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Automatic dependent surveillance – broadcast (ADS-B) Implementation Meeting (ADS-B/IMP)
Mexico City, Mexico, 27-29 April 2015

Agenda Item 3: Review of ADS-B Regional Operational Concept (CONOPS)

PROPOSAL ON ADS-B REGIONAL OPERATIONAL CONCEPT (CONOPS)

(Presented by the ANI/WG ADS-B Spec Ad-Hoc Group Rapporteur)

EXECUTIVE SUMMARY

During the ADS-B Implementation Meeting held in ICAO NACC Regional Office in May 23 2014, it was agreed to create several Ad-Hoc groups to work on the definition of a Regional Operational concept for ADS-B and for the specification of ADS-B receivers and trial activities.

This paper presents a draft version of the Regional Operational Concept (CONOPs) for the use/ implementation of ADS-B (Appendix) prepared by the Ad hoc- Group on ADS-B CONOPs of the ADS-B Task Force of the ANI/WG to serve as a reference for States/ANSPs planning on the use and implementation of ADS-B.

Action: The Meeting is invite to review this proposal

Strategic Objectives:	• Safety • Air Navigation Capacity and Efficiency • Environmental Protection

INTERNATIONAL CIVIL AVIATION ORGANIZATION CAR/NAM MEXICO OFFICE

REPORT OF

THE AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) SEMINAR, OPERATIONAL CONCEPT THE FIRST MEETING OF ADS-B STUDY AND IMPLEMENTATION TASK FORCE (ADS-B AD-HOC/1)

México D. F, 30 Sep 2014

SUMMARY

The AD-HOC group Meeting developed an outline for regional Automatic Dependent Surveillance–Broadcast (ADS-B) Operational concept for the CAR region Task Force meeting. The outline is as follows:

Section 1	Introduction
Section 2	Acronyms
Section 3	Reference Documents
Section 4	Objective
Section 5	Traffic Flow
Section 6	Training
Section 7	Phases of implementation

1. Introduction

1.1 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.

1.2 Currently, 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 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.

1.3 CAR Region has completed 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.

1.4 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).

2. Acronyms

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

3. Reference Documents

3.1 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.

4. Objectives:

Safety

The objective of this Focus Area is to complete all Safety Management System (SMS) related activities, such as the Safety Management Plan (SMP), Hazard Identification and Risk Assessment (HIRA) and Safety Management Report (SMR). The expected timeframe of activities is from 2012 to 2017. The SMP will be completed in accordance with ICAO established guidelines and procedures and must support all areas of the initiative to provide ATS surveillance services using space-based ADS-B.

Capacity

Reducing separation in the en-route and approach area in non-surveillance airspace would increase capacity.

Efficiency Cost Benefits

ATS surveillance directly benefits operators by providing a safer operating environment, which also allows them to more closely adhere to minimum cost flight profiles. Such profiles need not be limited to fixed speeds or flight levels; recent initiatives such as Top Flight and ENGAGE have demonstrated the economic and environmental benefits which can accrue if flights are able to vary their speed and altitude within a defined operating band. Such flexibility is more easily accommodated where ATS surveillance services are provided.
Flight profiles which result in reduced fuel burns directly decrease the environmental impact from that flight, along with reducing fuel costs.

- increased operational safety
- reduced fuel burns
- fewer greenhouse gas emissions
- lower operating costs
- increased ATM flexibility

5. Traffic flow

5.1 The projection is for growth in air traffic region wide (past, present, and future). The effective use of ADS-B enhances the management of air traffic.

5.2 Selected Airports

These airports must be selected in base to traffic complexity, orography and number of movements.

5.3 Applicability of ADS-B:

- TMA
- Upper Airspace
- Lower Airspace
- SMS type evaluation of Hazard and Risk

5.3.1 Applicability of ADS-B IN Terminal Control Area (TMA)

5.3.1.1 The Terminal Control Area consists of that portion of the airspace immediately surrounding the aerodrome. In this airspace there would be aircraft on approaches (instrument and visual), departing and operating in the vicinity of aerodromes at close proximity to terrain. Most aircraft in the TMA would be passing through levels of other aircraft since this is the area of initial climb out and final descent to land.

5.3.1.2 In the TMA environment ADS-B could be used to provide surveillance where SSR and PSR would not be a cost effective option based on geography. The topography of mountainous areas limit surveillance as it requires clear line of sight with the respective antennae. The deployment of several ADS-B antennae could cover areas that would normally be blind spots for a single radar antenna. The cost difference of ADS-B installation makes it feasible to install several antennae to provide overlapping coverage.

5.3.1.2 The position reporting of aircraft are done at a level of accuracy based on GPS and the refresh rate is higher than that of conventional radar. 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 required.

5.3.1.3 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 as well.

5.3.1.4 Airspace capacity would be increased in the terminal airspace if ADS-B surveillance results in a reduction in required separation. As a result of increased capacity there would be increase in flight schedule flexibility, increase in flight path efficiency and reduction in delays or flight disruptions.

5.3.1.5 ADS-B would provide safety nets such as Minimum Safe Altitude Warnings (MSAW) for aircraft flying close to terrain and act to reduce CFIT in procedural airspace. In Radar airspace, ADS-B would provide redundant coverage to strengthen the safety procedures. SIDs and STARs based on Minimum Vectoring Altitude map and surveillance increases efficiency and safety. Aircraft are able to execute climb and descent more effectively than having to fly safety based Minimum Safe Altitudes in a procedural environment.

