering
  - Issues surrounding the ability of RPA to follow ATC instructions in the air or on the maneuvering area (e.g. "follow green Cessna 172" or "cross behind the Air France A320")
  - Applicability of instrument approach minima to RPA operations
  - Necessity of RPA observers at aerodromes to assist the remote pilot with collision avoidance requirements
  - Implications for aerodrome requirements of RPA infrastructure, such as approach aids, ground handling vehicles, landing aids, launch/recovery aids, etc.
  - Rescue and fire fighting requirements for RPA (and remote pilot station, if applicable)
  - RPA launch/recovery at sites other than aerodromes
  - Integration of RPA with manned aircraft in the vicinity of an aerodrome
  - Aerodrome implications for RPAS-specific equipment (e.g. remote pilot stations)

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

| | |
|---|---|
| *Capacity* | Could be negatively impacted due to larger separations being applied for safety reasons between RPA and traditional traffic. Metric: sector capacity |
| *Efficiency* | Transparent access to airspace by RPAS<br><br>Metric: volume of RPA traffic |
| *Environment* | The uniform application of the module increases global interoperability by allowing pilots to be faced with understandable situations when flying in different States.<br><br>Metric: volume of interstate RPA traffic |
| *Predictability* | Increased predictability of RPA through global interoperability of communications and situational awareness. |
| *Safety* | Increased situational awareness; controlled use of aircraft<br><br>Metric: incident occurrences |

[5] [5] 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. |

## 3. Necessary Procedures (Air & Ground)

- Certified ATM procedures for RPAS to operate in all classes of airspace
- Procedures that allow for multiple RPA's in the same airspace at the same time
- Procedures that allow RPA's to operate out of all classes of airports
- Procedures that allow for autonomous operations including autonomous responses in any situation
- Where RPAs are operating alongside manned aircraft there needs to be ground and air procedures that insure harmonious operations.

## 4. Necessary System Capability (Air & Ground)

### *4.1 Avionics*

- Certified ABSAA algorithms
- Reliable C2 links
- Equipage of all aircraft, with proven detect and avoid technology
- Equipage of RPAS with necessary equipment to work within existing aerodrome parameters to the greatest extent practicable.

### *4.2 Ground Systems*

- GBSAA to supplement where applicable
- Certified autonomous algorithms

## *5. Human Performance*

### *5.1 Human Factor Considerations*

The controller-pilot relationship is well established.

### *5.2 Training and Qualifications Requirements*

TBD

### *5.3 Others*

TBD

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

TBD

## 7. Implementation and Demonstration Activities

TBD

### *7.1 Current Use*

TBD

### *7.2 Planned or On-going Trials*

TBD

## *8. Reference Documents*

- ICAO Circ 328 – *Unmanned Aircraft Systems (UAS)*
- Annex 2 — *Rules of the Air* proposal for amendment

- U.S. Department of Transportation FAA Air Traffic Organization Policy N JO 7210.766.
- NATO STANAG 4586 – *Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability*
- EUROCAE Document (under development)

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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

