INTERNATIONAL CIVIL AVIATION ORGANIZATION
CAR/NAM MEXICO OFFICE

ADS-B OUT OPERATIONAL CONCEPT (CONOPS)

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1. – INTRODUCTION:

Installing and maintaining ground-based aviation infrastructure in remote areas can be challenging and costly. In some cases, such as oceanic areas, there is no viable way it can be done.
Currently, some Air Traffic Services (ATS) providers depend upon ground-based infrastructure to receive Automatic Dependent Surveillance - Broadcast (ADS-B) data from aircraft. This concept of operations also proposes the use of Orbiting Satellites to receive ADS-B data from aircraft so as to expand the geographic area where ATS surveillance services can be provided.
CAR Region is working on the commissioning of ground-based ADS-B in its Flight Information Region (FIR). The supporting safety analyses, testing and monitoring for these implementations provides the foundation for expansion of ATS surveillance services based on ADS-B.
This concept of operations has been developed in accordance with the guidance provided in ICAO's Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689).

1.1 – Document Overview:

The purpose of this document is to facilitate coordination between stakeholders who will be involved in, or affected by, the implementation of services using Automatic Dependent Surveillance – Broadcast (ADS-B).
This Concept of Operations identifies at a high level both the needs and means to incorporate the use of ADS-B into Air Traffic Management (ATM) across the ICAO CAR Region.
Individual CAR Region states will develop complementary implementation documents that reflect their unique operating environments.
As developments occur this Concept of Operations may be required to be updated.

1.2 – Operational use:

1.2.1- Surveillance
1.2.1.1- En-route.
1.2.1.2- Terminal.
1.2.1.3- Search and Rescue.
1.2.1.4- Oceanic Areas.
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1.3 – System Overview:

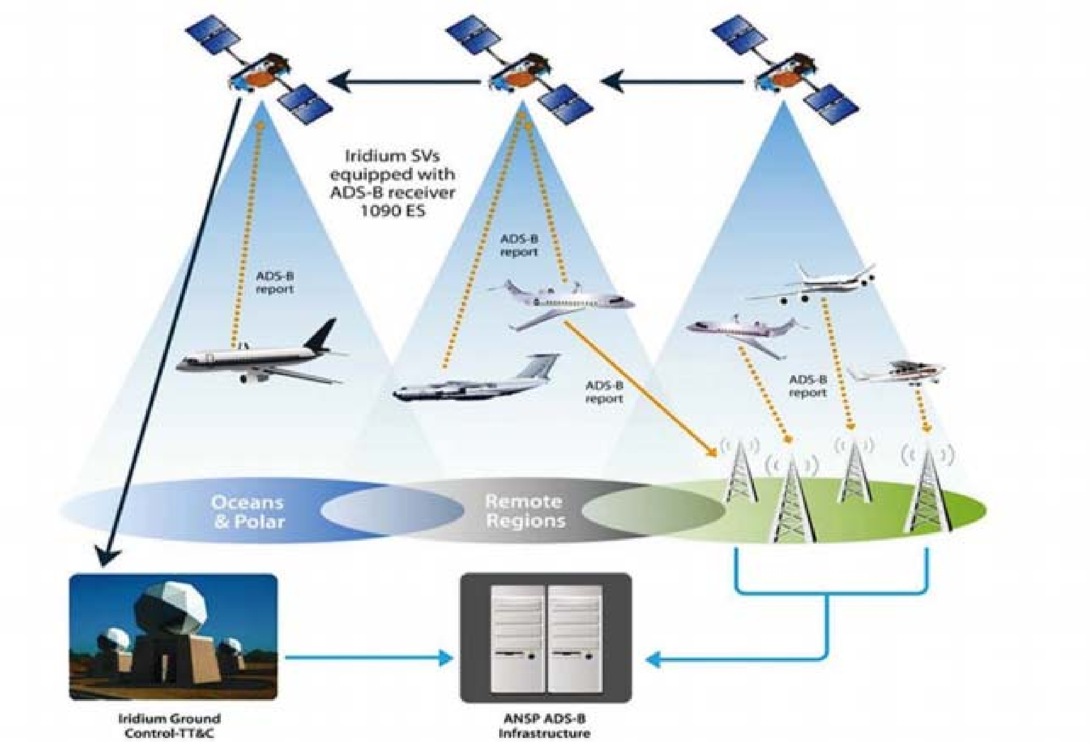

Image: AIRPLANE, Ground ADS-B ANTENNA, Iridium satellite (Space Base ADS-B), GPS Satellite and ATC Air Situation Display.

