

APPENDIX A

MODULE NO. B0-65: OPTIMIZATION OF APPROACH PROCEDURES INCLUDING VERTICAL GUIDANCE

Summary	The use of performance-based navigation (PBN) and ground-based augmentation system (GBAS) landing system (GLS ¹) procedures will enhance the reliability and predictability of approaches to runways, thus increasing safety, accessibility and efficiency. This is possible through the application of Basic global navigation satellite system (GNSS), Baro vertical navigation (VNAV), satellite-based augmentation system (SBAS) and GLS. The flexibility inherent in PBN approach design can be exploited to increase runway capacity.	
Main performance impact as per Doc 9854	KPA-01 – Access and Equity, KPA-02 – Capacity, 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) as per Doc 9854	AUO – Airspace user operations AO – Aerodrome operations	
Global plan initiatives (GPI)	GPI-5: Area navigation (RNAV) and RNP (PBN) GPI-14: Runway operations GPI-20: WGS84	
Main dependencies	Nil	
Global readiness checklist		Status (ready now or estimated date).
	Standards readiness	✓ (B0 - GLS CAT I only)
	Avionics availability	✓
	Ground system availability	✓
	Procedures available	✓
	Operations approvals	✓

1. NARRATIVE

1.1 General

1.1.1 This module complements other airspace and procedures elements (continuous descent operations (CDO), PBN and airspace management) to increase efficiency, safety, access and predictability.

1.1.2 This module describes what is available regarding approach procedures and can be more widely used now.

¹ As regards B0, GLS CAT I only. See B1 as regards GLS CAT II/III.

1.2 Baseline

1.2.1 Conventional navigation aids (e.g. instrument landing system (ILS), VHF omnidirectional radio range (VOR), non-directional radio beacon (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 to multiple runway ends. VOR and NDB procedures do not support vertical guidance and have relatively high minima that depend on siting considerations.

1.2.2 In the global context, GNSS-based PBN procedures have been implemented. Some States have implemented large numbers of PBN procedures. There are several GLS (CAT I) procedures in place.

1.3 Change brought by the module

1.3.1 With the exception of ground-based augmentation system (GBAS) for GLS, performance-based navigation (PBN) procedures require no ground-based navaids 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, along with continuous descent operations (CDO), thus reducing aircrew and controller workload and the probability that aircraft will not follow the expected trajectory.

1.3.2 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. GLS, which is not included in the PBN Manual, requires aerodrome infrastructure but a single station can support approaches to all runways and GLS 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.

1.3.3 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 typically await fleet renewal rather than equip existing aircraft; however retrofits providing RNP/LPV capability are available and have been applied to many bizjet aircraft.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT/METRIC TO DETERMINE SUCCESS

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Access and Equity</i>	Increased aerodrome accessibility.
<i>Capacity</i>	In contrast with ILS, the GNSS-based approaches (PBN and GLS) do not require the definition and management of sensitive and critical areas resulting in potentially increased runway capacity.
<i>Efficiency</i>	Cost savings related to the benefits of lower approach minima: fewer diversions,

	overflights, cancellations and delays. Cost savings related to higher airport capacity in certain circumstances (e.g. closely spaced parallels) by taking advantage of the flexibility to offset approaches and define displaced thresholds.
<i>Environment</i>	Environmental benefits through reduced fuel burn.
<i>Safety</i>	Stabilized approach paths.
<i>Cost Benefit Analysis</i>	Aircraft operators and air navigation service providers (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. Until there are GBAS (CAT II/III) Standards, GLS cannot be considered as a candidate to globally replace ILS. The GLS business case needs to consider the cost of retaining ILS or MLS to allow continued operations during an interference event.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 The *Performance-based Navigation (PBN) Manual* (Doc 9613), the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849) Annex 10 — *Aeronautical Telecommunications* and the *Procedures for Air Navigation Services — Aircraft Operations*, Volume I — *Flight Procedures* and Volume II — *Construction of Visual and Instrument Flight Procedures* (PANS-OPS, Doc 8168) provide guidance on system performance, procedure design and flight techniques necessary to enable PBN approach procedures. The *World Geodetic System — 1984 (WGS-84) Manual* (Doc 9674) provides guidance on surveying and data handling requirements. The *Manual on Testing of Radio Navigation Aids* (Doc 8071) (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 — *Validation of Instrument Flight Procedures* provides the required guidance for validation of instrument flight procedures including 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.

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

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 PBN approach procedures can be flown with basic instrument flight rules (IFR) GNSS avionics that support on board performance monitoring and alerting; these support lateral navigation (LNAV) minima. Basic IFR GNSS receivers may be integrated with Baro VNAV functionality to support vertical guidance to LNAV/vertical navigation (VNAV) minima. In States with defined SBAS service areas, aircraft with SBAS avionics 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 minimum descent altitude (MDA) when flown to an instrument runway. Within an SBAS service area, SBAS avionics can provide advisory vertical guidance when flying conventional non-directional beacon (NDB) and very high frequency omnidirectional radio range (VOR) procedures, thus providing the safety

benefits associated with a stabilized approach. Aircraft require avionics to fly GBAS land system (GLS) approaches.

4.2 Ground systems

4.2.1 SBAS-based procedures do not require any infrastructure at the airport served, but SBAS elements (e.g. reference stations, master stations, geostationary (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. A GLS station installed at the aerodrome served can support vertically guided CAT I approaches to all runways at that aerodrome.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 The implementation of approach procedures with vertical guidance enables improved cockpit resource management in times of high and sometime complex workload. By allowing crew procedures to be better distributed during the conduct of the procedure, exposure to operational errors is reduced and human performance is improved. This results in clear safety benefits over procedures that lack guidance along a vertical path. Additionally, some simplification and efficiencies may be achieved in crew training as well.

5.1.2 Human factors have been taken into consideration during the development of the processes and procedures associated with this module. Where automation is to be used, the human-machine interface has been considered from both a functional and ergonomic perspective. The possibility of latent failures, however, continues to exist and vigilance is requested during all implementation actions. It is further requested that human factor issues identified during implementation be reported to the international community through ICAO as part of any safety reporting initiative.

5.2 Training and qualification requirements

5.2.1 Training in the operational standards and procedures are required for this module and can be found in the links to the documents in Section 8 to this module. Likewise, the qualification requirements are identified in the regulatory requirements in Section 6 which form an integral part to the implementation of this module.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: use current published criteria as given in Section 8.4 as no new or updated regulatory guidance or standards documentation is needed at this time.
- Approval plans: no new or updated approval criteria are needed at this time. Implementation plans should reflect available aircraft, ground systems and operational approvals.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 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 wide area augmentation system (WAAS) (SBAS). Of the procedures with LPV minima, almost 500 have a 60 m (200 feet) decision height. Current plans call for all (approximately 5 500) runways in the United States to have lateral precision with vertical guidance (LPV) minima by 2016. The United States has a demonstration GLS CAT I procedure at Newark (KEWR); certification is anticipated August 2012 pending resolution of technical and operation issues. The United States currently has a GLS CAT I procedure in operation at Houston (KIAH).

United States – CAT II/III. Working with industry to develop prototype for CAT II/III operations. Planned operational approval by 2017.

- **Canada:** Canada has published 596 PBN approach procedures with LNAV minima as of July 2011. Of these, twenty-three have LNAV/VNAV minima and fifty-two 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 GLS 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 sixty under development. Only about 5 per cent 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 GLS CAT I trial at Sydney and will be installing a certified system for testing for full operational approval.
- **France:** France has published fifty PBN procedures with LNAV minima as of June 2011; three have LPV minima; none has LNAV/VNAV minima. The estimates for the end of 2011 are: eighty LNAV, ten LPV and 1 LNAV/VNAV. The objective is to have PBN procedures for 100 per cent of France's IFR runways with LNAV minima by 2016, and 100 per cent with LPV and LNAV/VNAV minima by 2020. France has a single GLS used to support aircraft certification, but not regular operations. France has no plans for CAT I GLS.
- **Brazil:** Brazil has published 146 PBN procedures with LNAV minima as of June 2011; forty-five have LNAV/VNAV minima. There are 179 procedures being developed, 171 of which will have LNAV/VNAV minima. A CAT I GBAS is installed at Rio de Janeiro with plans for GLS 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 standard instrument departures (SID) and standard terminal arrivals (STAR) procedures have been implemented in six major airports. India is planning to implement 38 RNP APCH procedures with LNAV and LNAV/VNAV minima at major airport. At some airports, these approach procedures will be linked with RNP-1 STARs.

7.2 Planned or ongoing trials

- **India:** India's SBAS system called GAGAN (GPS Aided Geo Augmented Navigation) is being developed. The certified GAGAN system will be available by June 2013 and should

support the APAC region and beyond. India has planned to implement GLS to support satellite-based navigation in terminal control area (TMA), to increase accessibility to airports. The first pilot project will be undertaken in 2012 at Chennai.

8. REFERENCE DOCUMENTS

8.1 Standards

ICAO Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids*. As of 2011 a draft Standards and Recommended Practices (SARPs) amendment for GLS to support CAT II/III approaches is completed and is being validated by States and industry.

8.2 Procedures

ICAO Doc 8168, *Procedures for Air Navigation Services — Aircraft Operations*

8.3 Guidance material

- ICAO Doc 9674, *World Geodetic System — 1984 (WGS-84) Manual*
- ICAO Doc 9613, *Performance-based Navigation (PBN) Manual*
- ICAO Doc 9849, *Global Navigation Satellite System (GNSS) Manual*
- ICAO Doc 9906, *Quality Assurance Manual for Flight Procedure Design*, Volume 5 — *Validation of Instrument Flight Procedures*
- ICAO Doc 8071, *Manual on Testing of Radio Navigation Aids*, Volume II — *Testing of Satellite-based Radio Navigation Systems*
- ICAO Doc 9931, *Continuous Descent Operations (CDO) Manual*

8.4 Approval documents

- FAA AC 20-138, TSO-C129/145/146
- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO *Flight Plan Classification*
- ICAO Doc 8168, *Aircraft Operations*
- ICAO Doc 9613, *Performance Based Navigation (PBN) Manual*
- ICAO Annex 10 — *Aeronautical Telecommunications*
- ICAO Annex 11 — *Air Traffic Services*
- ICAO Doc 9674, *World Geodetic System — 1984 (WGS-84) Manual*

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APPENDIX B

MODULE NO. B0-70: INCREASED RUNWAY THROUGHPUT THROUGH OPTIMIZED WAKE TURBULENCE SEPARATION

Summary	Improved throughput on departure and arrival runways through optimized wake turbulence separation minima, revised aircraft wake turbulence categories and procedures.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-06 – Flexibility.	
Operating environment/ Phases of flight	Arrival and departure	
Applicability considerations	Least complex – Implementation of revised wake turbulence categories is mainly procedural. No changes to automation systems are needed.	
Global concept component(s) as per Doc 9854	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

1.1.1 Refinement of ICAO procedures and standards will allow increased runway capacity with the same or increased level of safety. This will be accomplished without any changes to aircraft equipment 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 turbulence separation minima 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 parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, by modifying how wake turbulence separations are applied. Element 3 is increasing, at some aerodromes, the number of departure operations on parallel runways by modifying how wake separations are applied.

1.2 Baseline

1.2.1 Wake turbulence separation standards and procedures and associated procedures were developed over time, with the last comprehensive review occurring in the early 1990's. These 1990's standards and procedures are inherently conservative, particularly in terms of required aircraft-to-aircraft

wake turbulence separations, to account for inaccuracies in the then existing aircraft wake turbulence transport and decay models and lack of extensive data on actual aircraft wake behaviour.

1.3 Change brought by the module

1.3.1 This module will result in a change in the ability to apply reduced wake turbulence standards and streamlined procedures in some cases. Based on the standards developed, it safely modifies the separation minima and their application, to allow incremental increases to aerodrome runway throughput capacity. The capacity gains by Element 1 (changing wake separation minima) are predicted to be four per cent for European and seven per cent for United States capacity constrained aerodromes with similar gains expected for 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 application of specialized air navigation service provider (ANSP) procedures to enhance the runway throughput capacity. The aerodrome specific specialized procedures have been demonstrated to increased arrival capacity (five to ten more operations per hour) during instrument landing operations or increased departure capacity (two to four more operations per hour).

1.4 Element 1: Revision of the current ICAO wake turbulence separation minima

1.4.1 The last full review of ICAO's wake turbulence separation minima occurred nearly twenty 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 (VLJ), remotely piloted aircraft (RPA), etc) have been introduced. The twenty year old wake turbulence separation minima still provides safe wake vortex separation but it no longer provides the most capacity efficient spacing and sequencing of aircraft in approach and en-route operations. Lack of access to these spacing efficiencies is adding to the gap between the demand and the capacity that contemporary aviation infrastructure and procedure can provide.

1.4.2 The work in Element 1 is being accomplished, in coordination with ICAO, by a joint European Organization for the Safety of Air Navigation (EUROCONTROL) and Federal Aviation Administration (FAA) working group that has reviewed ICAO's wake separation standards and has determined the current standards can be safely modified to increase the operational capacity of aerodromes and airspace. Accordingly, in 2010, the working group provided a set of recommendations for ICAO review that focused on changes to the present set of ICAO wake turbulence separation minima and associated provisions. To reach these outcomes, the working group developed enhanced analysis tools to compare observed wake behavior to current standards and determined safety risks associated with potential new standards relative to existing ones. ICAO formed the Wake Turbulence Study Group to review the FAA/EUROCONTROL working group recommendations along with other recommendations received and comments from ICAO Member States. It is expected that by the end of 2013, ICAO will publish changes to the wake turbulence separation standards and associated procedures contained in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444).

1.5 Element 2: Increasing aerodrome arrival operational capacity

1.5.1 Wake turbulence separations and procedures applied to instrument landing operations on parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, are designed to protect aircraft for a very wide range of aerodrome parallel runway configurations. Prior to 2008, instrument landing operations conducted to parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, had to have the wake separation spacing equivalent to conducting instrument landing operations to a single runway.

1.5.2 Extensive wake transport data collection efforts and the resulting analyses indicated that the wakes vortices from other than HEAVY wake turbulence category aircraft travelled less distance than previously thought. Based on this knowledge, high capacity demand aerodromes in the United States that used their parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart for approach operations, were studied to see if approach procedures could be developed that provide more landing operations per hour than the ‘single runway’ rate obliged by current provisions. A dependent diagonal paired approach procedure was developed and made available for operational use in 2008 for five aerodromes that had parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, that met the runway layout criteria of the developed procedure. Use of the procedure provided an increase of up to ten more arrival operations per hour on the parallel runways. 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 aerodromes with parallel runways with centre lines spaced less than 760 m (2 500 feet) apart, with fewer constraints on the type of aircraft that must be the lead aircraft of the paired diagonal dependent approach aircraft.

