



**Agenda Item 6: Operational implementation of new ATM automated systems and integration of the existing systems**

**Activities to be taken under consideration in the Action Plan of the Project Improve ATM situational Awareness in the SAM Region**

(Paper presented by the Coordinator of the Project Improve ATM Situational Awareness in the SAM Region)

**SUMMARY**

This working paper has the aim of presenting the participants with information on the progress made to date with regard to the Project Improve ATM situational Awareness in the SAM Region.

**REFERENCES:**

- GREPECAS: Project C2: Improve ATM situational Awareness;
- Regional Unified Surveillance Strategy for the CAR/SAM Region;
- Air Navigation System Performance-Based Implementation plan for the SAM Region; and
- Final report of SAMIG/10 meeting (Lima, October 2012).

**ICAO strategic objectives:**

*A – Safety*

*C – Environmental protection and sustainable development of air transport*

**1. Background**

1.1 The ATM Automation and Situational Awareness Programme takes three Projects under consideration: Automation (Project C1), Improve ATM Situational Awareness (Project C2) and Implement the New ICAO Flight plan Format (Project C3).

1.2 Project C2 has made progress with the drafting of the *Guide on Technical and Operational Considerations for the Implementation of ADS-B in the SAM Region*, presented at SAM/IG/10 meeting.

**2. Analysis**

2.1 **Appendix A** presents the description of Project C2 and its situation to date. The activities of this Project take under consideration the drafting of guidance documentation to support States in the implementation of improvements to the ATM situational awareness.

2.2 In follow-up to Conclusion SAM/IG/10-3 - *Review of the Guide on technical and operational considerations for the implementation of ADS-B*, the Secretariat sent State letter LT 12/3.53-SA606 of 2 November 2012 with the aim of receiving comments on the Guide. In this respect, comments were received from Brazil, Chile and Guyana. **Appendix B** presents the Guide with inclusion of the comments received.

3. **Action suggested**

3.1 The Meeting is invited to:

- a) Take note of the information provided;
- b) Analyze the progress made in the activities of the Project, shown in Appendix A to this working paper;
- c) Analyze the *Guide on technical and operational considerations for the implementation of ADS-B* updated with comments received from States of the Region, and presented in Appendix B to this working paper, and
- d) Analyze any other aspects related with this subject that the Meeting might deem necessary.

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## APPENDIX A

SAM Region	PROJECT DESCRIPTION (PD)	PD N° C2	
Programme	Project Title	Starting Date	Ending Date
ATM Automation and Situational Awareness <i>(Programme Coordinator: Onofrio Smarrelli)</i>	<p>Improve ATM Situational Awareness in the SAM Region</p> <p><i>Project Coordinator: Paulo Vila (Peru)</i></p> <p><i>Contributing experts: José Rubira, Marcos Vidal and Jorge Otiniano (Peru); Javier Vittor (Argentina), André Jansen (Brazil)</i></p>	October 2011	November 2013
<b>Objective</b>	Develop guidelines supporting the implementation of improvements in the situational awareness of ATS units in the South American Region		
<b>Scope</b>	<p>Guidelines supporting the implementation of various applications, such as common traffic visualization, common meteorological conditions visualization and communications in general</p> <ul style="list-style-type: none"> <li>• Analysis of the current surveillance infrastructure and identification of necessary improvements to support en route and terminal airspaces, airspace classification, PBN and ATFM</li> <li>• Implementation of ADS-B, ADS-c and/or MLAT surveillance systems at selected airspaces</li> <li>• Minimum common electronic information and data bases required in support of decision-making process and alert systems towards an interoperable situational awareness among centralized ATFM units</li> <li>• Implement flight plan data process systems (new FPL format) and data communications tools among ACC's</li> <li>• Implement advanced automation support tools to contribute towards the sharing of aeronautical information</li> </ul>		
<b>Metrics</b>	<p>Drafting of following documents:</p> <ul style="list-style-type: none"> <li>• Regional surveillance strategy for the implementation of systems in support of improvement of situational awareness – revised</li> <li>• Evaluation of the surveillance systems coverage in the SAM Region - completed</li> <li>• Guideline on technical/operational considerations for ADS-B implementation – completed</li> <li>• Guideline on technical/operational considerations for MLAT implementation - completed</li> <li>• Guideline on technical considerations in support of ATFM implementation – completed</li> <li>• Guideline for the presentation of MET products in graphic format - completed</li> </ul>		
<b>Strategy</b>	<ul style="list-style-type: none"> <li>• All tasks will be conducted by experts nominated by States and organizations of the SAM Region members of the Project <i>Improve ATM situational awareness in the SAM Region</i>, under management of the project coordinator. Communications among project members, as well as between the project coordinator and programme coordinator, shall be carried out through teleconferences and the Internet.</li> <li>• Once studies are completed, the results will be submitted to the ICAO programme coordinator as a final consolidated document for its analysis, review, approval and presentation at the GREPECAS PPRC</li> </ul>		