1.4 – References:

1.4.1- "Automatic Dependent Surveillance-Broadcast (ADS-B) Concept of Use," Appendix to the AN/-Conf/11-WP/6, ICAO, April 2003.
1.4.2- APANPIRG ADS-B Study, Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689) and PANS-ATM (Doc 4444) and Annexes 2, 4, 11 and 15.
1.4.3- Space Based ADS-B Surveillance in Oceanic Airspace Concept of Operations Draft 0.2 dated February 1, 2012.
1.4.4- CAO Document 9854 "Global Air Traffic Management Operational Concept:" First Edition 2005
1.4.5- Doc 9689 Manual on Airspace Planning Methodology for the determination of separation Minima
1.4.6- DOC 4444, "Procedures for Air Navigation Services, Air Traffic Management", ICAO, November 2007
1.4.7- Annex 2 to the Convention on International Civil Aviation, "Rules of the Air", ICAO, November 2005
1.4.8- Annex 4 to the Convention on International Civil Aviation, "Aeronautical Charts", ICAO, July 2009.
1.4.9- Annex 11 to the Convention on International Civil Aviation, "Air traffic Services", ICAO, July 2001.
1.4.10- Annex 15 to the Convention on International Civil Aviation, "Aeronautical Information Services", ICAO, July 2013.
1.4.11- ICAO Cir 326, "Assessment of ADS-B and Multilateration Surveillance to Support Air traffic Services and Guidelines for implementation", ICAO, 2012
1.4.12- "Automatic Dependent Surveillance-Broadcast (ADS-B) Concept of Use," Appendix to the AN/-Conf/11-WP/6, ICAO, April 2003.

2. – OPERATIONAL NEED:

Optimization of Airspace
Improve Surveillance capability, reliability and accuracy
Reduce Cost of service provision

2.1. Current Environment

Surveillance- Different variation on equipment within the region
Procedural Separation Standards and Radar standards are used within the region

2.2. Capability Shortfalls

3. –SYSTEM JUSTIFICATION:

3.1. Description of Desired Change:
To use ADS-B surveillance information (airborne and airport surface) for air traffic control operations and traffic flow management and other services including situational awareness, separation assurance, and improved automation system safety functions.
Other authorized facilities (ramp control, airline operations center, etc.)
May use ADS-B surveillance information to track flight activities and optimize operations.
The inherent accuracy and high update rate will provide service providers and users improvements in safety, capacity, and efficiency.

3.2. Potential Benefit of new or Modified System.
The following Surveillance and capabilities will contribute to improved safety, capacity and efficiency:

Safety

- Provides aircraft-to-aircraft traffic surveillance capability.
- Provides ATC and in-the-cockpit, airport surface traffic surveillance capability.
- Provides surveillance capabilities in areas currently not served by ground-based surveillance systems.
- Provides near real-time, in-the-cockpit aeronautical information (weather, NOTAMs, Temporary Flight Restrictions, Special Use Airspace, etc.).
- Improves or supplements existing ground-based surveillance information.
- Improves air traffic control automation performance and safety features e.g., target accuracy improvement for MSAW and CA alerting capabilities.
- Provides cost effective, Controlled Flight Info Terrain (CFIT) awareness.

Capacity

- Provides radar-like separation procedures in remote or non-radar areas.
- Supports a potential common separation standard in select domains and airspace classifications.
- Supports a potential reduction in existing separation standards in all domains and airspace classifications.
- Supports increased airspace capacity through select user-executed airborne spacing, sequencing, and separation operations.

Efficiency

- Provides near real-time, in-the-cockpit aeronautical information during flight operations.
- Provides reduced cost infrastructure.

- Provides information not currently available resulting in enhanced sector & airport derived predictions.
- Provides improved information for traffic flow management, collaborative decision making, fleet management, and management by trajectory functions.
- Provides a rapidly deployable, mobile surveillance sensor for contingency operations.
- Provides precision surveillance and flight parameter information for unique operating areas.

4. OPERATIONAL DESCRIPTION:

ADS-B is a surveillance tool in which, like radar, aircraft transmit identity and altitude information that is received by the Air Traffic Services Unit. In addition to this basic data set, the position (and quality of this position) as determined by the aircraft sensors is also broadcast. Additionally ADS-B systems may be able to broadcast track vector, air speeds and alerts of abnormal conditions on the aircraft. These broadcasts are transmitted at intervals and any receiver may receive and process the data.
Some of the information transmitted by the aircraft can also be derived from radar data (speed, position and vertical rate) however, since ADS-B relies on high quality reports, it may be considered more accurate than radar.

ADS-B uses existing ACARS equipment operating on a protected frequency of 1090 MHz.

4.1 Surveillance

ATC will use ADS-B surveillance information in the same manner as current dependent/cooperative surveillance system information is used, e.g., to assist aircraft with navigation, to separate aircraft, and to issue safety alerts and traffic advisories. The ADS-B surveillance information will be used to enhance the quality of existing radar-based surveillance information for ATC automation system functions, i.e ., tracking, MSAW, Conflict Alert, and Mode-C Intruder Alert. The targeted implementation areas include surface, terminal, en route, offshore, and oceanic domains. ADS-B surveillance will allow ATC to provide separation services between ADS-B-to-ADS-B and ADS-B-to radar and fused targets. ADS-B can support a potential reduction in separation minima in certain En Route and some current non-radar environments.

4.2 ADS-B Applications

4.2.1 Surface movements

- The primary ADS-B surface application is Airport Traffic Situation Awareness.
- ASDE-X (?)

4.2.2 Terminal airspace

The airspace immediately surrounding an aerodrome is considered the Terminal Control Airspace (TMA). This is where aircraft on approach (instrument and visual), aircraft departing and those operating in the vicinity of aerodromes are at close proximity to terrain. Since this is the area of initial climb out and final descent to land aircraft would be crossing the levels of other aircraft.