1.6 Element 3: Increasing aerodrome departure operational capacity

1.6.1 Element 3 is the development of enhanced wake turbulence standards and ANSP departure procedures that safely allow increased departure capacity on aerodrome parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart. Procedures being developed are aerodrome specific in terms of runway layout and weather conditions. The wake independent departure and arrival operation (WIDAO) developed for use on parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, at Paris Charles de Gaulle aerodrome was developed as a result of an extensive wake turbulence transport measurement campaign at the aerodrome. WIDAO implementation allows the use of the inner parallel runway for departures independent of the arrivals on the outer parallel runway whereas previously a wake turbulence separation was required between the landing aircraft on the outer parallel runway, and the aircraft departing on the inner parallel runway.

1.6.2 Wake turbulence mitigation for departures (WTMD) is a development project by the United States that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind parallel runway, after a heavy aircraft departs on the downwind runway – without applying two to three minutes delay currently required. WTMD applies a runway crosswind forecast and monitors the actual crosswind to provide guidance to the controller that the two to three-minute wake turbulence delay can be eliminated and when the delay must again be applied. WTMD is being developed for implementation at eight to ten United States aerodromes that have parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, with frequent suitable crosswinds and a significant amount of heavy aircraft operations. Approval for operational use of WTMD is expected in the second quarter of 2013.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

Capacity	a) Capacity and departure/arrival rates will increase at capacity constrained aerodromes as wake categorization changes from three to six categories. b) Capacity and arrival rates will increase at capacity constrained aerodromes as specialized and tailored procedures for landing operations for on-parallel
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	runways, with centre lines spaced less than 760 m (2 500 feet) apart, are developed and implemented.
	c) Capacity and departure/arrival rates will increase as a result of new procedures which will reduce the current two-three minutes delay times. In addition, runway occupancy time will decrease as a result of these new procedures.
<i>Flexibility</i>	Aerodromes can be readily configured to operate on three (i.e. existing H/M/L) or six wake turbulence categories, depending on demand.
<i>Cost Benefit Analysis</i>	Minimal costs are associated with the implementation of enhanced separation standards and procedures in this module. The benefits are to the users of the aerodrome runways air surrounding airspace, ANSPs and operators. Conservative wake turbulence separation standards and associated procedures do not take full advantage of the maximum utility of runways and airspace. US air carrier data shows that when operating from a capacity constrained aerodrome, a gain of two extra departures per hour has a major beneficial effect in reducing overall delays. The ANSP may need to develop tools to assist controllers with the additional wake turbulence categories and decision support tools. The tools necessary will depend on the operation at each airport and the number of wake turbulence categories implemented.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 The change to the ICAO wake turbulence separation minima will involve increasing the number of ICAO wake turbulence categories from three to six categories along with the assignment of aircraft types to one of six new wake turbulence categories. It is expected that the existing ICAO aircraft categorization scheme, i.e. HEAVY/MEDIUM/LIGHT, will co-exist with the new scheme, at least during a period of transition.

3.2 Although not considered essential, ANSPs may decide to develop some local automation support in providing the wake turbulence category of each aircraft to the controller. Implementing Element 1 will not require any changes to air crew flight procedures.

3.3 The module component impacting the use of an aerodrome with parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, for arrivals, only affect the ANSP procedures for sequencing and segregating aircraft to the parallel runways. Element 2 products are additional procedures for use by the ANSP for situations when the aerodrome is operating during instrument meteorological conditions and there is a need to land more flights than can be achieved by using only one of its parallel runways. The procedures implemented by Element 2 require no changes to the aircrew procedures.

3.4 Element 3 implementations only affect the ANSP procedures for departing aircraft on aerodrome parallel runways. Element 3 products are additional procedures for use by the ANSP for situations when the aerodrome is operating under a heavy departure demand with a significant number of heavy aircraft in the operational mix. The procedures provide for transitioning to and from reduced wake turbulence separations between aircraft and criteria for when the reduced separations should or should not be used. The procedures implemented by Element 3 require no changes to the aircrew procedures. When a specialized parallel runway departure procedure is being used, pilots should be notified that the special procedure is in use and that they can expect a more immediate departure.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 No additional technology for the aircraft or additional aircrew certifications are required.

4.2 Ground systems

4.2.1 Some ANSPs may develop a decision support tool to aid in the application of the new set of six ICAO wake turbulence categories. The Element 2 and Element 3 products vary in their dependency on new technology and Element 3 implementation requires wind sensors and automation to predict crosswind strength and direction and to display actual crosswind information to the controllers.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 Human factors have been taken into consideration during the development of the processes and procedures associated with this module. Where automation is to be used, the human-machine interface has been considered from both a functional and ergonomic perspective (see Section 6 for examples). The possibility of latent failures, however, continues to exist and vigilance is necessary during all implementation actions. It is further requested that human factor issues, identified during implementation and operation, be reported to the international community through ICAO as part of any safety reporting initiative.

5.2 Training and qualification requirements

5.2.1 Controllers will require training on additional wake categories, new separation standards and procedures and the separation matrix, in accordance with the references in Section 8. The deployment of Element 3, components will also require training for controllers on the use of the new tools to monitor and predict crosswinds. Qualification requirements are identified in the regulatory requirements in Section 6 which form an integral part to the implementation of this module.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates will be required to current published criteria, in accordance with references in Section 8.4.
- Approval plans: to be determined following updates to standards.

Note.— Existing interim activities, including those associated with FAA wake turbulence mitigation for departures (WTMD) and wake independent departure and arrival operation (WIDAO) criteria in use at Charles De Gaulle (LFPG) will continue and are expected to be considered in the development of revised ICAO material.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

Revised wake turbulence separation minima

None at this time. Awaiting the ICAO approval of the revised wake turbulence separation minima, expected in 2013.

Increasing aerodrome arrival operational capacity

United States: The FAA procedure has been approved for seven United States aerodromes with Seattle-Tacoma (KSEA) and Memphis (KMEM) aerodromes using the procedure during runway maintenance closures. Use at Cleveland (KCLE) is awaiting runway instrumentation changes.

Increasing aerodrome departure operational capacity

- **France:** The wake independent departure and arrival operation (WIDAO) relaxation of wake separation constraints at Charles de Gaulle (LFPG) were approved in November 2008 (first constraints) and March 2009 (second constraints). The final set of LFPG constraints was lifted in 2010.
- **United States:** Wake turbulence mitigation for departures (WTMD) is currently at two sites, Houston (KIAH) and Memphis (KMEM).

7.2 Planned or ongoing trials

Revised wake turbulence separation minima

United States: Concurrent with the ICAO approval process, the FAA is developing documentation and adapting its automation systems to allow implementation of the wake separation standard. The ICAO approval is expected in 2013.

Increasing aerodrome arrival operational capacity

United States: Work is continuing to develop variations of the FAA procedure that will allow its application to more aerodromes with parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, 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 United States for use by an additional six or more aerodromes during periods when they use instrument approach landing procedures.

7.3 Increasing aerodrome departure operational capacity

United States: Wake turbulence mitigation for departures (WTMD) is a development project by the United States that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the up wind runway after a heavy aircraft departs on the downwind runway – without waiting the current required wake mitigation delay of two to three minutes. WTMD is being developed for implementation at eight to ten United States aerodromes that have parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, with

frequent suitable crosswinds and a significant amount of heavy aircraft operations. WTMD demonstrations at San Francisco (KSFO) are currently planned for 2013. Six additional aerodromes will be identified in the future.

8. REFERENCE DOCUMENTS

8.1 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9426, *Air Traffic Services Planning Manual*
- FAA Order 7110.308

APPENDIX C

MODULE NO. B0-15: IMPROVE TRAFFIC FLOW THROUGH RUNWAY SEQUENCING (AMAN/DMAN)

Summary	To manage arrivals and departures (including time-based metering) to and from a multi-runway aerodrome or locations with multiple dependent runways at closely proximate aerodromes, to efficiently utilize the inherent runway capacity.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-04 – Efficiency, KPA-09 – Predictability, KPA-06 – Flexibility.	
Applicability considerations	Runways and terminal manoeuvring area in major hubs and metropolitan areas will be most in need of these improvements. The improvement is least complex – runway sequencing procedures are widely used in aerodromes globally. However, some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this module.	
Global concept component(s) as per Doc 9854	TS – Traffic synchronization	
Global plan initiative	GPI-6: Air traffic flow management	
Main dependencies	Linkage with B0-15 and B0-80	
Global readiness checklist		Status (ready or date)
	Standards readiness	√
	Avionics availability	√
	Ground system availability	√
	Procedures available	√
	Operations approvals	√

1. NARRATIVE

1.1 General

1.1.1 In Block 0 (present – 2013), basic queue management tools such as arrival or departure sequencing systems will provide runway sequencing and metering/scheduling support to the ANSP, like traffic management advisor (TMA) in the United States or various implementations of arrival management (AMAN) at a number of aerodromes in Europe and other regions as well.

1.2 Baseline

1.2.1 The baseline of this module is the manual process by which the air traffic controller uses local procedures and his expertise to sequence departures or arrivals in real time. This is generally leading to sub-optimal solutions both for the realized sequence and the flight efficiency, in particular in terms of

taxi times and ground holding for departures, and in terms of holding for arrivals.

1.3 **Change brought by the module**

1.3.1 Metering. The module introduces system capabilities to provide assistance for sequencing and metering.

1.3.2 Arriving flights are “metered” by control time of arrival (CTAs) and must arrive at a defined point close to the aerodrome by this time. Metering allows ATM to sequence arriving flights such that terminal and aerodrome resources are utilized effectively and efficiently. The system enhances the ability of en-route ATC to anticipate and improve the presentation of traffic arriving at an airport over long distances from that airport.

1.3.3 For departures, the sequence will allow improved start/push-back clearances, reducing the taxi time and ground holding, delivering more efficient departure sequences, reducing surface congestion and effectively and efficiently making use of terminal and aerodrome resources.

1.3.4 Departure management tools maximize the use of airspace capacity and assure full utilization of resources. They have the additional benefit of fuel efficient alternatives to reduce airborne and ground holding in an era in which fuel continues to be a major cost driver and emissions are a high priority. The use of these tools to assure facility of more efficient arrival and departure paths is a main driver in some modules of Block 0.

1.4 **Element 1: AMAN and time-based metering**

1.4.1 Arrival management sequences the aircraft, based on the airspace state, wake turbulence, aircraft capability, and user preference. The established sequence provides the time that aircraft may have to lose before a reference approach fix, thereby allowing aircraft to fly more efficiently to the that fix and to reduce the use of holding stacks, in particular at low altitude. The smoothed sequence allows increased aerodrome throughput.

1.4.2 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 (CTA). 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.

1.5 **Element 2: Departure management**

1.5.1 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 department management (DMAN) or departure flow management (DFM). Dynamic slot allocation will foster smoother integration into overhead streams and help the airspace users to 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

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Time-based metering will optimize usage of terminal airspace and runway capacity. Optimized utilization of terminal and runway resources.
<i>Efficiency</i>	Efficiency is positively impacted as reflected by increased runway throughput and arrival rates. This is achieved through: a) harmonized arriving traffic flow from en-route to terminal and aerodrome. Harmonization is achieved via the sequencing of arrival flights based on available terminal and runway resources; and b) streamlined departure traffic flow and smooth transition into en-route airspace. Decreased lead time for departure request and time between call for release and departure time. Automated dissemination of departure information and clearances.
<i>Predictability</i>	Decreased uncertainties in aerodrome/terminal demand prediction.
<i>Flexibility</i>	By enabling dynamic scheduling.
<i>Cost Benefit Analysis</i>	A detailed business case has been built for the time-based flow management programme in the United States. The business case has proven the benefit/cost ratio to be positive. Implementation of time-based metering can reduce 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 Results from field trials of DFM, a departure scheduling tool in the United States, have been positive. Compliance rate, a metric used to gauge the conformance to assigned departure time, has increased at field trial sites from sixty-eight per cent to seventy-five per cent. Likewise, the EUROCONTROL 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 estimated time of arrivals (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 AND GROUND)

3.1 The United States time-based flow management (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.

² Exhibit 300 Programme Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 No avionics capability is required in support of the time-based metering for departure. For approach, time-based metering is mainly achieved through ATC speed clearance to adjust the aircraft sequence in the AMAN. This operation can be facilitated by requiring the aircraft to meet a CTA at a metering fix, relying on the aircraft required time of arrival function from current flight management system (FMS).

4.2 Ground systems

4.2.1 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 require extensive automation support to implement.

4.2.2 Both TBFM and arrival/departure management (AMAN/DMAN) application and existing technologies can be leveraged, but require site adaptation and maintenance.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 ATM personnel responsibilities will not be affected directly. However, human factors have been taken into consideration during the development of the processes and procedures associated with this module. Where automation is to be used, the human-machine interface has been considered from both a functional and ergonomic perspective (see Section 6 for examples). The possibility of latent failures however, continues to exist and vigilance is requested during all implementation actions. It is further requested that human factor issues, identified during implementation, be reported to the international community through ICAO as part of any safety reporting initiative.

5.2 Training and qualification requirements

5.2.1 Automation support is needed for air traffic management in airspace with high demands. Thus, training is needed for ATM personnel.

5.2.2 Training in the operational standards and procedures are required for this module and can be found in the links to the documents in Section 8 to this module. Likewise, the qualifications requirements are identified in the regulatory requirements in Section 6 which form an integral part to the implementation of this module.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates required to current published criteria given in Section 8.
- Approval plans: to be determined.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

Time-based metering

- **United States:** Traffic management advisor is currently used in the United States at twenty air route traffic control centres (ARTCCs) as the primary time-based metering automation. Future efforts will field time-based flow management, the augmentation to the traffic management advisor, incrementally.
- **Europe:** Basic AMAN is already implemented in some European States such as Belgium, Denmark, France, and the United Kingdom. DMAN is deployed at major European hubs such as Charles De Gaulle.
- **Other regions:** There is some AMAN implementation in Australia, South Africa and Singapore.

Departure flow management

- **United States:** Departure flow management has been in operational trial at two locations. Initial operational capability is expected to occur in 2014.
- **Europe:** DMAN is deployed at major European hubs such as Charles de Gaulle.

7.2 Planned or ongoing trials

Time-based metering

United States: Currently conducting simulation of terminal metering in support of RNAV/RNP procedures using KDAL as the scenario. Terminal metering capabilities are expected to be integrated into TBFM by 2018.

Departure flow management

- **United States:** DFM will be integrated with extended metering and become part of TBFM in the United States in 2014.
- **Europe:** DMAN deployment is expected to cover most major aerodromes in Europe.