**ARTCC**s. Air route traffic control centers

**AS**. Aircraft surveillance

**ASAS**. Airborne separation assistance systems

**ASDE-X**. Airport surface detection equipment

**ASEP**. Airborne separation

**ASEP-ITF**. Airborne separation in trail follow

**ASEP-ITM**. Airborne separation in trail merge

**ASEP-ITP**. Airborne separation in trail procedure

**ASM**. Airspace management

**A-SMGCS**. Advanced surface movement guidance and control systems

**ASP**. Aeronautical surveillance plan

**ASPA**. Airborne spacing

**ASPIRE**. Asia and South Pacific initiative to reduce emissions

**ATC**. Air traffic control

**ATCO**. Air traffic controller

**ATCSCC**. Air traffic control system command center

**ATFCM**. Air traffic flow and capacity management

**ATFM**. Air traffic flow management

**ATMC**. Air traffic management control

**ATMRPP**. Air traffic management requirements and performance panel

**ATN**. Aeronautical Telecommunication Network

**ATOP**. Advanced technologies and oceanic procedures

**ATSA**. Air traffic situational awareness

**ATSMHS**. Air traffic services message handling services

**ATSU**. ATS unit

**AU**. Airspace user

**AUO**. Airspace user operations

**B**

**Baro-VNAV**. Barometric vertical navigation

**BCR**. Benefit/cost ratio

**B-RNAV**. Basic area navigation

**C**

**CSPO**. Closely spaced parallel operations

**CPDLC**. Controller-pilot data link communications

**CDO**. Continuous descent operations

**CBA**. Cost-benefit analysis

**CSPR**. Closely spaced parallel runways

**CM**. Conflict management

**CDG**. Paris - Charles de Gaulle airport

**CDM**. Collaborative decision-making

**CFMU**. Central flow management unit

**CDQM**. Collaborative departure queue management

**CWP**. Controller working positions

**CAD**. Computer aided design

**CTA**. Control time of arrival

**CARATS**. Collaborative action for renovation of air traffic systems

**CFIT**. Controlled flight into terrain

**CDTI**. Cockpit display of traffic information

**CCO**. Continuous climb operations

**CAR/SAM**. Caribbean and South American region

**COSESNA**. Central American civil aviation agency.

**D**

**DAA**. Detect and avoid

**DCB**. Demand capacity balancing

**DCL**. Departure clearance

**DFM** Departure flow management

**DFS**. Deutsche Flugsicherung GmbH

**DLIC**. Data link communications initiation capability

**DMAN**. Departure management

**DMEAN**. Dynamic management of European airspace network

**D-OTIS**. Data link-operational terminal information service

**DPI**. Departure planning information

**DPI**. Departure planning information

**D-TAXI**. Data link TAXI

**E**

**EAD**. European AIS database

**e-AIP**. Electronic AIP

**EGNOS**. European GNSS navigation overlay service

**ETMS**. Enhance air traffic management system

**EVS**. Enhanced vision systems

**F**

**FABEC** Functional Airspace Block Europe Central

**FAF/FAP**. Final approach fix/final approach point

**FANS**. Future air navigation systems

**FDP**. Flight data processing

**FDPS**. Flight data processing system

**FF-ICE**. Flight and flow information for the collaborative environment

**FIR**. Flight information region

**FIXM**. Flight information exchange model

**FMC**. Flight management computer

**FMS**. Flight management system

**FMTP**. Flight message transfer protocol

**FO**. Flight object

**FPL**. Filed flight plan

**FPS**. Flight planning systems

**FPSM**. Ground delay program parameters selection model

**FRA**. Free route airspace

**FTS**. Fast time simulation

**FUA**. Flexible use of airspace

**FUM**. Flight update message

**G**

**GANIS**. Global Air Navigation Industry Symposium

**GANP**. Global air navigation plan

**GAT**. General air traffic

**GBAS**. Ground-based augmentation system

**GBSAA**. Ground based sense and avoid

**GEO satellite**. Geostationary satellite

**GLS**. GBAS landing system

**GNSS**. Global navigation satellite system

**GPI**. Global plan initiatives

**GPS**. Global positioning system

**GRSS**. Global runway safety symposium

**GUFI**. Globally unique flight identifier

**H**

**HAT**. Height above threshold

**HMI**. Human-machine interface

**HUD**. Head-up display

**I**

**IDAC**. Integrated departure-arrival capability

**IDC**. Interfacility data communications

**IDRP**. Integrated departure route planner

**IFR**. Instrument flight rules

**ILS**. Instrument landing system

**IM**. Interval Management

**IOP**. Implementation and Interoperability

**IP.