In the TMAs where the terrain restricts SSR and PSR, ADS-B could be used to provide surveillance. The topography of mountainous areas limit surveillance as it requires line of sight with the respective antennae. The deployment of several ADS-B antennae would be a cost effective way to provide surveillance where it would not be possible via single radar antenna. The cost difference of ADS-B installation makes it feasible to install several antennae to provide overlapping coverage.

Only high quality position reports are used by ADS-B processors. In the terminal airspace the minimum established radar separation in PANS-ATM (Doc 4444) 6.7.3.2.4; 6.7.3.2.5; 6.7.3.4.2 and 6.7.3.5.1 may be applied without any further safety assessment requirement.

ADS-B increases situational awareness in the cockpit as well as at the Controller Work Position (CWP). Aircraft equipped with ADS-B IN will receive information about other aircraft in the vicinity based on the positions transmitted. Minor adjustments in speed and heading could be made to increase spacing In the TMA where there is a convergence and concentration of aircraft increased situational awareness would mean an increase in safety. For controllers, having an accurate picture of traffic in the TMA would result in heightened situational awareness and improvement in safety.
ADS-B surveillance can result in reduction of separation and increase of terminal airspace capacity. As a result of increased capacity there can be increase in flight schedule flexibility, increase in flight path efficiency and reduction in delays or flight disruptions.
ADS-B integration supports safety nets such as Minimum Safe Altitude Warnings (MSAW) for aircraft flying close to terrain and reduce the occurrence of CFIT. In Radar airspace, ADS-B would provide redundant surveillance enhance safety.

4.2.3 En-route airspace

The rapid rate of interrogation of aircraft through ADS-B would increase the situational awareness of the controller since an accurate depiction of intended track is be provided and changes to the track more readily observed. This would improve the prediction trajectories and increase the effectiveness of ATM system conflict detection.
The coverage range of an ADS-B receiver is fifty (250) nautical miles. The distribution of land masses and pelagic structures, such oil rigs, in the region could create a coverage area without gaps if sufficient antennae are used. The data obtained from each FIR could be shared across boarders as long as there equipment compatible.
In a procedural environment, certain position report has to be omitted or an emergency (or urgency) report received from the pilot for the controller to know that an aircraft has an abnormal situation, in a surveillance area emergency reports are received instantaneously. The last position and flight path of such aircraft could be accurately determined increasing the likelihood of a favorable outcome.
There is a distribution radar antenna in the region but gaps exist the coverage. The strategic positioning of ADS-B could close these gaps and provide overlapping coverage. ADS-B could also provide redundant coverage for areas already served by SSR.
Accurate position reporting make up a significant amount of a pilot's work load. The priority in flight is to aviate, navigate and communicate. If less time is required to make position reports then there would be more time to spend on aviating and navigating. The cockpit workload would be reduced with the implementation of ADS-B.

4.2.3.1 Upper airspace

The characteristics of aircraft in the Upper Airspace would be level flying or change of cruising level by only a few thousand feet (Flight Levels). Lateral changes in flight path would be predicated upon weather deviations or the change airway (route) direction based navigational infrastructure.

In procedural (non-surveillance) high level airspace ADS-B would be a means of surveillance and reduce the required separation to that defined by PANS-ATM (Doc 4444) 8.7.3 provided:

- Identification of ADS-B equipped aircraft is established and maintained
- The data integrity measure of ABS-B message is adequate to support the separation minim
- There is no requirement for detection of aircraft not transmitting ADS-B
- There is no requirement for determination of aircraft position independent of the position-determining elements of the aircraft navigation system.

The surveillance provided by ADS-B could improve efficiency by facilitating more direct flight paths in the en-route phase of flight. More direct flight paths have a positive impact on fuel and greenhouse gas emission.

4.2.3.2 Lower en-route airspace

The lower airspace (below Flight Level 250) is characterized by a mix of aircraft types with varying performance characteristics. There are significant changes in altitude (several thousand feet) for some aircraft while others would be operation at their cruise levels. There is also a high concentration of aircraft converging and diverging of traffic to and from of airports.

The speed, rate of climb and descent and general maneuverability vary widely for aircraft in the lower airspace. The different classes of aircraft all have different performances and ADS-B would increase situational awareness for the controller. This leads to safer operations especially in areas of high traffic density. For aircraft with ADS-B IN this improvement of situational awareness is extended to the cockpit as well.

In areas of low traffic density, ADS-B is a cost effective way monitor a variety of aircraft. Surveillance increases safety and if the volume of traffic is not sufficiently high to justify the cost of installation of Radar, ADS-B could be employed.

Aircraft equipment and capability would vary because of the mix of aircraft class. Commercial aircraft, general aviation and military operations all share the lower airspace. Aircraft that carry TCAS equipment can be detected ADS-B in the lower airspace and with sufficient lead-time even the smallest operators and general aviation would be able to comply.

4.2.4 Oceanic and Remote airspace

The objective of this application is to enable more frequent approval of flight level requests between properly equipped aircraft using a reduced separation standard in Oceanic Airspace, improving flight efficiency and safety. Flight crews request flight level changes for various reasons to improve flight efficiency and safety including; optimum fuel burn, accessing favoring wind conditions, avoidance of turbulence. ITP enables flight level change maneuvers that are otherwise not possible using non-ADS-B based oceanic procedural separation standards. ITP allows ATC to approve these flight level change requests between properly equipped aircraft using reduced separation minima during the maneuver.