8. REFERENCE DOCUMENTS

8.1 Guidance materials

- European ATM Master Plan, Edition 1.0, March 2009, update in progress
- SESAR Definition Phase Deliverables
- TBFM Business Case Analysis Report
- NextGen Midterm Concept of Operations v.2.0
- RTCA Trajectory Operations Concept of Use

APPENDIX D

MODULE NO. B0-75: SAFETY AND EFFICIENCY OF SURFACE OPERATIONS (A-SMGCS LEVEL 1-2)

Summary	Basic A-SMGCS provides surveillance and alerting of movements of both aircraft and vehicles on the aerodrome thus improving runway/aerodrome safety. ADS-B information is used when available (ADS-B APT).	
Main performance impact as per Doc 9854	KPA- 01 – Access and Equity, KPA-02 – Capacity, KPA-04 – Efficiency, KPA-05 – Environment, KPA-10 – Safety.	
Operating environment/ Phases of flight	Aerodrome surface movements (aircraft + vehicles), taxi, push-back, parking	
Applicability considerations	A-SMGCS is applicable to any aerodrome and all classes of aircraft/vehicles. Implementation is to be based on requirements stemming from individual aerodrome operational and cost-benefit assessments. ADS B APT, when applied is an element of A-SMGCS, is designed to be applied at aerodromes with medium traffic complexity, having up to two active runways at a time and the runway width of minimum 45 m.	
Global concept component(s) as per Doc 9854	AO – Aerodrome operations CM – Conflict management	
Global plan initiatives (GPI)	GPI-9: Situational awareness GPI-13: Aerodrome design and management GPI-16: Decision support systems and alerting systems GPI-18: Electronic information services in the global plan initiatives	
Main dependencies	Linkage with B0-80 and B0-15	
Global readiness checklist		Status (indicate ready with a tick or input date)
	Standards readiness	√
	Avionics availability	√
	Infrastructure availability	√
	Ground automation availability	√
	Procedures available	√
	Operations approvals	√

1. NARRATIVE

1.1 General

1.1.1 This module builds upon traditional surface movement guidance and control system (SMGCS) implementation (visual surveillance, aerodrome signage, lighting and markings) by the introduction of capabilities enhancing air traffic control (ATC) situational awareness through:

- a) display to the aerodrome controller of the position of all aircraft on the aerodrome movement area;
- b) display to the aerodrome controller of all vehicles on the aerodrome manoeuvring area; and

- c) generation of runway incursion alerts (where local operational, safety and cost-benefit analyses so warrant).

1.1.2 For advanced surface movement guidance and control systems (A-SMGCS), 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 Blocks 1 and 2. The B0 level of implementation, corresponding to levels 1 and 2 of the A-SMGCS concept and being associated to the provision of ATS, is independent of aircraft equipage beyond that associated with cooperative surveillance equipage (e.g. SSR Mode S or A/C transponders).

1.1.3 For automatic dependent surveillance—broadcast (ADS-B) APT the facilities and procedures will be the same with the performance levels associated to conventional SMGCS. The B0 level of implementation is dependent of aircraft/vehicle ADS-B Out equipage.

1.2 **Baseline**

1.2.1 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.

1.3 **Change brought by the module**

1.3.1 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.
- SMR-like capabilities by implementing ADS-B APT at those aerodromes where surveillance is not available.

1.4 Element 1 – Surveillance

1.4.1 In the case of A-SMGCS, this element 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 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.

1.4.2 In the case of ADS-B APT, as an element of an A-SMGCS system, it provides controllers with traffic situational awareness on movement areas. The provision of surveillance information to the controller will allow the deployment of SMGCS procedures, augmenting the controller's situational awareness and helping the controller to manage the traffic in a more efficient way. In this respect, the ADS-B APT application does not aim to reduce the occurrence of runway incursions, but may reduce the occurrence of runway collisions by assisting in the detection of the incursions.

1.5 Element 2 – Alerting

1.5.1 In the case of A-SMGCS, 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 considerably between the various industrial solutions being offered. B0 implementations will serve as important initial validation for improved algorithms downstream.

1.5.2 In the case of ADS-B APT, system generated alerting processes and procedures have not been defined (as this is considered premature at this development stage). It is possible that future variations of the ADS-B APT application will assess the surveillance requirements necessary to support alerting functions.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT/METRIC TO DETERMINE SUCCESS

<i>Access and Equity</i>	A-SMGCS: 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. ADS-B APT: , as an element of an A-SMGCS system, provides traffic situational awareness to the controller in the form of surveillance information. The availability of the data is dependent on the aircraft and vehicle level of equipage.
<i>Capacity</i>	A-SMGCS: sustained levels of aerodrome capacity for visual conditions reduced to minima lower than would otherwise be the case. ADS-B APT: as an element of an A-SMGCS system, potentially improves capacity

	for medium complexity aerodromes.
<i>Efficiency</i>	A-SMGCS: reduced taxi times through diminished requirements for intermediate holdings based on reliance on visual surveillance only. ADS-B APT: as an element of an A-SMGCS system, potentially reduces taxi times by providing improved traffic situational awareness to controllers.
<i>Environment</i>	Reduced aircraft emissions stemming from improved efficiencies.
<i>Safety</i>	A-SMGCS: reduced runway incursions. Improved response to unsafe situations. Improved situational awareness leading to reduced ATC workload. ADS-B APT: as an element of an A-SMGCS system, potentially reduces the occurrence of runway collisions by assisting in the detection of the incursions.
<i>Cost Benefit Analysis</i>	A-SMGCS: 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 operator vehicles will benefit from improved access to all areas of the aerodrome, improving the efficiency of aerodrome operations, maintenance and servicing. ADS-B APT: as an element of an A-SMGCS system less costly surveillance solution for medium complexity aerodromes.
<i>Human Performance</i>	Reduced ATC workload. Improved ATC efficiencies.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 Procedures required in support of B0 operations are those associated with 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.

3.2 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.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

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

4.2 Vehicles

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

4.3 Ground systems

4.3.1 A-SMGCS: the surface movement radar should be complemented by a cooperative surveillance means allowing tracking aircraft and ground vehicles. A surveillance display including some alerting functionalities is required in the tower.

4.3.2 ADS-B APT: cooperative surveillance infrastructure deployed on the aerodrome surface; installation of a tower traffic situational awareness display.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 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.

5.1.2 Human factors have been taken into consideration during the development of the processes and procedures associated with this module. Where automation is to be used, the human-machine interface has been considered from both a functional and ergonomic perspective (see Section 6 for examples). The possibility of latent failures however, continues to exist and vigilance is requested during all implementation actions. It is further requested that human factor issues, identified during implementation, be reported to the international community through ICAO as part of any safety reporting initiative.

5.2 Training and qualification requirements

5.2.1 Training in the operational standards and procedures are required for this module and can be found in the links to the documents in Section 8 to this module. Likewise, the qualifications requirements are identified in the regulatory requirements in Section 6 which form an integral part to the implementation of this module.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

6.1 Standards approved for aerodrome multilateration, ADS-B and safety logic systems exist for use in Europe, the United States and other Member States. Standards for surface movement radar (SMR) exist for use globally.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

7.1.1 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.

7.2 **Planned or on-going trials**

7.2.1 The United States is supporting deployment to additional aerodromes, using various combinations of primary and secondary surveillance. This includes low cost ground surveillance programmes which may unite a more affordable primary radar system with ADS-B. 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 Doc 9924, *Aeronautical Surveillance Manual*
- ICAO Doc 9871, *Technical Provisions for Mode S Services and Extended Squitter*
- 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
- EUROCAE ED 163 Safety, Performance and Interoperability Requirements document for ADS-B Airport Surface surveillance application (ADS-B APT)

8.2 **ATC procedures**

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 7030, *Regional Supplementary Procedures* (EUR SUPPS)

8.3 **Guidance material**

- FAA NextGen Implementation Plan
- European ATM Master Plan

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APPENDIX E

MODULE NO. B0-80: IMPROVED AIRPORT OPERATIONS THROUGH AIRPORT-CDM

Summary	To implement collaborative applications that will allow the sharing of surface operations data among the different stakeholders on the airport. This will improve surface traffic management reducing delays on movement and manoeuvring areas and enhance safety, efficiency and situational awareness.	
Main performance impact as per Doc 9854	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) as per Doc 9854	AO – Airport operations IM – Information management	
Global plan initiatives (GPI)	GPI-8: Collaborative airspace design and management GPI-18: Aeronautical information GPI-22: Communication infrastructure	
Main dependencies	Linkage with B0-75 and B0-15	
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

Baseline

1.1.1 Surface operations, especially for the turnaround phase, involve all operational stakeholders at an airport. They each have their own processes that are conducted 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.

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

Change brought by the module

1.1.3 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.

1.1.4 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

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Enhanced use of existing infrastructure of gate and stands (unlock latent capacity). Reduced workload, better organization of the activities to manage flights.
<i>Efficiency</i>	Increased efficiency of the ATM system for all stakeholders. In particular for aircraft operators: improved situational awareness (aircraft status both home and away); enhanced fleet predictability and punctuality; improved operational efficiency (fleet management); and reduced delay.
<i>Environment</i>	• Reduced taxi time • Reduced fuel and carbon emissions • Lower aircraft engine run time
<i>Cost Benefit Analysis</i>	The business case has proven to be positive due to the benefits that flights and the other airport operational stakeholders can obtain. However, this may be influenced depending upon the individual situation (environment, traffic levels investment cost, etc.). A detailed business case has been produced in support of the EU regulation which was solidly positive.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 The existing procedures need to be adapted to the collaborative environment in order to provide full benefits. These changes will affect the way the pilot, controller, airlines operations and ATFM unit will exchange information and manage the departing queue. The pushback and engine start up are just in time taking in account assigned runway, taxiing time, runway capacity, departure slot and departure constraints.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 No airborne equipment is required.

4.2 Ground systems

4.2.1 Collaborative decision-making (CDM) does not require specific new functionalities. The difficulty is more to interconnect ground systems depending on the systems in place locally but experience has proven that industrial solutions/support exist. Where available, shared surveillance information may enhance operations.

5. HUMAN FACTORS

5.1 Human factors considerations

5.1.1 Human factors have been taken into consideration during the development of the processes and procedures associated with this module. Where automation is to be used, the human-machine interface has been considered from both a functional and ergonomic perspective (see Section 6 for examples). The possibility of latent failures however, continues to exist and vigilance is requested during all implementation

actions. It is further requested that human factor issues, identified during implementation, be reported to the international community through ICAO as part of any safety reporting initiative.

5.2 Training and qualification requirements

5.2.1 Training in the operational standards and procedures are required for this module and can be found in the links to the documents in Section 8 to this module. Likewise, the qualifications requirements are identified in the regulatory requirements in Section 6 which form an integral part to the implementation of this module.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates required to the following current published criteria:
 - ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
 - ICAO CDM *Manual*
- Approval plans: updates required for:
 - EUROCONTROL, A-CDM Implementation Manual
 - FAA NextGen Implementation Plan

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

7.1.1 **Europe:** EUROCONTROL Airport CDM has both developed and performed trials of a number of airport CDM elements and is currently proactively encouraging European airports to implement A-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 A-CDM and being rewarded by the proven benefits.

7.1.2 With A-CDM implemented locally at an airport the next steps are to enhance the integration of airports with the air traffic flow and capacity management (ATFCM) network and the central flow management unit (CFMU).

7.1.3 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.

7.1.4 Based on the successful implementation of FUM/DPI at the 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.

7.1.5 All information is at:

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

7.1.6 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 2009-2010, the A-CDM programme made great progress with more than thirty airports engaged in implementation with the target of A-CDM fully implemented at ten airports by the end of 2011.

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

7.2 **Planned or ongoing trials**

7.2.1 **United States:** The collaborative departure queue management (CDQM) concept will be evaluated in field tests by the FAA during the surface trajectory based operations (STBO) projects in 2011.

7.2.2 To evaluate the human-in-the-loop system feasibility and benefits, five airline dispatchers from United States 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 United States trial at NASA and was integrated into the FAA System-wide Enhancements for Versatile Electronic Negotiation (SEVEN) framework. The FAA has planned for SEVEN to become operational in fall 2011 under the collaborative trajectory options programme. The FAA has on-going trials with multiple airports and airlines. The FAA is conducting studies at various airports which have different environments.

7.2.3 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 programme, 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 eight-five per cent 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 and FedEx ramp towers handle their own flights. The Memphis tower handles access for the other airlines at the airport.

7.2.4 In 2010, New York John F. Kennedy International Airport (JFK) underwent a four-month runway resurfacing and widening project in one of the busiest airspaces in the United States. 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 were 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.

7.2.5 The FAA plans to expand CDQM to Orlando, Florida International Airport. In 2010 the FAA conducted field evaluations. None of the thirty-nine airlines using Orlando airport conduct hub operations there. Orlando 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.

7.2.6 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.

7.2.7 Boston Logan International Airport hosted a demonstration to study the maximum number of aircraft authorized to push back and enter an airport active movement area during a set time period. The goal was to conduct continuous runway operations without any stop and go movements. In August through September, preliminary findings indicated the following savings: eighteen hours of taxi-time, 5 100 gallons of fuel and fifty tons in carbon dioxide.

8. REFERENCE DOCUMENTS

8.1 Standards

- ICAO CDM Manual (being finalized)
- European Union, OJEU 2010/C 168/04: Community Specification ETSI EN 303 212 v.1.1.1: European Standard (Telecommunications series) Airport Collaborative Decision Making (A-CDM)
- EUROCAE ED-141: Minimum Technical Specifications for Airport Collaborative Decision Making (Airport-CDM) Systems
- EUROCAE ED-145: Airport-CDM Interface Specification
- ICAO CDM Manual (being finalized)
- European Union, OJEU 2010/C 168/04: Community Specification ETSI EN 303 212 v.1.1.1: European Standard (Telecommunications series) Airport Collaborative Decision Making (A-CDM)
- EUROCAE ED-141: Minimum Technical Specifications for Airport Collaborative Decision Making (Airport-CDM) Systems
- EUROCAE ED-145: Airport-CDM Interface Specification

8.2 Guidance material

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

8.3 Approval documents

Updates are required to the following:

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO CDM Manual
- EUROCONTROL, A-CDM Implementation Manual
- FAA NextGen Implementation Plan

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APPENDIX F

MODULE NO. B1-65: OPTIMIZED AIRPORT ACCESSIBILITY

Summary	To progress further with the universal implementation of PBN approaches. PBN and GLS (CAT II/III) procedures to enhance the reliability and predictability of approaches to runways increasing safety, accessibility and efficiency.	
Main performance impact as per Doc 9854	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) as per Doc 9854	AUO – Airspace user operations AO – Aerodrome operations	
Global plan initiatives (GPI)	GPI-5: RNAV and RNP (PBN) GPI-14: Runway operations GPI-20: WGS84	
Main dependencies	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. 2015

1. NARRATIVE

1.1 General

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

1.2 Baseline

1.2.1 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 PBN approaches, and in some States, virtually all runways will be served by PBN procedures. Where GLS and/or SBAS are available, precision instrument runways will have CAT I minima.