5.3.2 Applicability of ADS-B in Upper Airspace

5.3.2.1 Aircraft in the Upper Airspace would be the en-route phase of flight. The characteristics of this phase would be level flying for the most part or changes of cruising level of 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 on the layout of terrestrial Navigational Aids.

5.3.2.2 In procedural (non-surveillance) airspace ADS-B in the upper airspace would provide surveillance and allow separation as 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 minima, There is no requirement for detection of aircraft not transmitting ADS-B; and there is no requirement for determination of aircraft position independent of the position-determining elements of the aircraft navigation system.

5.3.2.3 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 would be provided and changes to the track more readily observed. This would improve the accuracy of predicted trajectories and increase the effectiveness of ATM safety nets (STCAs).

5.3.2.4 The coverage range of an ADS-B is typically two hundred (200) to two hundred and fifty (250) nautical miles. The distribution of land masses and structures such oil rigs in the region could offer coverage region wide if sufficient antennae are used. The data obtained from each FIR could be shared across boarders as long as the equipment is compatible. Where different equipment is used the processed data can be exchanged to provide overlapping areas of coverage.

5.3.2.5 The region has a distribution SSR and PSR antennae. These installations would have areas where gaps or a hole in the coverage exists. 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.

5.3.2.6 ADS-B coverage range increases with altitude thus aircraft in the upper airspace would be “visible“at a greater distance than aircraft at lower altitudes. Aircraft in the upper airspace would be facilitated by having access to more receivers.

5.3.2.7 The surveillance created by ADS-B could lead to more direct flight paths in the en-route phase of flight. Aircraft traversing a FIR in the upper airspace can be permitted to enter and exit via the most direct routes and not be cleared along particular airways. This type of routing would lead to fewer track miles and consequent savings in fuel and reduction in emissions.

5.3.3 Applicability of ADS-B in the Lower Airspace

5.3.3.1 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 especially in the vicinity of airports with convergence and divergence of traffic.

5.3.3.2 Airborne equipment and aircraft capability would vary because of the mixed operation. Commercial aircraft landing and departing, general aviation and military operations all share the lower airspace. Owing to the wide range of equipment in this portion of airspace, mandating ADS-B in the lower airspace would add commonality in the equipment carried onboard aircraft. With sufficient lead-time even the smaller operators and general aviation would be able to comply.

5.3.3.3 Conventional separation based of procedural control require aircraft to navigate between ground based navaids. This is not the most efficient route structure and restricts the capacity of the airspace. ADS-B would allow for more direct flight paths and increased capacity due to reduced required spacing between aircraft. This increase in capacity would lead to fewer delays and greater flexibility in schedules in high density airspaces. Shorter routes would mean lower fuel costs and fewer emissions.

5.3.3.4 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.

5.3.3.5 In areas of low traffic density, ADS-B is a cost effective way monitor the variety of aircraft. With mixed aircraft performance, surveillance increases safety. If the volume of traffic is not sufficiently high to justify the cost of installation of a Radar, ADS-B could be employed. This would provide surveillance but more cost effectively than SSR or PSR.

5.3.3.6 As compared to a procedural environment, where a certain time lapse has to occur or an emergency (or urgency) report has to be received from the pilot for the controller to know that an aircraft has a problem, in a surveillance area emergency reports are received instantaneously. The last position and flight path could be accurately determined for aircraft in unusual situations. This increases the likelihood of a favorable outcome.

5.3.3.7 Accurate position reporting make up a significant amount of a pilot’s work load. The priority in flight is to aviate, navigate and communicate in that order. 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.

5.3.4 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)

Likelihood	*Severity*				
	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
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

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 positionof 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 groung station are used in the operational trials. Ensure Route adherence monitoring is implemented for ADS-B tracks.			
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

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 comissioned 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	medaerte		site monitoring installed to provide a degree of on-line monitoring and warning to ATC if site moni			
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

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-deliberat actions	loss of ADS-B positional data to the ATS unit resultin in an increase in workload due to transitioning to procedural control.	improbable		3D	Increase in the level of security and secutriy response at ground installations			
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 callsign affixed to aircraft trach leading to increase work load for controller to rationalize the proper callsign	remote	minor	2C	work by plight plan monitoring group to identify how often this occurs and put measures to reduce the incidents with operator	improbab le	minor	2D
Failure of commun ication 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 relaibility 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	sheduled checks on site monitoring equipment done at frequent intrevals and data collection and analysis	remote	moderate	3C

Mixed operatin g environ ment	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 peocedures and regular refresher training to ensure controller competence	unlikely	moderate	3D

6. Training

- Controllers
- Pilots
- CNS technicians

7 Phases of implementation

Concept Phase

a) Construct Operational Concept
b) Identify benefits
c) Identify constraints
d) Prepare Business case

Design Phase

a) Identify operational requirements
b) Identify human factors issues
c) Identify technical requirements
d) Equipment development, test and evaluation
e) Develop procedures
f) Prepare design phase safety case

Implementation Phase

a) Prepare implementation phase safety case
b) Conduct operational test and evaluation
c) Obtain systems certification
d) Obtain regulatory approvals
e) Implementation transition
f) Performance monitoring to ensure that the agreed performance is maintained.