4.3 Proposed environment

- In the short term ADS-B would support ATC surveillance and cockpit based situational awareness
- Radar would continue to be a surveillance source until the various antennae reach the end of their life cycle when their coverage would be replaced by ADS-B

5. – SYSTEM DESCRIPTION:

5.1. Surveillance and Broadcast Services System

The Surveillance and Broadcast Services system's functions (Aircraft/Vehicle, Data Link Processor, Broadcast Server, and ATC/TFM Automation) provide the ADS-B services that support ADS-B applications. The ADS-B surveillance service is supported by Aircraft/Vehicle, Data Link Processor, and ATC Automation functions. TIS-B and FIS-B services are supported by the Aircraft/Vehicle, Data Link Processor, and Broadcast Server functions. The ADS-B Rebroadcast (ADS-R) is implemented by the Aircraft/Vehicle and Data Link Processor functions.

5.2 Functional Description

The purpose of each function of the Surveillance and Broadcast Services System, how they interoperate with each other, and how the Surveillance and Broadcast Services System fits into the Region are described below.

5.2.1 Aircraft/Vehicle.

The Aircraft/Vehicle is the source of ADS-B information. The Aircraft/Vehicle gathers information including position data from GPS or other navigation source, crew input, barometric altitude, vertical speed and aircraft identification data. The Aircraft/Vehicle processes the information gathered and determines the associated integrity and accuracy indicators. The Aircraft/Vehicle encodes and broadcasts all the information in an ADS-B Message. The ADS-B system will monitor information broadcast by the aircraft avionics package. The quality of the data will be evaluated to ensure aircraft compliance with the mandated performance measurements and standards. Detailed reporting of compliant and non-compliant aircraft broadcast with the associated avionics package will be provided to Aviation Safety (AVS) for analysis. The Aircraft/Vehicle receives and decodes ADS-B Messages transmitted by other Aircraft/ Vehicles equipped with the same data link and TIS-B and ADS-R Messages transmitted by the Data Link Processor. Aircraft/Vehicles equipped with the 978 UAT data link additionally receive and decode FIS-B Messages transmitted by the Data Link Processor. The Aircraft/Vehicle may display ADS-B and TIS-B data on a CDTI/MFD. Properly equipped 978 UAT-equipped Aircraft/ Vehicles can display FIS-B data.

5.2.2 Data Link Processor.

The Data Link Processor receives ADS-B Messages broadcast by Aircraft/Vehicles over both the 978 UAT and 1090ES data links. The Data Link Processor processes the received ADS-B Messages, formats them into ADSB Reports and WAM Reports, and sends the reports to the Broadcast Server and ATC Automation. Service coverage. The Data Link Processor generates status reports, containing information on alarms and events in the Data link Processor subsystems and send them to ATC Automation. The Data Link Processor will also generate internal test target messages and send the resulting ADS-B Reports to ATC Automation.

5.2.3 Broadcast Server.

The Broadcast Server receives ADS-B Reports and status reports from the Data Link Processor. The Broadcast Server provides Surveillance and Broadcast Services information to authorized external users. The Broadcast Server includes a TIS-B Server function. The Broadcast Server receives surveillance data from radar and WAM systems and potentially other surveillance sources. The Broadcast Server processes the surveillance data, including tracking, filtering, and applying quality indicators to the data. The Broadcast Server generates TIS-B Reports and forwards them to the Data Link Processor. The Broadcast Server includes a FIS-B function. The Broadcast Server receives textual and graphical weather information and other data that will be used in generating FIS-B Reports. The Broadcast Server sends FIS-B Reports to the Data Link Processor. The Broadcast Server includes a control and monitoring function. The Broadcast Server provides an interface for control and monitor to the Maintenance Technician. The Broadcast Server provides control information to the Data Link Processor and receives monitor information from the Data Link Processor.

5.2.4 ATC Automation.

ATC Automation receives ADS-B Reports and status reports from the Data link Processor. ATC Automation receives ADS-B Reports in both an ADS-B only environment as well as a mixed surveillance (e.g., radar, WAM and ADSB) environments. ATC Automation performs Minimum Safe Altitude Warning (MSAW) and Conflict Alert (CA) processing using the ADS-B data and radar data if in a mixed surveillance environment. ATC Automation may be able to improve tracking and safety feature functions using the high accuracy and greater update rate of ADS-B Reports. ADS-B Reports will also feed targeted surface surveillance systems and support their alerting functions. ATC Automation tracks the targets given the information provided in the ADS-B Reports. ATC Automation displays target positions based on ADS-B Reports. In addition, systems such as User Request Evaluation Tool (URET) will probe for conflicts between aircraft trajectories based on flight plan data and aircraft position information. In the future, new decision support tools will be implemented in the En Route, Terminal, and Surface Automation systems. These decision support tools may exchange information with the Broadcast Server to provide enhanced situational awareness to aircraft.

5.2.5 ATFM Automation.

ATFM automation receives ADS-B reports as part of the surveillance data passed from the en route and terminal ATC systems. As the coverage areas increase, ATFM decision support tools will incorporate the data to produce more accurate demand projections, operational response strategies, (such as traffic management initiatives (TMIs)) for periods of excess demand relative to capacity and weather. Additionally, the resultant aggregate demand data provided to the ATM community will reflect the increased accuracy and support better informed collaborative decision-making through traffic management.