1.3 Change brought by the module

1.3.1 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.

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

1.3.3 Increased aerodrome accessibility via lower approach minima to more runways will be reflected in fewer flight disruptions, reduced fuel burn and reduced greenhouse gas emissions. The more widespread availability GLS procedures will enhance aerodrome throughput in conditions of reduced visibility.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Efficiency</i>	Cost savings related to the benefits of lower approach minima: fewer diversions, overflights, cancellations and delays. Cost savings related to higher airport capacity by taking advantage of the flexibility to offset approaches and define displaced thresholds.
<i>Environment</i>	Environmental benefits through reduced fuel burn.
<i>Safety</i>	Stabilized approach paths.
<i>Cost Benefit Analysis</i>	Aircraft operators and ANSPs can quantify the benefits of lower minima by modelling airport accessibility with existing and new minima. Operators can then assess benefits against avionics and other costs. The GLS 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 GLS is complicated at airports where a significant proportion of aircraft are not equipped with GLS avionics.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 New criteria for instrument flight procedures will need to be developed for GLS CAT II/III to become operational.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 Module B0-65 describes the avionics required to fly PBN approach procedures, and explains the requirements for, benefits and limitations of SBAS based on a single-frequency global positioning system (GPS). It is expected that standards will exist for CAT II/III GLS in 2014, that some ground stations will be in place in some States and that there may be avionics available to support CAT II/III GLS operationally. There will likely be some expansion of CAT I GLS operations in some States.

4.1.2 The majority of operations globally will continue to be based on single-frequency GPS, although in some regions (e.g. Russia) avionics will integrate GLObal NAVigation Satellite System (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 — *Aeronautical Telecommunications*. 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

4.2.1 CAT II/III GLS ground stations.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 The integration of PBN with GLS for flight operations presents a number of possible issues for human performance. The effects of crew operations and procedures will be dictated by the integration of capability in the aircraft avionics e.g. if the aircraft avionics simply has a mode transition from a RNP system flying the PBN procedure to a GLS system flying the GLS procedure, what is required for crew monitoring, action or procedures could be substantially different than a system where the transition is managed internally by the avionics leaving the crew to monitor operational conformance. The difference in human performance could be the difference from what essentially exists today to one with reduction in total workload but a difference from other operations. These need to be considered in assessing human performance.

5.1.2 The identification of human factors considerations is an important enabler in identifying processes and procedures for this module. In particular, the human-machine interface for the automation aspects of this performance improvement will need to be considered and where necessary accompanied by risk mitigation strategies such as training, education and redundancy.

5.2 Training and qualification requirements

5.2.1 Training in the operational standards and procedures will be identified along with the Standards and Recommended Practices necessary for this module to be implemented. Likewise the qualifications requirements will be identified and included in the regulatory readiness aspects of this module when they become available.

6. **REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)**

- Regulatory/standardization: updates to published criteria given in Section 8.4
- Approval plans: updated approval criteria are needed for CAT II/III GLS at this time. Implementation plans should reflect available aircraft, ground systems and operational approvals.

7. **IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)**

7.1 **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 60 m (200 feet) decision height LPV minima based on WAAS (SBAS). CAT II/III working with industry to develop prototype for CAT II/III operations. Planned operational approval by 2017.
- **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 GLS.
- **Europe:** CAT II/III GLS flight trials planned in 2014. RNP to GLS transition validation planned in 2014.
- **Australia:** By 2018, Australia expects a considerable expansion of PBN approach service. Subject to the successful introduction of the CAT I GLS service into Sydney, air services will further validate GLS 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 GLS capability in Australia include development of a CAT II/III capability during the three years following 2011.
- **France:** The objective is to have PBN procedures for 100 per cent of IFR runways with LNAV minima by 2016, and 100 per cent with LPV and LNAV/VNAV minima by 2020. France has no plans for CAT I GLS and it is unlikely that there will be CAT II/III GLS in France by 2018 because there is no clear business case.
- **Brazil:** By 2018, Brazil expects a considerable expansion of PBN procedures. Plans call for GLS to be implemented at main airports from 2014.

8. **REFERENCE DOCUMENTS**

8.1 **Standards**

ICAO Annex 10 — *Aeronautical Telecommunications*

8.2 Procedures

ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*

8.3 Guidance material

- ICAO Doc 8071, *Manual on Testing of Radio Navigation Aids, Volume II — Testing of Satellite-based Radio Navigation Systems*
- ICAO Doc 9613, *Performance-based Navigation (PBN) Manual*
- ICAO Doc 9674, *World Geodetic System — 1984 (WGS-84) Manual*
- ICAO Doc 9849, *Global Navigation Satellite System (GNSS) Manual*
- ICAO Doc 9906, *Quality Assurance Manual for Flight Procedure Design, Volume 5 — Validation of Instrument Flight Procedures*

8.4 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9613, *Performance Based Navigation Manual*
- ICAO Annex 10 — *Aeronautical Telecommunications*
- ICAO Annex 11 — *Air Traffic Services*
- FAA AC 20-138(), TSO-C129/145/146

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APPENDIX G

MODULE NO. B1-70: INCREASED RUNWAY THROUGHPUT THROUGH DYNAMIC WAKE TURBULENCE SEPARATION

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 as per Doc 9854	KPA-02 – Capacity, KPA-04 – Efficiency, KPA-05 – Environment, KPA-06 – Flexibility.	
Operating environment/ Phases of flight	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) as per Doc 9854	CM - Conflict management	
Global plan initiatives (GPI)	GPI-13: Aerodrome design GPI 14: Runway operations	
Main dependencies	B0-70	
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

1.1.1 Refinement of the wake turbulence standards and associated procedures 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 equipment or changes to aircraft performance requirements. Full benefit from the upgrade would require significantly more aircraft broadcasting their aircraft-based weather observations during their approach and departure operations. The upgrade contains three elements that would be implemented by the end of 2018. Element 1 is the establishment of wake turbulence separation minima based on the wake generation and wake upset tolerance of individual aircraft types rather than ICAO Standards based on either 3 or 6 broad categories of aircraft. Element 2 is increasing, at some airports, the number of arrival operations on closely spaced (runway centre lines spaced less than 760 m (2 500 feet) apart) parallel runways and on single runways taking into account the winds present along the approach corridor in modifying how wake turbulence separations are applied. Element 3 is increasing, at selected additional airports, the number of departure operations on parallel runways by modifying how wake turbulence separations are applied by the ANSP.

1.2 Baseline

1.2.1 Wake turbulence standards and associated procedures were developed over time, with the last comprehensive review occurring from 2008 to 2012, resulting in the ICAO approved six category wake turbulence separation minima. The new ICAO Standards (2013) allow greater runway utilization than the earlier wake turbulence separation minima. However, the new standards can be enhanced to define safe runway capacity and efficient wake turbulence separations for typical aircraft operating at an airport. By the end of 2013, some airports will be approved to use modified wake turbulence separation procedures on their parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, if certain runway layout and instrumentation criteria were met. Also by the end of 2013, some airports will be using wake turbulence separation departure procedures for parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart based on predicted and monitored crosswinds.

1.3 Change brought by the module

1.3.1 This module (B1–70) represents an expansion on the wake turbulence separation minima and wake turbulence procedures 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 minima and the ease by which they can be applied. Element 1's expansion of the six category wake turbulence separation minima to a leader/follower pair-wise static matrix of aircraft type wake separation pairings (potentially pairings for all possible leader/follower pairs of the 9 000 + civil aircraft types) is expected to yield an average increased airport capacity of four per cent above that which was obtained by the Block 0 upgrade to the ICAO six category wake separation minima. Element 2 expands the use of specialized wake turbulence separations procedures to more airports by using airport wind information (predicted and monitored) to adjust the needed wake turbulence separations 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 suitable. Element 1 (changing to leader/follower pair-wise static wake turbulence separations) will provide capacity gains for capacity constrained airports worldwide. Elements 2 (increasing airport arrival operational capacity) and 3 (increasing departure operational capacity) provide runway capacity improvements to a wider range of airports than the Block 0 could deliver. These Element 2 and 3 technology aided airport specific specialized procedures will provide for additional airports increased airport arrival capacity (nominally, five to ten more operations per hour) during instrument landing operations and increased airport departure capacity (nominally, two to four more operations per hour) during suitable airport wind conditions and in the absence of other capacity restraining operational conditions, e.g. runway surface contamination.

1.4 Other remarks

1.4.1 The work accomplished in Block 1 builds on the upgrades of Block 0 and will be the basis for further enhancement in wake turbulence standards and associated procedures that will occur in Block 2 developments. The wake turbulence separation standards development provides a progression of steps available to global aviation in order to gain capacity from existing airport runway structure and to place new airport runways by 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 turbulence procedures and separation minima that will assure the safety towards wake turbulence criteria of innovations (trajectory based, high density, intended performance operational improvement/metric to determine success, flexible terminal) in air traffic control while at the same time it will provide the least wake turbulence constraints. The upgrades of Block 1 will incorporate the experience obtained with the Block 0 upgrades.

1.5 **Element 1: Implement leader/follower pair-wise static matrix wake separation minima**

1.5.1 The work in Element 1 is being accomplished, in coordination with ICAO, by a joint EUROCONTROL and FAA working group that reviewed the wake turbulence separation re-categorization to 6 different categories.

1.5.2 It will take the analysis tools developed for its six category wake turbulence 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 three to five per cent increase to airport capacity could, in the absence of other constraining operational factors (e.g. use of a single runway for both departures and arrivals), 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 associated paired wake turbulence separation minima for operations involving those aircraft types would be applied. For all other aircraft types, a more general wake turbulence separation could be applied. It is planned that the leader/follower pair-wise static matrix wake turbulence separation minima recommendation will be provided at the end of 2014 and ICAO would approve use of the matrix by 2016. Modifications to the ATC systems would likely be required to support effective use of the leader/follower pair-wise static matrix wake turbulence separation minima.

1.6 **Element 2: Increasing airport arrival operational capacity at additional airports for parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart.**

1.6.1 Wake turbulence procedures applied to instrument landing operations on parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, 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 parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, required wake turbulence separation spacing equivalent to that of conducting instrument landing operations to a single runway.

1.6.2 Block 0, Element 2 upgrade provided a dependent diagonal paired instrument approach wake separation procedure for operational use in 2008 at five airports that had parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, meeting the runway layout criteria of the developed procedure. Use of the procedure provided an increase of up to ten more arrival operations per hour on the airport parallel runways during airport operations requiring instrument approaches.

1.6.3 Block 1 work will expand the use of the dependent instrument landing approach procedure to capacity constrained airports that use their parallel runways for arrival operations but do not have the runway configuration to satisfy certain constraints of the basic procedure. The mechanism for this expansion is the wake turbulence mitigation for arrivals (WTMA) capability that will be added to ATC systems. WTMA relies on predicted and monitored winds along the airport approach path to determine if wake turbulences of arriving aircraft will be prevented by crosswinds from moving into the path of aircraft following on the adjacent parallel runway. The WTMA capability may be expanded during Block 1 to include predicting when steady crosswinds would blow wakes vortices out of the way of aircraft following directly behind the generating aircraft, allowing the ANSP to safely reduce the wake turbulence 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 six or more airports with parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart.

1.6.4 A critical component of the WTMA capability is wind information along the airport approach corridor. The use of WTMA will be limited by the timely availability of this information. During the 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. The use of aircraft wind data will significantly increase WTMA capability to forecast and monitor wind changes, allowing WTMA wake turbulence separations to be used during times when before, due to uncertainty of wind information, use of the reduced wake turbulence separations was precluded.

1.7 **Element 3: Increasing airport departure operational capacity at additional airports**

1.7.1 Element 3 is the development of technology aided enhanced wake turbulence mitigation ANSP departure procedures that safely allow increased departure capacity on an airport's parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart.

1.7.2 Wake turbulence mitigation for departures (WTMD) is a development project that allows, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the upwind parallel runway after a heavy aircraft departs on the downwind runway – without waiting the current required delay of two to three minutes. WTMD applies a runway crosswind forecast and monitors the current runway crosswind to determine when the WTMD will provide guidance to the controller in order to eliminate the two to three minute delay when the delay must again be applied.

1.7.3 Block 1 will enhance the WTMD capability to predict when crosswinds will be of sufficient strength to prevent the wake vortex of a departing aircraft from being transporting into the path of an aircraft departing on the adjacent parallel runway. WTMD will be modified to receive and process aircraft derived wind information observed during their departure from the airport. Use of aircraft wind data will significantly increase WTMD capability to forecast and monitor wind changes, allowing WTMD wake separations to be used during times when before, due to uncertainty of wind information, use of the reduced wake turbulence separations was precluded.

2. **INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT**

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Element 1: Better wind information around the aerodrome to enact reduced wake mitigation measures in a timely manner. Aerodrome capacity and arrival rates will increase as the result of reduced wake mitigation measures.
<i>Flexibility</i>	Element 2: Dynamic scheduling. ANSPs have the choice of optimizing the arrival/departure schedule via pairing number of unstable approaches.
<i>Efficiency/Environment</i>	Element 3: Changes brought about by this element will enable more accurate crosswind prediction.

<i>Cost Benefit Analysis</i>	The change in Element 1 to the ICAO wake turbulence separation minima will yield an average nominal four per cent additional capacity increase for airport runways. The four per cent increase translates to one more landing per hour for a single runway that normally could handle thirty 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. The impact of the Element 2 upgrade is the reduced time that an airport, due to weather conditions, must operate its parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, as a single runway. Element 2 upgrade allows more airports to better utilize such parallel runways when they are conducting instrument flight rules operations – resulting in a nominal eight to ten 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. Impact of the Element 3 upgrade is reduced time that an airport must space departures on its parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart, by two to three minutes, depending on runway configuration. Element 3 upgrade will provide more time periods that an airport ANSP can safely use WTMD reduced wake separations on their parallel runways. The airport departure capacity increases four to eight 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.
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3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 Element 1

3.1.1 The change to the ICAO wake separation minima implemented in the Block 1 time frame will add the aircraft-to-aircraft leader/follower pair-wise static wake turbulence separations to be applied in 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 categories standard put in place by Block 0. The procedures, using the leader/follow pair-wise static set of standards, will need automation support in providing the required aircraft-to-aircraft wake turbulence separations to its air traffic controllers.

3.1.2 Implementing Element 1 will not require any changes to air crew flight procedures.

3.2 Element 2

3.2.1 The Block 0 implementations impacting the use of an airport parallel runway for arrivals only affect the procedures for sequencing and segregating aircraft to the parallel runways. Block 1 upgrade adds procedures for applying reduced wake turbulence separations between pairs of aircraft

during arrivals on airport parallel runways when crosswinds along the approach path are suitable for the reduced separations. Use of Block 1 procedures requires the addition to the ANSP automation platforms of 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 parallel runways.