** Internetworking protocol

**IRR**. Internal rate of return

**ISRM**. Information service reference model

**ITP**. In-trail-procedure

**K**

**KPA**. Key performance areas

**L**

**LARA.** Local and sub-regional airspace management support system

**LIDAR**. Aerial laser scans

**LNAV**. Lateral navigation

**LoA**. Letter of agreement

**LoC**. Letter of coordination

**LPV**. Lateral precision with vertical guidance OR localizer performance with vertical guidance

**LVP**. Low visibility procedures

**M**

**MASPS**. Minimum aviation system performance standards

**MILO**. Mixed integer linear optimization

**MIT**. Miles-in-trail

**MLS**. Microwave landing system

**MLTF**. Multilateration task force

**MTOW**. Maximum take-off weight

**N**

**NADP**. Noise abatement departure procedure

**NAS**. National airspace system

**NAT**. North Atlantic

**NDB**. Non-directional radio beacon

**NextGen**. Next generation air transportation system

**NMAC**. Near mid-air collision

**NOP**. Network operations procedures (plan)

**NOTAM**. Notice to airmen

**NPV**. Net present value

**O**

**OLDI**. On-line data interchange

**OPD**. Optimized profile descent

**OSED** Operational service & environment definition

**OTW**. Out the window

**P**

**P(NMAC).** Probability of a near mid-air collision

**PACOTS**. Pacific organized track system

**PANS-OPS**. Procedures for air navigation services - aircraft operations

**PBN** - Performance-based navigation

**PENS** Pan-European Network Service

**PETAL**. Preliminary EUROCONTROL test of air/ground data link

**PIA**. Performance improvement area

**P-RNAV**. Precision area navigation

**R**

**RA**. Resolution advisory

**RAIM**. Receiver autonomous integrity monitoring

**RAPT**. Route availability planning tool

**RNAV** Area navigation

**RNP**. Required navigation performance

**RPAS**. Remotely-piloted aircraft system

**RTC**. Remote tower centre

**S**

**SARPs**. Standards and recommended practices

**SASP**. Separation and airspace safety panel

**SATCOM**. Satellite communication

**SBAS**. Satellite-based augmentation system

**SDM**. Service delivery management

**SESAR**. Single European sky ATM research

**SEVEN**. System-wide enhancements for versatile electronic negotiation

**SFO**. San Francisco international airport

**SIDS**. Standard instrument departures

**SMAN**. Surface management

**SMS**. Safety management systems

**SPRs**. Special programme resources

**SRMD**. Safety risk management document

**SSEP**. Self-separation

**SSR**. Secondary surveillance radar

**STA**. Scheduled time of arrival

**STARS**. Standard terminal arrivals

**STBO**. Surface trajectory based operations

**SURF**. Enhanced traffic situational awareness on the airport surface

**SVS**. Synthetic visualisation systems

**SWIM**. System-wide information management

**T**

**TBD**. To be determined

**TBFM.** Time based flow management

**TBO**. Trajectory-based operations

**TCAS**. Traffic alert and collision avoidance system

**TFM**. Traffic flow management

**TIS-B**. Traffic information service-broadcast

**TMA**. Trajectory management advisor

**TMIs**. Traffic management initiatives

**TMU** Traffic management unit

**TOD**. Top of Descent

**TRACON**. Terminal radar approach control

**TS**. Traffic synchronisation

**TSA**. Temporary segregated airspace

**TSO**. Technical standard order

**TWR**. Aerodrome control tower

**U**

**UA.** Unmanned aircraft

**UAS.** Unmanned aircraft system

**UAV**. Unmanned aerial vehicle

**UDPP**. User driven prioritisation process

**V**

**VFR**. Visual flight rules

**VLOS**. Visual line-of-sight

**VNAV**. Vertical navigation

**VOR**. Very high frequency (VHF) omnidirectional radio range

**VSA**. Enhanced visual separation on approach

**W**

**WAAS**. Wide area augmentation system

**WAF**. Weather avoidance field

**WGS-84**. World geodetic system - 1984

**WIDAO**. Wake independent departure and arrival operation

**WTMA**. Wake turbulence mitigation for arrivals

**WTMD**. Wake turbulence mitigation for departures

**WXXM**. Weather exchange model

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