<p style="text-align: center;"><b>Goals</b></p>	<ul style="list-style-type: none"> <li>• Regional surveillance strategy for the implementation of systems in support to situational awareness improvement for July 2012.</li> <li>• Evaluation of SAM surveillance systems coverage for October 2012.</li> <li>• Guideline on technical/operational considerations for ADS-B implementation for June 2012</li> <li>• Guideline for technical/operational considerations for MLAT implementation for June 2013</li> <li>• Guideline for technical considerations in support of ATFM implementation for October 2013</li> </ul>
<p style="text-align: center;"><b>Justification</b></p>	<ul style="list-style-type: none"> <li>• Improve situational awareness has been identified as a great support for ATM, contributing in the increase of safety and in flight efficiency</li> <li>• During the seventh meeting of the SAM Implementation Group (SAM/IG/7), a review was made to the project <i>Improve ATM situational awareness in the SAM Region</i>, considering the nomination of a coordinator for the SAM Region</li> <li>• In addition, a close relationship with the other programmes and their respective projects is necessary, with the aim of collecting the operational requirements demanded by the mentioned applications and their respective tentative implementation dates</li> <li>• This project contributes to the implementation of SAM PFF CNS 04, ATM 05, ATM 06 and MET 03 of the <i>Air Navigation System Performance-Based Implementation Plan for the SAM Region (SAM PBIP)</i></li> </ul>
<p style="text-align: center;"><b>Related Projects</b></p>	<ul style="list-style-type: none"> <li>• Air Navigation Systems in Support of PBN</li> <li>• Automation</li> <li>• ATFM</li> <li>• Implementation of the ICAO New Flight Plan Format</li> <li>• ATN Ground-ground and Air-ground Applications</li> </ul>

Project Deliverables	Relationship with Performance Based Regional Plan (PFF)	Responsible	Status of Implementation <sup>1</sup>	Delivery Date	Remarks
<i>Evaluation of surveillance infrastructure and identification of surveillance systems improvements</i>					
Revision to regional surveillance strategy for the implementation of systems in support to improvement of situational awareness	PFF SAM CNS 04 PFF SAM ATM 06	Paulo Vila (Peru)		June 2012	An initial revision to the strategy was presented at SAM/IG/8 meeting (Lima, Peru, 10-14 October 2011)
Evaluation of current surveillance systems coverage in the SAM Region	PFF SAM CNS 04	Paulo Vila (Peru)		October 2012	Presented as Appendix 7 to the Guideline on technical/operational considerations for ADS-B implementation.
<i>Drafting of regional plan for ADS-B and MLAT implementation</i>					
Guideline on technical/operational considerations for ADS-B implementation	PFF SAM CNS 04 PFF SAM ATM 06	José Rubira (Peru) Marco Vidal (Peru)		October 2012	Guide presented at SAM/IG/10 meeting, and examined during the Meeting, with some comments. It was then circulated to SAM States, receiving comments from three. The changes were introduced to the Guide, which will be reviewed by SAM/IG/11 meeting. Peru will later include considerations to determine the values recommended for NIC, SIL and NAC for operational application.
Guideline on technical/operational considerations for MLAT implementation	PFF SAM CNS 04 PFF SAM ATM 06	Andre Jansen (Brazil)		November 2013	

<sup>1</sup> **Gray:** Activity has not started  
**Green:** Activity has or will deliver planned milestone as scheduled  
**Yellow:** Activity is behind schedule on milestone, but still within acceptable parameters to deliver milestone on time  
**Red:** Activity has failed to deliver milestone on time, mitigation measures need to be identified and implemented

Project Deliverables	Relationship with Performance Based Regional Plan (PFF)	Responsible	Status of Implementation <sup>1</sup>	Delivery Date	Remarks
Guideline on technical considerations in support of ATFM implementation	PFF SAM CNS 01 PFF SAM ATM 05	Javier Vittor (Argentina)		October 2013	The guideline will base itself on the CAR/SAM ATFM Manual approved through GREPECAS Conclusion 16/35
Guideline for the presentation of MET products in graphical format	PFF SAM MET 03	Jorge Otiniano (Peru) Daniel Gomez (Peru)		May 2013	Guide is presented at SAM/IG/11 meeting and is based on the Peruvian experience in the use of meteorological information graphic formats, including the graphic SIGMET
Resources necessary					

**APPENDIX B**



**INTERNATIONAL CIVIL AVIATION ORGANIZATION  
SOUTH AMERICAN REGIONAL OFFICE**

**ASSISTANCE FOR THE IMPLEMENTATION OF A REGIONAL ATM SYSTEM  
TAKING INTO ACCOUNT THE ATM OPERATIONAL CONCEPT AND THE  
CORRESPONDING CNS TECHNOLOGICAL SUPPORT**