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

3.3 **Element 3**

3.3.1 Block 1 Element 3 implementations only affect the ANSP procedures for departing aircraft on an airport parallel runways, with centre lines spaced less than 760 m (2 500 feet) apart. Element 3 products are additional procedures for situations when the airport is operating under a heavy departure demand load and the airport will be having a significant number of heavy 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 procedures for accomplishing a departure from the airport. When a specialized parallel runway 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**

4.1.1 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**

4.2.1 ANSPs, if they choose to use the leader/follower pair-wise static wake turbulence separation minima Element 1 upgrade will develop an ATC decision support tool to support the application of the standards. The Element 2 and Element 3 Block 1 upgrades require the ANSP, if the ANSP chooses to use the reduced wake turbulence separations on its parallel runways, to add the capability to predict crosswind strength and direction and display that information to the controllers. This capability will be provided by a combination of X-band radar and Lidar scanner technology. The delivery of the weather information required to compute the reduced wake turbulence separations will be best supported by a system-wide information management (SWIM) infrastructure and associate services.

5. **HUMAN PERFORMANCE**

5.1 **Human factors considerations**

5.1.1 The identification of human factors considerations is an important enabler in identifying processes and procedures for this module. In particular, the human-machine interface for the automation aspects of this performance improvement will need to be considered and where necessary accompanied

by risk mitigation strategies such as training, education and redundancy.

5.2 Training and qualification requirements

5.2.1 Training will be required for controllers in the use of new pair-wise static matrix of aircraft type wake turbulence separation pairings and decision support tools.

5.2.2 Training in the operational standards and procedures will be identified along with the PANS provisions necessary for this module to be implemented. Likewise the qualifications requirements will be identified and included in the regulatory readiness aspects of this module when they become available.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates required to current published criteria given in Section 8.4.
- Approval plans: to be determined.

6.1 Element 1

6.1.1 The product of Element 1 is a recommended set of leader/follower pair-wise static additional wake separation changes to the ICAO wake turbulence separation minima and supporting documentation. Once approved, ICAO's revised wake turbulence separation minima will allow all ANSPs to base their procedures on the ICAO approved standards. ICAO approval of the leader/follower pair-wise static wake turbulence separation minima is estimated to occur in the 2015/2016 time frame.

6.2 Elements 2 and 3

6.2.1 Elements 2 and 3 products will be published by ICAO in the form of performance based standards derived from requirements established from experience gained from certain States.

6.2.2 There is no air approval plan required for the implementation of the wake turbulence standards – refined Module Block 1.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

7.1.1 The WTMD system has been operationally demonstrated at three United States airports beginning in 2011.

7.2 Planned or ongoing trials

7.2.1 Concurrent with the ICAO approval process, the FAA is developing documentation and adapting its automation systems to allow implementation of the wake separation standard. The ICAO

approval is expected in 2015/2016.

7.2.2 Work is continuing on developing crosswind-based wake turbulence separation procedures and technology upgrades for arrival operations to an airport parallel runways. 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.

7.2.3 Wake turbulence mitigation for departures (WTMD) is a development project by the United States that will allow, when runway crosswinds are of sufficient strength and persistence, aircraft to depart on the upwind parallel runway after a heavy aircraft departs on the downwind runway – without waiting the current required delay of two to three minutes. WTMD is being developed for implementation at eight to ten United States airports that have parallel runways with frequent favourable crosswinds and a significant amount of heavy aircraft operations. First operational use of WTMD is expected in spring 2013.

8. REFERENCE DOCUMENTS

8.1 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9426, *Air Traffic Services Planning Manual*

APPENDIX H

MODULE NO. B1-15: IMPROVED AIRPORT OPERATIONS THROUGH DEPARTURE, SURFACE AND ARRIVAL MANAGEMENT

Summary	Extension of arrival metering and integration of surface management with departure sequencing will improve runway management and increase airport performance and flight efficiency.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-04 – Efficiency, KPA-05 – Environment, KPA-06 – Flexibility, KPA-09 – Predictability, KPA-10 – Safety	
Operating environment/ Phase of flight	Aerodrome and terminal	
Applicability considerations	Runways and terminal manoeuvring areas in major hubs and metropolitan areas will be most in need of these improvements. Complexity in implementation of this module depends on several factors. Some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this module. PBN routes need to be in place.	
Global concept component(s) as per Doc 9854	TS – Traffic synchronization AO – Airport operations	
Global plan initiative	GPI-6: Air traffic flow management GPI-12: Functional integration of ground systems with airborne systems GPI-14: Runway operations GPI-16: Decision support systems and alerting systems	
Main dependencies	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

1.1.1 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.

1.1.2 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.

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

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

1.1.5 The expansion of time-based arrival metering into the adjacent en-route domain is also a 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 uniform and their interpretation consistent.

1.1.6 This module also seeks to increase the utilization 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.

1.2 **Baseline**

1.2.1 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.

1.2.2 **Arrival metering in terminal airspace** reduced the uncertainty in airspace and aerodrome demand. Flights are controlled via controlled time of arrival (CTA). 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 the terminal airspace and aerodrome. The terminal ATC authority can now adjust the arrival sequence to better utilize limited resources in the terminal domain.

1.2.3 **Departure management automation** provides departure scheduling. Departure scheduling will optimize the sequence in which the flow is fed to the adjacent ATC authorities. Departure is sequenced-based on flight 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.

1.2.4 Arrival and departure metering automation efforts maximize the use of capacity and 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.

1.3 **Change brought by the module**

1.3.1 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 and 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.

1.3.2 Extended arrival metering will foster greater accuracy and consistency in 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.

1.3.3 Performance-based procedures such as RNAV/RNP in high density areas will lead to more optimal utilization of airspace. In addition to optimal airspace utilization, RNAV/RNP routes are more fuel efficient. The RNAV/RNP procedures streamline and untangle 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.

1.4 **Element 1: Surface management**

1.4.1 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 streamlines the sequence to the departure threshold and ensures streamline operations. Such streamlined surface operations facilitate 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.

1.5 **Element 2: Departure and surface integration**

1.5.1 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.

1.5.2 These measures serve to increase aerodrome throughput and departure rates.

1.6 Element 3: Extended arrival metering

1.6.1 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 absorbed by incoming flights. In addition, synchronization will foster a common method and message set amongst ATC authorities.

1.7 Element 4: Utilization of RNAV/RNP routes

1.7.1 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 the 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 enables the utilization of optimized 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

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Time-based metering will optimize usage of terminal airspace and runway capacity.
<i>Efficiency</i>	Surface management decreases runway occupancy time, introduces more robust departure rates and enables dynamic runway rebalancing and re-configuration. Departure/surface integration enables dynamic runway rebalancing to better accommodate arrival and departure patterns. Reduction in airborne delay/holding. Traffic flow synchronization between en-route and terminal domain. RNAV/RNP procedures will optimize aerodrome/terminal resource utilization.
<i>Predictability</i>	Decrease uncertainties in aerodrome/terminal demand prediction. Increased compliance with assigned departure time and more predictable and orderly flow into metering points.

	Greater compliance to controlled time of arrival (CTA) and more accurate assigned arrival time and greater compliance.
<i>Flexibility</i>	Enables dynamic scheduling.
<i>Safety</i>	Greater precision in surface movement tracking.
<i>Environmental</i>	Reduction in fuel burn and environment impact (emission and noise).
<i>Cost Benefit Analysis</i>	Surface management streamlines traffic flow on the aerodrome surface and facilitates more efficient use of runways and increase runway capacity. In addition, surface management streamlines departure flow and provides more predictable and gate-arrival times. Greater precision in surface movement tracking can reduce runway incursions and ensure aerodrome user safety. Surface management also offers environmental benefits in fuel burn and noise abatement in some aerodromes. 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. Extended metering enables adjacent ATM authorities to 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. 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 AND GROUND)

3.1.1 The TBFM and AMAN/DMAN efforts, along with other surface initiatives, provide the systems and operational procedures necessary. New procedures should be defined to describe the role of each actor (crew, ATS units).

4. NECESSARY SYSTEM CAPABILITY

4.1 Ground systems

4.1.1 For Element 1, a surface management functionality that includes precise surface movement tracking, taxi routing and monitoring is required. Airports may choose to provide the taxi clearance using an air-ground data link functionality. For Element 2, automation support is required to support the integration of departure sequencing with surface management. For Element 3, a functionality is required to extend the arrival metering into en-route through enhanced coordination. Finally for Element 4, the arrival metering function needs to be updated to cater for aircraft navigation performances. As a consequence, information exchange between ATC, airport operations and airline operations will best be implemented using the SWIM infrastructure.

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 Automation support is needed for air traffic management in airspace with high demands. The identification of human factors considerations is an important enabler in identifying processes and procedures for this module. In particular, the human-machine interface for the automation aspects of this performance improvement will need to be considered, and where necessary, accompanied by risk mitigation strategies such as training, education and redundancy.

5.2 Training and qualification requirements

5.2.1 Training on the required automation is needed for ATM personnel. ATM personnel responsibilities will not be affected. Training in the operational standards and procedures will be identified along with the Standards and Recommended Practices necessary for this module to be implemented. Likewise the qualifications requirements will be identified and included in the regulatory readiness aspects of this module when they become available.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates required for surface management, surface CDM, and operations to current published criteria given in Section 8.4.
- Approval plans: to be determined.

6.1 Discussion

6.1.1 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 United States, should be established to serve as a forum for all stakeholders to discuss relevant issues and concerns.

6.1.2 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.

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

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

7. **IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KOWN AT TIME OF WRITING)**

7.1 **Current use**

Surface management

7.1.1 None at this time.

Departure and surface integration

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

Extended metering

United States: Extended metering is in current use in the United States as part of TBFM.

Utilization of RNAV/RNP routes

United States: Terminal metering which will provide merging and spacing capability to enable utilization of RNAV/RNP routes will be implemented by 2018.

7.2 **Planned or ongoing trials**

7.2.1 Surface manager (SMAN) will be introduced as the go-to surface management tool in Europe. Similarly, tower flight data manager (TFDM) will be introduced in the United States to fulfil the same role. SMAN is a function in the ASMGCS tool to maintain a safe and efficient traffic flow on the surface.

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

7.2.3 The TBFM programme in the United States seeks to augment trajectory management advisor (TMA) and strives to close the performance gaps in TMA. Generally, time-based flow management (TBFM) aims to improve and optimize 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 traffic management initiatives (TMIs). Similarly, AMAN/DMAN works toward integrated, synchronized sequencing of all flight phases.

7.2.4 Extended AMAN is considered in the European project. The aim of the United States and European efforts are congruous. Extended metering will be implemented along with these capabilities as they mature.

7.3 Surface management

7.3.1 Surface movement tracking and navigational systems, such as the ASDE-X in the United States and initial advanced-surface movement guidance and control system (A-SMGCS) in Europe, are deployed to support tracking, guidance, routing and planning of surface operations.

United States: The collaborative departure queue management (CDQM) concept will be evaluated in field tests by the FAA during the surface trajectory-based operations (STBO) projects. The human-in-the-loop 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.

7.3.2 In 2010, 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 were allocated a precise departure slot and waited at the gate rather than near congesting taxiways. The procedures used during the construction project worked so well that they were retained for use after the runway work had been completed.

7.3.3 Boston Logan International Airport hosted 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 was to conduct continuous runway operations without any stop and go movements. In August through September, preliminary findings indicated the following savings: eighteen hours of taxi time, 5 100 gallons of fuel and fifty tons in carbon dioxide.

7.3.4 **Europe:** Surface manager (SMAN) will be introduced as the go-to surface management tool in Europe. Similarly, TFDm will be introduced in the United States to fulfil the same role. SMAN is a function in the ASMGCS tool to maintain a safe and efficient traffic flow on the surface. Enhanced surveillance will be defined, verified and in-field validated in Europe in the 2010-2015 time frame.

7.4 Departure and surface integration

- **Europe:** Trials on the integration of surface management with arrival management and departure management in the CDM processes validating the route generator ability to propose conflict free routes and the provision of planned routes though data link in 2014.
- Trials on coupled departure management capabilities for establishing the pre-departure sequence with sufficient quality taking into account surface and departure management processes in 2011.

7.5 Extended metering

- **United States:** 3D PAM will provide extended metering from en-route airspace to the meter to the terminal areas with merging and spacing required for RNAV/RNP procedures.
- **Europe:** Validation of P-RNAV application integrated with arrival management in complex TMAs with more than one airport in the 2012-2014 timeframe.
- Validation of extended arrival management in en-route airspace in the 2012-2014 timeframe.

7.6 Utilization of RNAV/RNP routes

- **United States:** Demonstration of terminal metering to merge and space RNAV/RNP procedures are currently being conducted to determine functional and operational requirements.
- **Europe:** Trials on computed and predicted single CTAs in the 2012-2013 timeframe.
- Validation of multiple controlled time of arrival (CTAs) in 2015.

8. REFERENCE DOCUMENTS

8.1 Guidance material

- European ATM Master Plan, Edition 1.0, March 2009, update in progress
- SESAR Definition Phase Deliverables
- TBFM Business Case Analysis Report
- NextGen Midterm Concept of Operations v.2.0
- RTCA Trajectory Operations Concept of Use

8.2 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9426, *Air Traffic Services Planning Manual*

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APPENDIX I

MODULE NO. B1-75: ENHANCED SAFETY AND EFFICIENCY OF SURFACE OPERATIONS – SURF, SURF-IA AND ENHANCED VISION SYSTEMS (EVS)

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 (SURF), runway safety alerting logic (SURF-IA), and enhanced vision systems (EVS) for low visibility taxi operations.	
Main performance impact as per Doc 9854	KPA-10 – Safety, KPA-4 – Efficiency.	
Operating environment/ Phase of flight	Aerodrome operations	
Applicability considerations	For SURF and SURF-IA, applicable to large aerodromes (ICAO codes 3 and 4) and all classes of aircraft; cockpit capabilities work independently of ground infrastructure, but other aircraft equipage and/or ground surveillance broadcast will improve.	
Global concept component(s) as per Doc 9854	AO – Aerodrome operations CM – Conflict management	
Global plan initiatives (GPI)	GPI-9: Situational awareness GPI-13: Aerodrome design and management GPI-16: Decision support systems and alerting systems GPI-18: Electronic information services	
Main dependencies	B0-75: Surface surveillance	
Global readiness checklist		Status (indicate ready with a tick or input date)
	Standards readiness	SURF✓ /SURF-IA Est. 2015
	Avionics availability	SURF Est. 2015-2017/SURF-IA Est. 2015-2017
	Infrastructure availability	SURF N/A/SURF-IA N/A
	Ground automation availability	N/A
	Procedures available	SURF 2013/SURF-IA Est. 2015
	Operations approvals	SURF 2013/SURF-IA Est. 2015

1. NARRATIVE

1.1 General

1.1.1 This module builds upon the work completed in B0-75 Safety and Efficiency of Surface Operations (A-SMGCS Level 1-2) and cockpit moving map, by the introduction of new capabilities that enhance surface situational awareness and surface movement capabilities:

- a) enhanced ANSP surface surveillance capability with safety logic;
- b) enhanced cockpit surface surveillance capability with indications and alerts; and

- c) enhanced vision systems for taxi operations.