5.2.6 Modes of Operation.

The Surveillance and Broadcast Services system is a system of systems, making the definition of modes of operation more complicated than those of a single system providing a single function. Applications are enabled by services provided by specific Surveillance and Broadcast Services system functions. Under normal operating conditions, all functions are available and operational, thus all services and applications are supported, depending upon the implementation segment. Degradation or loss of a system function leads to degradation or loss of the services supported by that function, and ultimately of the applications enabled by the service.

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Function	Service				
	Surveillance			Broadcast	
	ADSB	WAM	ADS-R	TIS-B	FIS-B
Aircraft /Vehicle (Para 5.2.1)					
Transmit	x	x			
Receive	X note		x	x	x
Data Link Processor (Para 5.2.2)					
Transmit			x	x	x
Receive	x	x	x		
Broadcast Server (Para 5.2.3)			x	x	x
ATC/TFM Automation (Para 5.2.4/5.2.5)	x	x			

5.3.1 Normal Operations (All Services Available).

When all Broadcast Services System functions are available and operational, all services can be provided, depending upon the implementation segment. In the case of the Broadcast Server, this also assumes that the interfacing systems providing the surveillance reports for TIS-B and weather and aeronautical data for FIS-B are operational and providing that data. Otherwise, the TIS-B and FIS-B services would not be available.

5.3.2 Aircraft/Vehicle Degradation or Loss.

The Aircraft/Vehicle is required for all services and applications. The Aircraft/Vehicle could degrade such that transmit only, receive only, or both are lost. Additionally, this function can degrade or be lost on a per aircraft basis and also NAS wide or regionally. Each of these outages has a different impact.

5.3.2.1 Loss of Reception Capability (ADS-B air-to-ground available, ADS-B air-to air, ADS-R, TIS-B, and FIS-B lost).

Degradation or failure of the Aircraft/Vehicle reception functionality would result in loss of ADS-B, ADS-R, TIS-B, and FIS-B information in the cockpit. The cockpit-based applications could no longer be supported in the failed aircraft, but could continue for other equipped aircraft in the vicinity.

5.3.2.2 Loss of Transmit Capability (TIS-B and FIS-B available, ADS-B ground-to-air and ADS-R lost).

Degradation or failure of the Aircraft/Vehicle transmit function would result in the loss of ADS-B information to the Data Link Processor and to other aircraft. If the aircraft is in coverage of another surveillance source, the TIS-B service would begin including that aircraft's information in TIS-B message transmissions. This would permit the continuation of cockpit-based situational awareness and spacing applications, but cockpit-based separation applications would not be supported for the failed aircraft. Additionally, other equipped aircraft in the vicinity could not perform cockpit-based separation applications involving the failed aircraft.

5.3.2.3 Loss of ADS-B Surveillance Source.

Due to the criticality of aircraft surveillance data, a backup plan must be in place. In areas covered by other surveillance sources, including radar and WAM systems, data from the other system would be used as backup surveillance in ATC/TFM Automation System when this occurs. In non-radar areas, controllers would have to revert to procedural separation. In addition to the ground-based surveillance backup systems, navigational backup systems are also being considered. The loss of the ADS-B surveillance source, GPS, would result in NAS-wide or regional loss of ADS-B and ADS-R services. This would result in the loss of the Aircraft/Vehicle's ability to transmit ADS-B state vector information. The Aircraft/Vehicle receive functionality would not be impacted. ATC controllers would lose all ADS-B surveillance data on all aircraft. Pilots would lose their own position reference, as well as, surveillance information on other ADS-B equipped aircraft in the vicinity. The Aircraft/Vehicle would be able to receive TIS-B and FIS-B transmissions, providing some situational awareness applications. FAA Surveillance and Broadcast Services Concept of Operations (CONOPS) SBS-006, Rev.06 – June 26, 2012 Page 39 of 66 5.3.3 Data Link Processor Degradation or Loss.

5.3.3.1 Loss of ADS-B Reception Capability (TIS-B & FIS-B available, ADS-B air-to ground & ADS-R lost).

Degradation or loss of the Data Link Processor reception would result in the loss of ADS-B, supporting core surveillance applications. ADS-R would additionally be lost. As the TIS-B service continues to be available, information on all aircraft in coverage of another surveillance system would be broadcast, continuing support for cockpit-based situational awareness and spacing applications in that airspace. And, TIS-B would unnecessarily generate radar-based target reports on ADS-B aircraft resulting in aircraft receiving two reports (TIS-B generated and ADS-B aircraft generated) on a single aircraft.

5.3.3.2 Loss of ADS-B Transmit Capability (ADS-B available, ADS-R, TIS-B, & FISB lost).

Degradation or failure of the Data Link Processor transmit would result in loss of ADS-R, TIS-B, and FIS-B, thus loss of all cockpit-based applications other than pair-wise applications for the airspace covered by that Data Link Processor.

5.3.4 Broadcast Server Degradation or Loss (ADS-B & ADS-R available, TIS-B & FIS-B lost).

Degradation or loss of the Broadcast Server, or supporting data sources, would impact only the TIS-B and FIS-B services, supporting the cockpit-based situational awareness and spacing applications. It's expected that the Broadcast Server will have system-specific back-up strategies.