**SAM IMPLEMENTATION GROUP - SAMIG**

**GUIDE ON TECHNICAL AND OPERATIONAL  
CONSIDERATIONS FOR THE  
IMPLEMENTATION OF ADS-B IN THE SAM  
REGION**

Lima, Peru

Version 1.1

2012

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## LIST OF ACRONYMS

A/A	Air/air
AC	Advisory circular
ACAS	Airborne collision avoidance system
ACC	Area control centre
ACID	Aircraft identification
ADLP	Airborne data link processor
ADS-B	Automatic dependent surveillance — broadcast
ADS-C	Automatic dependent surveillance — contract
ADS-R	Automatic dependent surveillance — rebroadcast
AIP	Aeronautical information publication
AIRPROX	Aircraft proximity incidents
ANSP	Air navigation service provider
ASBU	Aviation system block upgrades
ASD	Aircraft situation display
ASTERIX	All-purpose structured Eurocontrol surveillance information exchange
ATC	Air traffic control
ATCO	Air traffic controller
ATM	Air traffic management
ATN	Aeronautical telecommunication network
ATS	Air traffic service
BW	Bandwidth
CAA	Civil Aviation Authority
CDTI	Cockpit display of traffic information
CNS	Communications, navigation and surveillance
CPDLC	Controller-pilot data link communications
DME	Distance measuring equipment
ES	Extended squitter
FDP	Flight data processing
FIR	Flight information region
FMC	Flight management computer
FMS	Flight management system
FPL	Flight plan presented
GNSS	Global navigation satellite system
GPI	Global performance indicator
GPS	Global positioning system
GUI	Graphical user interface
IFR	Instrument flight rules
IMC	Instrument meteorological conditions
INS	Inertial navigation system
ISO	International Organization for Standardization
KVM	Keyboard, video and mouse
LAN	Local area network
MLAT	Multilateration
MSAW	Minimum safe altitude warning system
MSSR	Monopulse SSR
MTBF	Mean time between failures
NTP	Network time protocol
NAC	Navigation accuracy category

NIC	Navigation integrity category
NUC	Navigation uncertainty category
ICAO	International Civil Aviation Organization
PSR	Primary surveillance radar
RAIM	Receiver autonomous integrity monitoring
REDAP	Peruvian digital network
RF	Radio frequency
RNAV	Area navigation
RNP	Required navigation performance
RTCA	Radio Technical Commission for Aeronautics
SAM	ICAO South American Region
SARPs	ICAO standards and recommended practices
SDP	Surveillance data processing
SIC	System identification code
SIL	Surveillance integrity level
SLG	Local management system
SRG	Remote management system
SSR	Secondary surveillance radar
G/A	Ground/air
TCAS	Traffic alert and collision avoidance system
TGPS	All-purpose synchronization card
TIS	Traffic information service
TIS-B	Traffic information service — broadcast
TOA	Time of arrival
TPPG	All-purpose process card
TSO	United States FAA Technical Standard Order
TRPG	All-purpose reception card
TIS-B	Traffic information service — broadcast
UAT	Universal access transceiver
UDP	User datagram protocol
UPS	Uninterruptible power supply
URPA	ADS-B reception and processing unit
UTC	Coordinated universal time
VDL	VHF digital link
VHF	Very high frequency
VFR	Visual flight rules

## DEFINITIONS

1. **ADS-B (Automatic Dependent Surveillance – Broadcast)** – Means by which the aircraft, aerodromes and other objects can transmit and/or receive, automatically, data such as identification, position and additional data, as corresponds, as a data link broadcast.
2. **ADS-B in (reception)**: airborne function that receives surveillance data transmitted by the ADS-B OUT functions installed in other aircraft. It could also receive, from the ground, additional data from other aircraft that do not transmit ADS-B OUT or whose ADS-B OUT systems transmit using a different ADS-B technology.
3. **ADS-B out (transmission)**: Function of an aircraft or vehicle that is periodically broadcasting its status vector (position and speed) and other information obtained from airborne systems in a format suitable for ADS-B-IN receivers.
2. **ADS-R (Rebroadcast)**: Function of a ground station that permits the interoperability among aircraft equipped with ADS-B systems that operate with different data links. The ADS-R ground station receives ADS-B messages from a link (*e.g.*, UAT), and processes and broadcasts them through a different data link (*e.g.*, 1 090 MHz ES). Docs 9861 and 9871 contain details of TIS-B and ADS-R.
3. **Downlink**: Link associated to signals transmitted over the 1 090 MHz frequency response channel.
4. **Aircraft identification**: A group of letters, figures, or a combination thereof, which is either identical to, or the coded equivalent of, the aircraft call sign to be used in air-ground communications, and which is used to identify the aircraft in ground-ground or air traffic services communications (*the aircraft identification is frequently known as flight identification*).
5. **Mode S**: Improved mode SSR that permits selective questions and answers. Mode S that permits selective addressing of aircraft using a 24-bit aircraft address that unequivocally identifies each aircraft and has a bidirectional data link between the ground station and the aircraft for the exchange of information.
6. **Mode S SS (Mode S short squitter)**: Periodic unsolicited output of a Mode S transponder (nominally once per second) in a specific format to facilitate passive acquisition.
7. **Mode S ES (Mode S extended squitter)**: Periodic unsolicited output in a 112-bit 1 090-MHz Mode S signal format containing 56 bits of additional information (*e.g.*, used for ADS-B, TIS-B and ADS-R).
8. **TIS-B**: Broadcast of aircraft surveillance data by ground stations using an ADS-B data link.