1.2 **Baseline**

1.2.1 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 safety. 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.

1.2.2 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.

1.2.3 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.

1.3 **Change brought by the module**

1.3.1 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 (SURF). The system can be enhanced by the addition of alerts to reduce the risk of collisions in runway operations (SURF-IA). 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 the tower and cockpit systems, and where necessary, would be equipped with map and traffic capabilities similar to the cockpit.

1.4 **Element 1: Basic surface situation awareness (SURF) and enhanced traffic situational awareness on the surface of airport with indications and alerts (SURF-IA)**

1.4.1 Initial enhancements allow for other aerodrome traffic to be depicted on the display (SURF). 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.

1.4.2 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.

1.4.3 The addition of traffic depictions on cockpit electronic maps, further enhanced by safety logic, provides enhanced redundancy for the detection of potentially unsafe situations. 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.

1.4.4 These capabilities could also be applied to support drivers of equipped ground vehicles.

1.5 **Element 2: Enhanced vision systems for taxi operations**

1.5.1 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.

1.5.2 The addition of cockpit enhanced vision capabilities will improve flight crew awareness of own ship 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**

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Efficiency</i>	Element 1: Reduced taxi times Element 2: Fewer navigation errors requiring correction by ANSP
<i>Safety</i>	Element 1: Reduced risk of collisions Element 1: Improved response times to correction of unsafe surface situations (SURF-IA only). Element 2: Fewer navigation errors
<i>Cost Benefit Analysis</i>	The business case for this element can be largely made around safety. Currently, the aerodrome surface is often the regime of flight which has the most risk for aircraft safety, due to the lack of good surveillance on the ground acting in redundancy with cockpit capabilities. Visual scanning augmentation in the cockpit acting in conjunction with service provider capabilities enhances operations on the surface. Efficiency gains are expected to be marginal and modest in nature. Improving flight crew situational awareness of own ship position during periods of reduced visibility will reduce errors in the conduct of taxi operations, which lead to both safety and efficiency gains.

3. **NECESSARY PROCEDURES (AIR AND GROUND)**

3.1 When implementing SURF or SURF-IA, adherence to aircraft flight manual approved procedures for the use of the equipment is required.

3.2 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.

3.3 The procedure for the use of ADS-B traffic display is being proposed for inclusion in the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168) for applicability in November 2013. (SURF).

3.4 The procedure for the use of indications and alerts will be developed for inclusion in the PANS-OPS (and possibly in the PANS-ATM) (SURF-IA).

3.5 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.

3.6 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

4.1.1 The aircraft choosing to equip for operations in this environment will add basic surface situation awareness (SURF) and enhanced traffic situational awareness on the airport surface with indications and alerts (SURF-IA) including ADS-B/traffic information service broadcast receiver (SURF), and runway safety logic (SURF-IA). ADS-B Out avionics will be required for direct aircraft-to-aircraft surveillance.

4.1.2 These capabilities could also be applied to support drivers of equipped ground vehicles.

4.1.3 With the addition of enhanced vision systems for use during taxi operations, an enhanced flight vision system in the aircraft will be required.

4.2 Ground systems

4.2.1 For SURF, no ground system is required. For SURF-IA, it is essential to have a complete traffic situation on the runway and either a mandatory carriage of ADS-B Out and/or TIS-B ground stations are required.

4.2.2 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

5.1.1 Human performance is a critical aspect in resolving runway incursions; it must be accounted for in avionics system design to determine how far in advance of the predicted runway incursion or other factors the system must identify so that flight crew action can be taken to avoid it.

5.2 Training and qualification requirements

5.3 Since automation support is needed for the pilots, 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/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: use current published criteria that include the material given in Sections 8.1 and 8.4.
- Approval plans: no new or updated approval criteria are needed at this time. Implementation plans should reflect available aircraft, ground systems and operational approvals.

6.1 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.

- SURF: DO322/ED165 and DO317A/ED194
- SURF-IA DO323
- EVS DO315B
- Possibly Annex 6 and Annex 10 for SURF and SURF-IA requirements

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

7.1.1 The United States and Europe already developed standards for SURF. They are in the process of defining avionics standards for SURF-IA, with operational capabilities expected to be phased in now through 2017. Standards are being developed for ground vehicle equipment to allow them to be “seen” via ADS-B.

7.1.2 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

7.2.1 As part of the ATSAW Pioneer Project sponsored by EUROCONTROL in 2012, SURF is one of the applications evaluated with revenue aircraft. In the first step, focus is put on AIRB and ITP but SURF is planned to be evaluated in a second step.

7.2.2 Similar trials are planned in the United States with US Airways by 2013.

8. REFERENCE DOCUMENTS

8.1 Standards

- FAA Advisory Circular, AC120-86, Aircraft Surveillance Systems and Applications
- FAA Advisory Circular, AC120-28D, Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout
- FAA Advisory Circular, AC120-57A Surface Movement Guidance and Control System
- ED-165/DO-322 (SURF SPR/INTEROP)
- ED-194/DO-317A
- And RTCA document only: DO-323 (SURF IA SPR/INTEROP)
- 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

8.4 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Flight Plan Classification
- 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

APPENDIX J

MODULE NO. B1-80: OPTIMIZED AIRPORT OPERATIONS THROUGH A-CDM TOTAL AIRPORT MANAGEMENT

Summary	To enhance the planning and management of airport operations and allow their full integration in the air traffic management using performance targets compliant with those of the surrounding airspace. This entails implementing collaborative airport operations planning (AOP) and where needed an airport operations centre (APOC).	
Main performance impact as per Doc 9854	KPA-03 – Cost-effectiveness, KPA-04 – Efficiency, KPA-05 – Environment, KPA-09 – Predictability.	
Operating environment/ Phases of flight	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). APOC: will be implemented at major/complex airports (sophistication will depend on the complexity of the operations and their impact on the network). Not applicable to aircraft.	
Global concept component(s) as per Doc 9854	AO – Airport operations IM – Information management	
Global plan initiatives (GPI)	GPI-13: Aerodrome design and management	
Main dependencies	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

1.1.1 Major airports are complex organizations involving multiple stakeholders/partners. Each has its own operations principles and sub-processes and mostly operates in an independent and non-collaborative manner. Optimization based on those individual processes very often lead to a sub-optimal and inefficient total airport performance.

1.1.2 Uncoordinated operations at an airport often translate into additional delays, holding times on the surface and in the air and 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 entire ATM network.

1.1.3 The lack of timely access to information regarding flight operations (e.g. arrival, departure turnaround and surface movement sequencing) increases gate-to-gate times and decreases the utilization efficiency of airport resources such as aircraft stands, ground equipment and services. For example delays in

managing demand increase delays and holding times (airborne and ground) result in greater fuel burn with a negative environmental impact.

1.1.4 Today, information on airport operations such as the resources availability plan (e.g. runway, taxiway, gate) and aircraft readiness is not fully taken into account into the flow planning of the overall ATM system.

1.1.5 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.

1.2 Baseline

1.2.1 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 No B0-35.

1.3 Change brought by the module

1.3.1 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) a collaborative airport operations plan (AOP) which encompasses “local” airport information and “shared” information with the ATM system/ATM network manager in order to develop a synchronized view and fully integrate the airport operations into the overall ATM network;
- b) an airport performance framework and steering with specific performance indicators and targets fully integrated into the AOP and aligned with the regional/national performance frameworks;
- c) a decision making support enabling airport stakeholders to communicate and coordinate, to develop and maintain dynamically joint plans and to execute those in their respective area of responsibility;
- d) information aggregation of resources availability plans and aircraft operations planning into a consistent and pertinent reference for the different operational units on the airport and elsewhere in ATM; and
- e) a real-time monitoring capability, as a trigger (e.g. alerts & warnings) to decision making processes, and a set of collaborative procedures to ensure a fully integrated management of airside airport processes, taking the impact on landside processes into account and supported by up-to-date and pertinent meteorological information.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Cost-effectiveness</i>	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).
<i>Efficiency</i>	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.
<i>Environment</i>	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.
<i>Predictability</i>	Through the operational management of performance, reliability and accuracy of the schedule and demand forecast will increase (in association with initiatives being developed in other modules).
<i>Cost Benefit Analysis</i>	To be determined.

3. **NECESSARY PROCEDURES (AIR AND GROUND)**

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

4. **NECESSARY SYSTEM CAPABILITY**

4.1 **Ground systems**

4.1.1 The following supporting systems functions need to be developed and implemented: a data repository to host the AOP, a display and human-machine interfaces to provide an access to the AOP and warn the appropriate airport stakeholders when a decision is required, some airport monitoring tools and decision support tools.

4.1.2 A communication network across the major airport stakeholders (e.g. AOC, APOC) and the network management systems need to be deployed.

5. **HUMAN PERFORMANCE**

5.1 **Human factors considerations**

5.1.1 The identification of human factors considerations is an important enabler in identifying processes and procedures for this module. In particular, the human-machine interface for the automation aspects of this performance improvement will need to be considered and where necessary accompanied by risk mitigation strategies such as training, education and redundancy.

5.2 **Training and qualification requirements**

5.2.1 Training in the operational standards and procedures will be identified along with the Standards and Recommended Practices necessary for this module to be implemented. Likewise the qualifications requirements will be identified and included in the regulatory readiness aspects of this module when they become available.

6. **REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)**

- Regulatory/standardization: to be determined.
- Approval plans: to be determined.

7. **IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)**

7.1 **Planned or ongoing trials**

- **Europe:** For validation carried out by 2015
- **United States:** For validation carried out by 2015

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APPENDIX K

MODULE NO. B1-81: REMOTELY OPERATED AERODROME CONTROL

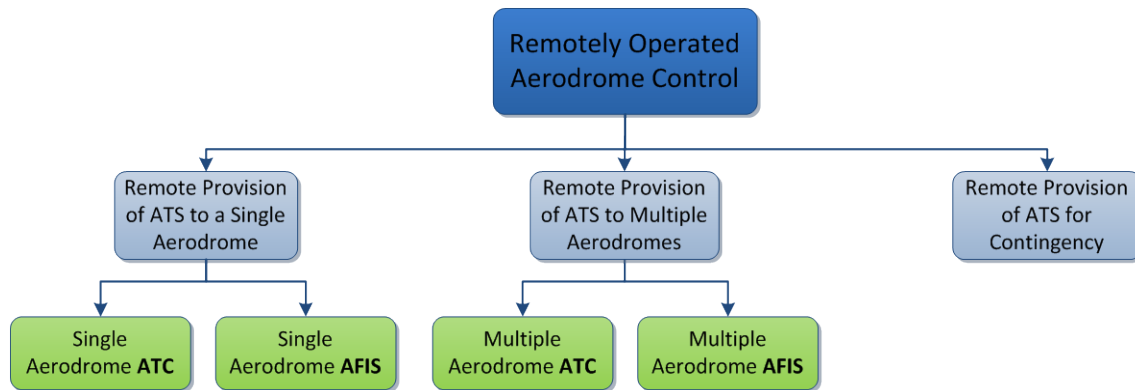
Summary	To provide a safe and cost effective ATS from a remote facility, to one or more aerodromes where dedicated, local ATS is no longer sustainable or cost effective, but there is a local economic and social benefit from aviation. This can also be applied to contingency situations and depends on enhanced situational awareness of the aerodrome under remote control.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-03 – Cost-effectiveness; KPA-06 – Flexibility; KPA-10 – Safety.	
Operating environment/ Phases of flight	TMA, descent, airport surface, climb out.	
Applicability considerations	The main target for the single and multiple remote tower services are small rural airports, which today are struggling with low business margins. Both ATC and AFIS aerodromes are expected to benefit. The main targets for the contingency tower solution are medium to large airports – those that are large enough to require a contingency solution, but who require an alternative to A-SMGCS based “heads down” solutions or where maintaining a visual view is required. Although some cost benefits are possible with remote provision of ATS to a single aerodrome, maximum benefit is expected with the remote of ATS to multiple aerodromes.	
Global concept component(s) as per Doc 9854	CM – Conflict management AO – Airport operations	
Global plan initiatives (GPI)	GPI-13: Aerodrome design and management GPI-15: Match IMC and VMC operating capacity GPI-9: Situational awareness	
Main dependencies	None	
Global readiness checklist		Status (ready or 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

1.1.1 Remotely operated aerodrome control concerns the provision of ATS to aerodrome(s) from a facility which is not located at the aerodrome itself.

1.1.2 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 below.



1.1.3 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.

1.1.4 The visual surveillance will be provided by a reproduction of the out-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 objects 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.

1.1.5 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.

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

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

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

1.1.9 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 they primarily will focus on the pure ATS tasks, and other tasks will be secondary and/or performed by personnel local to the aerodrome.

1.1.10 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.

1.2 Baseline

1.2.1 Remotely operated aerodrome control will be built on today’s local aerodrome operations and services.

1.3 Change brought by the module

1.3.1 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.

1.3.2 Specifically, the out-the-window component of this solution will enhance existing contingency solutions, e.g. London Heathrow virtual contingency facility.

1.3.3 The main improvements will be:

- a) safety;
- b) lower operating costs for the aerodrome;
- c) lower cost of providing ATS to the airspace users;
- d) more efficient use of staff resources;
- e) higher levels of standardization/interoperability across remote aerodrome systems and procedures;
- f) higher situational awareness in low visibility conditions using visual enhancements;
- g) greater capacity in low visibility conditions; and
- h) greater capacity in contingency situations.

1.4 Element 1: Remote provision of ATS for single aerodromes

1.4.1 The objective of remote provision for a single aerodrome is to provide the ATS defined in ICAO Docs 4444, 9426 and the EUROCONTROL 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.

1.4.2 The main change is that the ATCO or AFISO will no longer be located at the aerodrome. They will be relocated to a remote tower facility or a remote tower centre (RTC).

1.4.3 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.

1.5 **Element 2: Remote provision of ATS for multiple aerodromes**

1.5.1 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.

1.5.2 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.

1.5.3 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 synchronization 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; and
- 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.

1.6 Element 3: Remote provision of ATS for contingency situations

1.6.1 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.

1.6.2 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; and
- systems such as A-SMGCS are not available.