5.3.5 ATC Automation.

Each ATC Automation system has system-specific backup strategies that will apply regardless of the source of surveillance data.

6. ASSUMPTIONS, CONSTRAINTS, AND DEPENDENCIES:

6.1 Organizational Impacts.

6.1.1 Staffing. The introduction of the ADS-B applications may require adjustments to current ATC facility staffing schemes to optimize facility operations. Technical Operations personnel adjustments may need to be made to support and maintain local and remotely deployed ADS-B equipment, in addition to the maintenance responsibilities for existing infrastructure equipment. An adequate number of field support facilities and personnel will be required to install, maintain, and certify ADS-B avionics equipment.

6.1.2 Acquisition Management System (AMS) Surveillance and Broadcast Services ground infrastructure will require certification and acceptance by Technical Operations. Organizations with acquisition and implementation responsibilities must complete necessary System management training requirements.

6.1.3 Safety Management System/Safety Risk Management (SMS/SRM).
The Surveillance and Broadcast Services system must conform to Safety Management System and Safety Risk Management (SRM) processes. Organizations with development and deployment responsibilities must comply with SMS/SRM requirements.

6.1.4 Regulation and Policy.
Rules may be required and procedures will be necessary to support ADS-B-enabled spacing and separation operations. States may need to develop policy and performance standards for aircraft and operators to support the ADS-B technology. Any changes to flight rules may require public comment and resolution.
Other actions, such as airspace design, may be necessary to realize full operational benefits. It is expected that initial ADS-B applications will be informational, providing pilots with an improved situational awareness to enhance safety, and probably will not require rule or procedural changes. The strategy initially depends on users voluntarily equipping for ADS-B. However, it is expected that over time more users will equip to gain the operational benefits. In line with the industry agreed policy of "Best-equipped, Best-served", States may consider airspace rules or may designate areas to provide preferred service for users who are capable and equipped for ADS-B operations

6.1.5 Publication/Notices. Changes to current publications will be required to reflect operational and compliance changes. Development of new operational, procedural, and training documentation is required. Notices announcing changes to operational, procedural, and compliance requirements will need to be developed and distributed. Examples of documentation that may or may not be affected include, but are not limited to:
Advisory Circulars (AC)
Maintenance and Technical Standard Orders (TSO)
Facility Operations and Administration
Aeronautical Information Manual (AIM)
Terminal Instrument Approach Procedures
Instrument Approach Procedure Charts (IAP)

Standard Terminal Arrival Routes (STAR)
Departure Procedures (DP)
High/Low/Sectional Navigation Charts
Letters of Agreement (LOA)

6.2 Operational Impacts.

6.2.1 ATC Automation. For ATC surveillance application, Data Link Processors will provide ADS-B reports and status reports to all current and future ATC Automation Systems. ADS-B reports received by automation will include not only aircraft position and Mode 3A/C codes, but also additional surveillance related parameters such as, but not limited to, velocity, aircraft flight identification and accuracy/ integrity measure of ADS-B position report. ADS-B ground stations will provide surveillance reports to automation at a higher update rate than radar. ADS-B reports will also be used by automation to improve aircraft tracking accuracy and safety functions such as Conflict Alert and Minimum Safe Altitude Warning. Because of the additional surveillance provided by ADS-B, SBS has implemented the use of fusion on most ATC automation platforms. This fuses any available surveillance source (e.g., ADS-B, Radar, WAM) and displays a single tracked target to ATC. This allows automation to provide ATC with a faster synchronous display update and, when ADS-B surveillance is part of the fused target, a more accurate target position will be displayed to the controller.

6.2.2 TFM Automation.
For TFM automation, ADS-B reports will be incorporated as elements of the already established provision of surveillance from en route and terminal systems. There are no anticipated significant operational impacts. The resolution of any asynchronous reporting/timing issues is expected to be resolved within the ATC automation systems prior to exchange with TFM (other than TMA and other metering systems). TMA and other higher resolution metering system may be impacted by the asynchronous reporting and changes to those systems may be necessary. The use of the improved surveillance by TFM systems, processes and personnel will be as described above.

6.2.3 Radar-based Surveillance Systems.
A communication interface method with existing primary and secondary radars and existing surface and wide area multilateration systems will be required to provide sensor measurements and/or track data for the TIS-B uplink.

6.2.4 Service Provider and User Procedures.
The introduction of ADS-B will necessitate Air Traffic Control procedural changes in order to optimize potential operational efficiency gains. New procedures should be designed to minimally impact current procedures. The goal is to minimize increase to cognitive workloads due to the implementation of ADS-B surveillance applications. New cockpit and ground automation capabilities provided by ADS-B give users the ability to achieve spacing and separation without fundamentally changing the overall responsibilities between pilots and controllers. Users may request or accept an ADS-B-enabled operation while service providers retain the authority for approving or applying a procedure depending on factors such as duty priorities and the operational situation at the time. However, procedures to clearly define the roles, responsibilities, and methods between users and service providers for initiating, executing, or terminating an ADS-B application will be required. Human factors analysis will be required to examine aircrew and controller workloads. Analysis will be required to develop rules and procedures defining all factors associated with the application or operations. Examples include, but are not limited to:

- ADS-B specific phraseology for application/operations.
- Rules and procedures between pilot and controller for the positive transfer of separation responsibilities.
- Designated areas, conditions, and types of ADS-B operations authorized.
- Service provider procedures for mixed operations (ADS-B participants versus non-participants) environments.