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

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Capacity may be increased through the use of digital enhancements in low visibility.
<i>Efficiency</i>	Efficiency benefits are provided in three main areas. The first is the cost effectiveness benefits described above, centred on using assets and resources more efficiently leading to a more cost effective service. The second is the ability to exploit the use of technology in the provision of the services. Digital enhancements can be used to maintain throughput in low visibility conditions, thus making a more efficient use of available capacity.
<i>Cost Effectiveness</i>	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 centralized training and resource pools). For multiple aerodrome additional cost effectiveness benefits can be achieved through the ability to control a greater number of aerodromes with fewer individual facilities and controllers.
<i>Flexibility</i>	Flexibility may be increased through a greater possibility to extend opening hours when through remote operations.
<i>Safety</i>	The provision of air traffic services (facilities and staff) from a remote location should provide the same, or greater if possible, levels of safety as if the services were provided locally. The use of the digital visual technologies used in the RVT may provide some safety enhancements in low visibility.
<i>Cost Benefit Analysis</i>	Cost benefit assessments (CBA) for previous remote tower research programmes have shown a cost benefit to exist in the target environment. Since there are no current operational remote towers these CBA were necessarily based on some assumptions. However, these assumptions were developed by a working group of

	subject matter experts and considered reasonable working assumptions. There are costs associated with remote tower implementation including the costs of procurement and installation of equipment. There are additional capital costs in terms of new hardware and adaptation of buildings. New operating costs are incurred in the form of facilities leases, repairs and maintenance and communication links. There are then short term transition costs such as staff re-training, re-deployment and relocation costs. Against this, savings are derived from remote tower implementation. A significant portion of these are the result from savings in employment costs due to reduction in shift size. Previous CBA indicated a reduction in staff costs of ten per cent to thirty-five per cent depending on the scenario. Other savings arise from reduced capital costs, particularly savings from not having to replace and maintain tower facilities and equipment and from a reduction in tower operating costs. The CBA concluded that remote tower does produce positive financial benefits for ANSP. Further assessment of costs and benefits (ACB) will be conducted during 2012 and 2013 using a range of implementation scenarios (single, multiple, contingency).
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3. NECESSARY PROCEDURES (AIR AND GROUND)

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

3.2 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.

3.3 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.

3.4 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 Ground systems

4.1.1 For remotely operated aerodrome control the main technology is the development of camera-based solutions. Camera and display technologies 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.

4.1.2 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.

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

5. HUMAN PERFORMANCE

5.1 Human factors considerations

5.1.1 The identification of human factors considerations is an important enabler in identifying processes and procedures for this module. In particular, the human-machine interface for the automation aspects of this performance improvement will need to be considered and where necessary accompanied by risk mitigation strategies such as training, education and redundancy.

5.2 Training and qualification requirements

5.2.1 Training in the operational standards and procedures will be identified along with the Standards and Recommended Practices necessary for this module to be implemented. Likewise the qualifications requirements will be identified and included in the regulatory readiness aspects of this module when they become available.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: to be determined.
- Approval plans: to be determined.

6.1 Discussion

6.1.1 Material for provision of ATS in contingency situations already exists, but not for the solutions delivered by this concept. However, no regulatory or standardization 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 (AS KNOWN AT TIME OF WRITING)

7.1 Current use

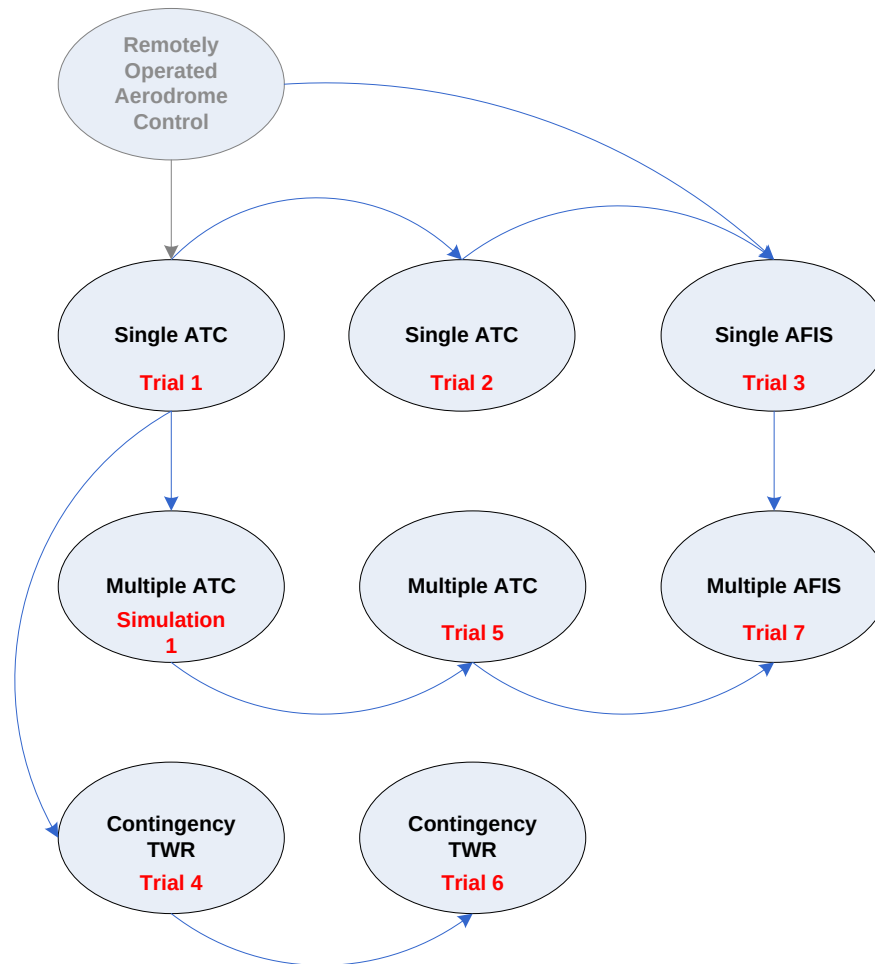
7.1.1 There is no current operational use of remotely operated aerodrome control in normal operations. Some aerodromes have contingency facilities, but none that include an OTW view.

7.1.2 **Europe:** 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

7.2.1 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.



7.2.2 Shadow mode trials for the single tower service will take place in 2011 and 2012.

7.2.3 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.

7.2.4 **United States:** Completed trial for staffed towers which conducted shadow mode for single tower services in 2011.

7.2.5 **Europe:** In 2011 a live trial was conducted for providing ATS to Ängelholm airport from the Malmö ATCC R and D remote tower centre, testing the feasibility of conducting remotely

nominal and non-nominal operations, as well as the technical feasibility of capturing the “out-the-window” traffic situation and operational environment from a single airport and displaying this picture in the remote site.

7.2.6 Trials on remote provision of ATS to an aerodrome during contingency situations are expected in the 2012 – 2014 timeframe.

7.2.7 Trials on remote provision of ATS to multiple aerodromes in parallel from one single remote control facility are expected in the 2012 – 2014 timeframe.

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APPENDIX L

MODULE NO. B2-70: ADVANCED WAKE TURBULENCE SEPARATION (TIME-BASED)

Summary	The application of time-based aircraft-to-aircraft wake separation minima and changes to the procedures the ANSP uses to apply the wake separation minima.	
Main performance impact as per Doc 9854	KPA-02 – Capacity	
Operating environment/ Phases of flight	Aerodrome	
Applicability considerations	Most complex - establishment of 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) as per Doc 9854	CM – Conflict management	
Global plan initiatives (GPI)	GPI-13: Aerodrome design GPI 14: Runway operations	
Main dependencies	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

1.1.1 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.

1.2 Baseline

1.2.1 Turbulence Module B1-70 will have resulted in the use of dynamic wake turbulence separations to increase runway throughput while maintaining safety levels.

1.3 Change brought by the module

1.3.1 Module B2-70 represents a shift to time-based application of module B1-70 expanded distance based wake separation minima and ANSP wake mitigation procedures upgrade. B1-70 represented technology being applied to make available further runway capacity savings by enhancing the efficiency of wake turbulence separation minima by expanding the six category wake separation minima to a leader/follower pair-wise static matrix of aircraft type wake separation pairings (potentially sixty-four 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.

1.3.2 The goal of Module B1-70 was to reduce the number of operations in which an excessive wake spacing buffer reduced runway throughput. This module 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 expected 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 utilizes 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

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Increased capacity and arrival rates through time-based separation coupled with weather dependent separation (WDS) concept
<i>Efficiency/Environment</i>	Further implementation of WDS will enable more accurate cross wind prediction

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 Implement leader/follower pair-wise time-based separation minima

3.1.1 The change to the ICAO wake turbulence separation minima implemented in the Block 2 timeframe will change from a distance based separation that was expanded through the previous blocks from three to sixty or more to tailored time-based minima.

3.1.2 Implementing Block 2 will not require any changes to air crew flight procedures.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 To be determined.

4.2 Ground system

4.2.1 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

5.1.1 This module is still in the research and development phase so the human factors considerations are still in the process of being identified through modelling and beta testing. Future iterations of this document will become more specific about the processes and procedures necessary to take the human factors considerations into account. There will be a particular emphasis on identifying the human-machine interface issue if there are any and providing the high risk mitigation strategies to account for them.

5.2 Training and qualification requirements

5.2.1 This module will eventually contain a number of personnel training requirements. As and when they are developed, they will be included in the documentation supporting this module and their importance signified. Likewise, any qualifications requirements that are recommended will become part of the regulatory needs prior to implementation of this performance improvement.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: new or updated criteria for advanced wake vortex based operations are needed to the documents given in Section 8.4.
- Approval plans: to be determined.

6.1 Implement leader/follower pair-wise time-based separation minima

6.1.1 The product of this activity is a new procedure with supporting automaton requirements to establish time-based separation minima for high density and high throughput terminal areas. This will require an expansion of ICAO wake separation minima and supporting documentation. Once approved, ICAO's revised wake separation minima will allow all ANSPs to base their wake mitigation procedures on the ICAO approved standards.

7. **IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)**

7.1 **Current use**

7.1.1 None at this time.

7.2 **Planned or ongoing trials**

7.2.1 United States: no current trials or demonstration planned at this time.

8. **REFERENCE DOCUMENTS**

8.1 **Guidance materials**

8.1.1 This module also incorporates R199 Doc 9882.

8.2 **Approval documents**

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9426, *Air Traffic Services Planning Manual*

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APPENDIX M

MODULE NO. B2-15: LINKED AMAN/DMAN

Summary	Integrated AMAN/DMAN to enable dynamic scheduling and runway configuration to better accommodate arrival/departure patterns and integrate arrival and departure management. The module also summarizes the benefits of such integration and the elements that facilitate it.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-04 – Efficiency, KPA-09 – Predictability, KPA-06 – Flexibility.	
Operating environment/ Phases of flight	Aerodrome and terminal	
Applicability considerations	Runways and terminal manoeuvring area in major hubs and metropolitan areas will be most in need of these improvements. The implementation of this module is least complex. Some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this block. Infrastructure for RNAP/RNP routes need to be in place.	
Global concept component(s) as per Doc 9854	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

1.1.1 In Block 2 (2023), departure and arrival sequencing will be synchronized. Arrival and departure exact strains on the same aerodrome resources. Thus, the coupling of the 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.

1.1.2 Synchronization 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 shared 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 synchronization.

1.2 Baseline

1.2.1 Block 1 brought about the synchronization 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 improves conformance to assigned departure time. RNAV/RNP procedures usage in a high density terminal domain is more prevalent. Greater usage of RNAV/RNP procedures optimizes throughput and provides fuel-efficient routes for airspace users. Metering will also be extended into adjacent FIR airspace and ensure greater monitoring on conformance to control time of arrivals. Extended metering will also assist in transitioning flights from en-route to terminal airspace.

1.3 Change brought by the module

1.3.1 In Block 2, arrival and departure sequencing will be synchronized, establishing a predictable and efficient stream of flights in the terminal and aerodrome airspace and optimizing both terminal procedures and runway configuration to accommodate the maximum volume of aircraft. Runway and airspace configuration can be dynamically adjusted to accommodate any change in the arrival/departure flow patterns. 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.

1.3.2 The primary benefits of such synchronization are optimized allocation of airspace/aerodrome resources, resulting in greater runway and airspace throughput. Arrival and departure flow can be sequenced to circumvent the negative impacts of natural phenomena, separation restrictions, and conflicts. This gives ATM greater latitude in coping with excess demand. Integrated arrival and departure management ensure that aircraft are optimally spaced to achieve the maximum throughput.

1.3.3 The synchronized information flow as the result of harmonization between departure and arrival also foster greater common situational awareness for all stakeholders. Information transferred between all ATC authorities involved will be reconciled to provide a common operational picture. This reduces the complexity.

2. INTENDED PERFORMANCE OPERATIONAL IMPROVEMENT

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Decrease in miles-in-trail (MIT) restrictions implies greater capacity in the terminal and aerodrome domain.
<i>Efficiency</i>	Optimize utilization of terminal and runway resources. a) Optimize and coordinate arrival and departure traffic flows in the terminal and aerodrome domain
<i>Predictability</i>	Decrease uncertainties in aerodrome/terminal demand prediction.

<i>Flexibility</i>	Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns.
<i>Cost Benefit Analysis</i>	Linked AMAN/DMAN will reduce ground delay. In the United States 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 enhance throughput and airspace capacity. Reconfiguration of airspace to accommodate different arrival/departure patterns entails more agile terminal operations.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 The ICAO *Manual on Global Performance of the Air Navigation System* (Doc 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.

3.2 Integration of AMAN, DMAN through increased automation is subject to research and validation. Supported by Airport CDM it will also require changes in the relationships between the actors. These efforts would provide the necessary operational procedures defining the role of each actor (crew, ATS units, airport) and their relations.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 No additional avionics (FMS) beyond Block 0 are required for the implementation of this module.

4.2 Ground systems

4.2.1 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

5.1.1 ATM personnel responsibilities will not be affected, however, this module is still in the research and development phase so the human factors considerations are still in the process of being identified through modelling and beta testing. Future iterations of this document will become more

³ Exhibit 300 Program Baseline Attachment 2: Business Case Analysis Report for TBFM v2.22

specific about the processes and procedures necessary to take the human factors considerations into account. There will be a particular emphasis on identifying the human-machine interface issue, if any, and providing the high risk mitigation strategies to account for them.

5.2 Training and qualification requirements

5.2.1 Automation support is needed for air traffic management in airspace with high demands. Thus, training is needed for ATM personnel.

5.2.2 This module will eventually contain a number of personnel training requirements. As and when they are developed, they will be included in the documentation supporting this module and their importance signified. Likewise, any qualifications requirements that are recommended will become part of the regulatory needs prior to implementation of this performance improvement.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: updates required for policies on arrival and departure information sharing, roles and responsibilities of all users of the aerodrome surface and terminal airspace, and mutual understanding/acceptance of operational procedures in published criteria that includes those given in Section 8.4.
- Approval plans: to be determined.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

7.1.1 There is no current operational use of departure and arrival management integration automation.

7.2 Planned or ongoing trials

7.2.1 No currently planned trials or demonstrations at this time.

8. REFERENCE DOCUMENTS

8.1 Guidance material

- European ATM Master Plan, Edition 1.0, March 2009, update in progress
- SESAR Definition Phase Deliverables
- TBFM Business Case Analysis Report
- NextGen Midterm Concept of Operations v.2.0
- RTCA Trajectory Operations Concept of Use

8.2 Approval documents

- ICAO Doc 4444, *Procedures for Air Navigation Services — Air Traffic Management*
- ICAO Doc 9426, *Air Traffic Services Planning Manual*

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APPENDIX N

MODULE NO. B2-75: OPTIMIZED SURFACE ROUTING AND SAFETY BENEFITS (A-SMGCS LEVEL 3-4 AND SVS)

Summary	To improve efficiency and reduce the environmental impact of surface operations, even during periods of low visibility. Queuing for departure runways is reduced to the minimum necessary to optimize runway use and taxi times are also reduced. Operations will be improved so that low visibility conditions will have a minor effect on surface movement.	
Main performance impact as per Doc 9854	KPA-01 – Access and Equity, KPA-04 – Efficiency, KPA-06 – Flexibility, KPA-10 – Safety.	
Operating environment/ Phases of flight	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) as per Doc 9854	AO – Aerodrome operations CM – Conflict management DCB – Demand capacity balancing TS – Traffic synchronization	
Global plan initiatives (GPI)	GPI-14: Runway operations GPI-16: Decision support systems and alerting systems GPI-17: Data link applications GPI-18: Electronic information services	
Main dependencies	B1-75 B1-40 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

1.1.1 This module is focused on improving the baseline case (completion of B0-75, improved runway safety) (A-SMGCS Levels 1 and 2 and cockpit moving), 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);
- enhanced cockpit surface surveillance capability with indications and alerts; and
- synthetic vision systems.

1.1.2 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 enhances the common situational awareness between the ANSP and flight crew.

1.2 Baseline

1.2.1 The baseline for this module is the level of capability achieved by Module B1-75, with the combination of A-SMGCS Levels 1 and 2 and airport surface surveillance with safety logic for ANSPs and flight crews, as well as moving map displays and enhanced vision systems for taxi operations.

1.2.2 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.

1.3 Change brought by the module

1.3.1 This module implements additional surface traffic management (A-SMGCS Level 3) capabilities which include 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.

1.3.2 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 ATFM strategies. Flight deck operations are enhanced by taxi route guidance and synthetic vision displays.

1.3.3 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 expanded use of virtual or remote towers as described in the B1-81 module.

1.3.4 These capabilities will include changes to ANSP, airspace user and airport operations, and flight deck operations.

1.4 **Element 1: Initial surface traffic management (A-SMGCS Level 3)**

1.4.1 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 digitally 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.

1.4.2 These activities are intended to directly improve efficiency by maximizing runway use while minimizing taxi times, within the context of any higher level ATFM 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.

1.4.3 Further, data sharing will improve the information available to ATFM, 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 digitally, to further reduce potential confusion about taxi routes. These capabilities also lessen the impact of reduced visibility conditions on the aerodrome operation.

1.5 **Element 2: Enhanced surface traffic management (A-SMGCS Level 4)**

1.5.1 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 de-conflicting 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 head-up display (HUD).
- 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 HUD.
- 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 ATFM activities. Flight will be permitted to pushback with the intent to meet targeted departure times.

1.6 Element 3: Synthetic vision systems

1.6.1 The addition of synthetic vision capabilities will further improve flight crew awareness of own ship position, and reduce navigation errors during periods of reduced visibility, and 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

<i>Access and Equity</i>	This activity contributes to airport access during periods of reduced visibility, by augmenting visual scanning in the tower and in the cockpit by a common surveillance picture, safety logic, and taxi routing, conformance, and guidance. The impact of visual obscuration and night operations on aerodrome operations is lessened.
<i>Efficiency</i>	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. a) reduced taxi out times:

	1) reduced fuel burn and other direct operating cost; 2) associated reduced impact to environment; b) reduced start/stop of during taxi: 1) reduced fuel burn and other direct operating cost; and 2) associated reduced impact to environment.
<i>Flexibility</i>	a) improved ability to re-sequence departing aircraft to meet changing conditions; b) coordination with air traffic flow management: 1) improved ability to predict congestion (actual demand vs. capacity); c) improved application of air traffic flow management by trajectory; d) improved Information to air traffic flow management: 1) improved ability to predict congestion (actual demand vs. capacity); 2) improved application of air traffic flow management actions; and e) improved flexibility on the aerodrome surface by improving the ability to re-sequence departing aircraft to meet changing conditions.
<i>Safety</i>	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 de-confliction of path intersections such as runway crossings. Aerodrome operations are less affected by low visibility conditions. a) reduced taxi non-conformance; and b) reduced taxi clearance communications errors.
<i>Cost Benefit Analysis</i>	The business case for this element is based on minimizing taxi times, thus reducing the amount of fuel burned during the taxi operation. Air traffic flow management delays are taken at the gate, stands, apron, and taxiway holding areas rather than in queues at the departure end of the runway. Runway utilization will be maintained so as to not impact throughput.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 Significant ANSP procedures 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.

3.2 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.

4. FLIGHT DECK PROCEDURES FOR USE AND INTEGRATION OF DATA LINK TAXI CLEARANCES ARE REQUIRED

4.1 Avionics

4.1.1 In addition to the aircraft equipment required by B1-75 (ATSA (SURF-IA,)) the following aircraft technology is required:

- a) data link communications;
- b) synthetic vision system; and
- c) taxi trajectory guidance capability.

4.2 Ground systems

4.2.1 The following ANSP technology is required:

- a) initial and enhanced A-SMGCS /Surface traffic management automation;
- b) data sharing with air traffic flow management; and
- c) data link communications.

4.2.2 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

5.1.1 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.

5.1.2 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.

5.1.3 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

5.2.1 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 the likelihood of occurrences of off nominal situations so the full capability of this module can be implemented.

6. REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)

- Regulatory/standardization: new or updated criteria and standards are needed that includes:
 - Initial and enhanced A-SMGCS/surface traffic management automation
 - 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)
 - data link communications
 - Flight deck taxi trajectory guidance
 - Flight deck synthetic vision systems (RTCA SC-213/EUROCAE WG-79).
- Approval plans: to be determined.

7. IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)

7.1 Current use

Initial surface traffic management (A-SMGCS Level 3)

7.1.1 ANSPs and commercial companies have developed initial capabilities in this area. These capabilities allow for data exchange of surface surveillance data between ANSPs, airspace users, and airport operators. Enhancements to operations are largely centered on improvements that shared surface situational awareness provides.

Enhanced surface traffic management (A-SMGCS Level 4)

7.1.2 The operations of this element are still under research, and have not yet been implemented in current use.

7.2 Planned or ongoing trials

Initial surface traffic management (A-SMGCS Level 3)

7.2.1 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 Package 6, EUROCONTROL, and others. Deployment in the United States of initial capabilities is slated for the 2018 timeframe.

Enhanced surface traffic management (A-SMGCS Level 4)

7.2.2 Collaborative departure scheduling is under research in the United States by the FAA, but has not yet undergone operational trials. Laboratory simulation experiments on more advanced capabilities such as taxi route guidance (NASA) have been performed. Other areas such as management of aerodrome surface operations by trajectory are still under concept formulation. Operational deployment in the United States of capabilities is slated for beyond 2018.

8. REFERENCE DOCUMENTS

8.1 Standards

- EUROCAE ED-100A/RTCA DO-258A, Interoperability Requirements for ATS Applications using ARINC 622 Data Communications
- EUROCAE ED-110/RTCA DO-280, Interoperability Requirements Standard for Aeronautical Telecommunication Network Baseline 1 (Interop ATN B1)
- EUROCAE ED-120/RTCA DO-290, Safety and Performance Requirements Standard For Initial Air Traffic Data Link Services In Continental Airspace (SPR IC)
- EUROCAE ED-122/RTCA DO-306, Safety and Performance Standard for Air Traffic Data Link Services in Oceanic and Remote Airspace (Oceanic SPR Standard)
- EUROCAE ED-154/RTCA DO-305, Future Air Navigation System 1/A – Aeronautical Telecommunication Network Interoperability Standard (FANS 1/A – ATN B1 Interop Standard)
- EUROCAE WG78/RTCA SC214 Safety and Performance requirements and Interoperability requirements

8.2 Procedures

8.2.1 To be determined.

8.3 Guidance material

- ICAO Doc 9694, *Manual of Air Traffic Services Data Link Applications*
- ICAO Doc 9830, *Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual*

8.4 Approval documents

- FAA Advisory Circular, AC120-28D Criteria for Approval of Category III Weather Minima for Take-off, Landing, and Rollout
- FAA Advisory Circular, AC120-57A Surface Movement Guidance and Control System
- New updates and material is needed for the following:
 - Initial and enhanced A-SMGCS/surface traffic management automation

- 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)
- Data link communications
- Flight deck taxi trajectory guidance
- Flight Deck Synthetic Vision Systems (RTCA SC-213/EUROCAE WG-79)

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APPENDIX O

MODULE NO. B3-15: INTEGRATION AMAN/DMAN/SMAN

Summary	This module includes a brief description of integrated arrival, en-route, surface, and departure management.	
Main performance impact as per Doc 9854	KPA-02 – Capacity, KPA-04 – Efficiency, KPA-09 – Predictability, KPA-06 – Flexibility.	
Operating environment/ Phases of flight	All phases of flight (JORDAN).	
Applicability considerations	Runways and terminal manoeuvring area in major hubs and metropolitan areas will be most in need of these improvements. Complexity in implementation of this block depends on several factors. Some locations might have to confront environmental and operational challenges that will increase the complexity of development and implementation of technology and procedures to realize this block. Infrastructure for RNAP/RNP routes need to be in place.	
Global concept component(s) as per Doc 9854	TS – Traffic synchronization	
Global plan initiative	GPI-6: Air traffic flow management	
Main dependencies	B2-15. Reinforces benefits derived from B3-10, B3-25, B3-85 and B3-05	
Global readiness checklist	Standards readiness	Status (ready now or estimated date)
	Avionics availability	Est. 2025+
	Ground systems availability	Est. 2025+
	Procedures available	Est. 2025+
	Operations approval	Est. 2025+

1. NARRATIVE

1.1 General

1.1.1 With 4D trajectory operations, Block 3 will see the achievement of capabilities which optimize both the individual trajectories, the traffic flows and the use of scarce resources such as runways and surface. This module is focused on the capabilities related to the airport aspects.

1.1.2 Synchronization of all flight phases represents the full integration of all control loops. The use of 4D trajectories will increase predictability and reduce uncertainty between the planned and executed trajectory. Traffic synchronization also implies that information is synchronized across flight phases.

1.2 Baseline

1.2.1 Module B2-15 brings about the synchronization of arrival and departure management. Arrival and departure sequencing are linked to further augment airspace capacity and efficient terminal and aerodrome airspace design. However, the quality of the process is limited by the accuracy and predictability of trajectories available in the ground systems and the uncertainties in the actions of upstream stakeholders on the trajectory.

1.3 Change brought by the module

1.3.1 With this module, a full traffic synchronization will be realized. The integration of surface, arrival, and departure management as well as en-route aspects lead to further optimize traffic flows and the efficient utilization of airspace and airport infrastructures. Conflict management, demand and capacity, and synchronization will be fully integrated.

1.3.2 This will exploit 4D control of flights in all phases of flight. In addition to the increased predictability, it will allow maximization of the airport throughput and flight efficiency. In particular, the integrated consideration of the downstream constraints will minimize the impact of tactical local interventions on the rest of the network or traffic flow.

1.3.3 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

2.1 Metrics to determine the success of the module are proposed in the *Manual on Global Performance of the Air Navigation System* (Doc 9883).

<i>Capacity</i>	Mitigate impacts of various restrictions and conflicts and allow a greater throughput.
<i>Efficiency</i>	Optimize and coordinate arrival, departure, and surface traffic flows in the terminal and aerodrome domain.
<i>Predictability</i>	Optimized time profile and greater ATM decision compliance. Gate-to-gate 4D trajectory will mitigate uncertainties in demand prediction across all domains and enable better planning through all airspace.
<i>Flexibility</i>	Enables dynamic scheduling and dynamic runway configuration to better accommodate arrival/departure patterns.
<i>Cost Benefit Analysis</i>	Traffic synchronization brings about optimized flow free of conflict and choke points. The use of time profile enables both strategic and tactical flow management and improves predictability. In addition, traffic synchronization can be used as a tool to reconcile demand and capacity by reduction of traffic density.

3. NECESSARY PROCEDURES (AIR AND GROUND)

3.1 Full integration AMAN, DMAN and SMAN through increased automation and use of data link is subject to research and validation. These efforts would provide the necessary operational procedures defining the role of each actor (crew, ATS units, airport) and their relations.

4. NECESSARY SYSTEM CAPABILITY

4.1 Avionics

4.1.1 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

4.2.1 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

5.1.1 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.

5.1.2 This module is still in the research and development phase so the human factors considerations are still in the process of being identified through modelling and beta testing. Future iterations of this document will become more specific about the processes and procedures necessary to take the human factors considerations into account. There will be a particular emphasis on identifying the human-machine interface issue, if any, and providing the high risk mitigation strategies to account for them.

5.2 Training and qualification requirements

5.2.1 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.

5.2.2 This module will eventually contain a number of personnel training requirements. As and when they are developed, they will be included in the documentation supporting this module and their importance signified. Likewise, any qualifications requirements that are recommended will become part of the regulatory needs prior to implementation of this performance improvement.

6. **REGULATORY/STANDARDIZATION NEEDS AND APPROVAL PLAN (AIR AND GROUND)**

- Regulatory/standardization: new or updated policies for full traffic synchronization and all stakeholders are needed, addressing information sharing, roles and responsibilities in 4D trajectory management, along with new operational procedures.
- Approval plans: to be determined.

7. **IMPLEMENTATION AND DEMONSTRATION ACTIVITIES (AS KNOWN AT TIME OF WRITING)**

7.1 **Current use**

7.1.1 None at this time.

7.2 **Planned or ongoing trials**

- **Europe:** None at this time.
- **United States:** None at this time.

8. **REFERENCE DOCUMENTS**

8.1 **Guidance material**

- European ATM Master Plan, Edition 1.0, March 2009, update in progress
- SESAR Definition Phase Deliverables
- TBFM Business Case Analysis Report
- NextGen Midterm Concept of Operations v.2.0
- RTCA Trajectory Operations Concept of Use