- Rules governing airborne spacing and separation operations.
- Backup, contingency, and transition procedures when ADS-B surveillance is lost.

6.2.5 ADS-B Separation Standards

Analysis will be required to determine separation standards between mixed equipage targets received from different surveillance systems including the transition boundaries between these surveillance areas. Additional analysis is required to support reduced separation using ADS-B in En Route airspace. The goal is a common, standardized separation minimum for service providers. Future analysis will be undertaken to determine

6.3 Service Provider and User Impacts.

The equipage decision will vary for different users and consideration must be given on the effect ADS-B implementation and operations will have on those that do or do not equip. Each state will define and enforce avionics and navigation equipment standards through Technical Standard Orders (TSO), Advisory Circulars, Airworthiness Inspections, etc. but must be within the minimum standards specified by ICAO.

Each state will issue TSO's that prescribe minimum performance standards for navigation equipment used by the civil aviation community. The ICAO issues standards and recommended practices for international civil aviation. The development of minimum performance standards for military users is the responsibility of the separate department Services. These military standards must conform to civil airspace required navigation performance requirements, prevent violation of civil air traffic clearances, and ensure safe separation of military and civil air traffic.

6.3.1 User and Service Provider Training. Users and service providers will require training to understand the new technology's capabilities, characteristics, and limitations. Users and service providers must have an understanding about one another's use of the ADS-B technologies and the Surveillance and Broadcast Services system. Both service providers and users will require training on the operation of ADS-B equipment and knowledge of ADS-B-specific terms, **phraseologies, and display symbology**. Users and service providers will require training and certification/qualification on the use of ADS-B applications and operations. This will include, but not be limited to:

- Rules governing areas and conditions allowing an ADS-B application.
- Rules governing certified equipment levels and personnel qualifications.
- Rules and procedures for spacing and separation applications.

APPENDIX A – Definitions and Glossary

ACAS	(ICAO) Airborne Collision Avoidance System
ACC	Area Control Centre
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ANS	Air Navigation Services
ANSP	Air Navigation Services Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
CPDLC	Controller Pilot Data Link Communications
CRM	Collision Risk Model
CSP	Communication Service Provider
CTA	Control Area
DCPC	Direct Controller Pilot Communication
Doc 4444	(ICAO) Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM)
FIR FL (number)	Flight Information Region Flight Level
GNSS	Global Navigation Satellite System
HF	High Frequency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IGA	International General Aviation
MNPS	Minimum Navigation Performance Specifications
MTCD	Medium Term Conflict Detection
NAT	(ICAO) North Atlantic (Region)
NM	Nautical Miles
OCA	Oceanic Control Area
PBN	Performance Based Navigation
RCP	Required Communication Performance
RNPC	Required Navigation Performance Capability
RVSM	Reduced Vertical Separation Minima
SAR	Search and Rescue
SATCOM	Satellite Communications
SATVOICE	Satellite Voice Communications
SMS	Safety Management System
TCAS	Traffic Collision Avoidance System
VHF	Very High Frequency

APPENDIX B: Hazard and Risk Evaluation of ADS-B Application:

Table Att-1. Severity table (basic)

Level	*Descriptor*	*Severity description (customize according to the nature of the product or the service provider's operations)*
1	Insignificant	No significance to aircraft-related operational safety
2	Minor	Degrades or affects normal aircraft operational procedures or performance
3	Moderate	Partial loss of significant/major aircraft systems or results in abnormal application of flight operations procedures
4	Major	Complete failure of significant/major aircraft systems or results in emergency application of flight operations procedures
5	Catastrophic	Loss of aircraft or lives

Table Att-3. Likelihood table

Level	*Descriptor*	*Likelihood description*
A	Certain/frequent	Is expected to occur in most circumstances
B	Likely/occasional	Will probably occur at some time
C	Possible/remote	Might occur at some time
D	Unlikely/improbable	Could occur at some time
E	Exceptional	May occur only in exceptional circumstances

Table Att-4. Risk index matrix (severity × likelihood)

	Severity				
Likelihood	*1. Insignificant*	*2. Minor*	*3. Moderate*	*4. Major*	*5. Catastrophic*
A. Certain/frequent	Moderate (1A)	Moderate (2A)	High (3A)	Extreme (4A)	Extreme (5A)
B. Likely/occasional	Low (1B)	Moderate (2B)	Moderate (3B)	High (4B)	Extreme (5B)
C. Possible/remote	Low (1C)	Low (2C)	Moderate (3C)	Moderate (4C)	High (5C)
D. Unlikely/improbable	Negligible (1D)	Low (2D)	Low (3D)	Moderate (4D)	Moderate (5D)
E. Exceptional	Negligible (1E)	Negligible (2E)	Low (3E)	Low (4E)	Moderate (5E)

(Adapted from Doc 9859)

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
ADS-B Operational Trial	Failure of Ground Station	Loss of ADS-B positional data to he controller. Increase in workload due to transitioning to procedural control and reassess traffic.	Unlikely	Insignificant	3D	Revert to procedural control and apply appropriate separation standard for affected aircraft. A site monitoring system shall provide a degree of on-line integrity monitoring. Warnings would be provided to ATC if site monitoring is not received.	Unlikely	Insignificant	3D

Operational Activity	**Identified Hazards and Risks**	**Description of Risk**	**Initial Risk Assessment**			**Further Mitigation factors**	**Revised Risk Assessment**		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Incorrect Data broadcast by an aircraft due to data corruption	Incorrect data due to data corruption broadcast by the aircraft ADS-B transponder. The GPS on the aircraft still operating correctly.	Significant error in the displayed position of the aircraft that could lead to a breakdown in separation without the controller being aware.	Remote	Moderate	3D	Controller observation of history trail and look for track jump	Remote	Minor	2D

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Corruption of Data by the ground station	Incorrect data displayed to the controller due to data corruption at the ADS-B ground station	Error in the reported position of the aircraft therefore could lead to a breakdown in separation without the controller being aware. This may affect all data.	Improbable		3D	Controller observation of history trail and look for track jump. Ensure only tested and proven ADS-B ground station are used in the operational trials. Ensure Route adherence monitoring is implemented for ADS-B tracks.			

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Loss of position accuracy of reported position	The accuracy performance of the navigational equipment in the aircraft has deteoriated to the level that it is not acceptable to support the specified separation standard	Loss of ADS-B positional data to the controller. Increase in workload due to transitioning back to procedural control and reassess traffic	Remote	Moderate	3D	Ensure the ATM system will detect degradation in accuracy performance below a specified threshold and provide appropriate visual notification to the Unit concerned (NuC value). Revert to procedural control for the affected aircraft. Site monitoring is used to validate that it is only one aircraft affected.	Remote	Minor	2D

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Incorrect processing of ADS-B Data by the ATM system	Data reaching the ATM system processed in such a way as to give a false indication of position, altitude or trajectory	Possible error in the displayed position of the aircraft therefore could lead to a breakdown in separation	Remote	Moderate	3C	Conduct comprehensive testing of the ADS-B processing and displaying functionality of the ATM. Test should include the conduct flight tests and compare results to commissioned radar information.	Improbable	Moderate	3D
Failure of GPS satellites	Loss of ADS-B tracks at the ATS unit	Loss of ADS-B data and Nuc drops causes an increase in workload and procedural control in re-established.	Unlikely	Moderate		site monitoring installed to provide a degree of on-line monitoring and warning to ATC if site monitoring			

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Inadequate ATS Training	Introduction of ADS-B function to an ATS unit without adequate training introduces a new hazard.	Insufficient training in MHI, new procedures and transition from ADS-B control to procedural control and may increase the probability of breakdown in separation.	Possible	Moderate	3C	prove comprehensive training that covers all operational aspects including contingencies	Unlikely	Moderate	3D

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Inadequate Operational Procedures	Introduction of new ADS-B function is new to ATS and adequate operational procedures will introduce a hazard to the system	inadequate operational procedures for managing and controlling ADS-B areas increases the probability of a breakdown	Remote	Minor	3C	Maximize the reuse of proven operational procedures to handle ADS-B control areas. Ensure sufficient procedures are developed and tested for the transition between ADS-B and Procedural control	Unlikely	Minor	2D
RF Jamming	Radio Frequency Jamming of ADS-B due to deliberate or non-deliberate actions	Loss of ADS-B positional data to the ATS unit result in in an increase in workload due to transitioning to procedural control.	Improbable		3D	Increase in the level of security and security response at ground installations			

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Incorrect altitude data transmitted by aircraft	Aircraft transmitting wrong altitude because or faulty barometer or wrong geometric levels on display	Could lead to a loss of separation between aircraft or CFIT	Unlikely	Major	4D	obtain verbal verification of altitude when ADS-B target is observed	Improbable	Major	4D
Incorrect 24 bit code	Incorrect 24 bit code filed on the flight plan leading to mismatch or no match ADS-B target to filed FPL	Wrong call sign affixed to aircraft track leading to increase work load for controller to rationalize the proper call sign	Remote	Minor	2C	work by plight plan monitoring group to identify how often this occurs and put measures to reduce the incidents with operator	Improbable	Minor	2D

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Failure of communication link between the ground station and ATS unit	Loss of ADS-B position at the ATS unit due to the loss of data from ground station	Increase in controller workload transitioning to procedural control and possible loss of separation between aircraft	Unlikely	Moderate	3D	Ensure redundancy of communication lines and power and reliability of technical support for the ground installation	Unlikely	Moderate	3D
Failure of site monitor	Site monitor relays information on the suitability of data received from ADS-B returns	erroneous data could be reaching the ATM system and be undetected by the controller leading to loss of separation	Remote	Moderate	3C	scheduled checks on site monitoring equipment done at frequent intervals and data collection and analysis	Remote	Moderate	3C

Operational Activity	Identified Hazards and Risks	Description of Risk	Initial Risk Assessment			Further Mitigation factors	Revised Risk Assessment		
			Likelihood	**Consequence**	**Risk Level**		**Likelihood**	**Consequence**	**Risk Level**
Mixed operating environment	Controller having different tracks to work with ADS-B, Flight Plan and SSR tracks this introduces the	Increase in controller workload transitioning different separation standards and possible loss of separation between aircraft	Possible	Moderate	3C	adequate initial training in procedures and regular refresher training to ensure controller competence	Unlikely	Moderate	3D