9. **TYPES OF ES MESSAGES:**
  - 10.1 **AIRBORNE POSITION:** The airborne position message provides basic surveillance information, which includes 3-D position, in addition to time of validity and surveillance status information.
  - 10.2 **AIRBORNE VELOCITY:** The airborne velocity message contains velocity information and other aircraft status data.
  - 10.3 **SURFACE POSITION:** The surface position message provides the complete surface status vector in a single message.
  - 10.4 **AIRCRAFT IDENTIFICATION AND EMITTER CATEGORY:** The identification and category squitter provides the aircraft type category as well as the aircraft identification, which corresponds to box 7 of the ICAO flight plan.
  - 10.5 **EVENT-DRIVEN:** Event-driven squitter is a message transfer protocol for the transmission of additional information that might be occasionally needed.
10. **Uplink:** Link associated to signals transmitted by the 1 030 MHz frequency interrogation channel.

## REFERENCE DOCUMENTS

- Doc 4444, Air Traffic Management (PANS-ATM)
- Doc 9924, Aeronautical Surveillance Manual
- Doc 9871, Technical Provisions for Mode S Services and Extended Squitter RTCA/DO-249, DEVELOPMENT AND IMPLEMENTATION PLANNING GUIDE FOR AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) APPLICATIONS
- RTCA/DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance – Broadcast (ADS-B)
- RTCA/DO-260B, Minimum Operational Performance Standards for 1090 MHz extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B) RTCA/D0-260 A, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)
- RTCA/DO260, Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B)
- Annex 10, Aeronautical Telecommunications, Volumes 4 and v3,
- SAM Surveillance Strategy Document,
- SAM Performance-Based Air Navigation Implementation Plan (SAM PBIP),
- Global Air Navigation Plan for CNS/ATM Systems (Doc 9750), “Aviation System Block Upgrades (ASBU)” Initiative.
- FAA AC No: 20-165 of 2010.
- EASA Acceptable Means of Compliance - AMC 20-24

## 1. INTRODUCTION

### 1.1 Objective

1.1.1 Based on the ATM Operational Concept, the Global Plan, the Regional Plan, and the SAM Performance-Based Plan, it is foreseen that the implementation of the ADS-B system will begin in the medium term.

1.1.2 Likewise, following the guidelines of the Global Plan in its GPI 9, “Situational Awareness”, it was determined that one of the activities of Project “Enhancement of ATM situational awareness” would be the development of this guide, which is intended to serve as a reference for SAM States that need to start operating an ADS-B surveillance system. The guide lists the aspects that must be taken into account before deciding to test and then operate the system.

### 1.2 Scope of the Guide

1.2.1 This guide is addressed to air navigation service providers, civil aviation authorities, and aircraft operators of the ICAO South American (SAM) Region that need introductory information on technical and operational concepts and issues that should be taken into account before planning and implementing ADS-B as an ATS surveillance sensor or as on-board traffic monitoring system to enhance the situational awareness of the crew. This guide does not replace or supplement the international standards specified by ICAO or other standards developers for the industry, but rather provides a common starting point so that SAM States that are planning to acquire an ADS-B or a new control centre may know what are the performance and technical characteristics that will permit the interoperability of the systems involved.

## 2. OVERVIEW OF THE ADS-B

### 2.1 OPERATION OF THE ADS-B

2.1.1 According to Doc 9924 AN/474, Aeronautical Surveillance Manual, ADS-B involves the broadcasting by an aircraft of its position (latitude and longitude), altitude, velocity, identification, and other information obtained from on-board systems. All ADS-B position messages contain data quality indication that allows users to determine if data is good enough to support the function foreseen.

2.1.2 Quality indicators of aircraft position, velocity and other related aircraft data are normally obtained from the airborne GNSS system. Existing inertial sensors alone do not provide the required accuracy or integrity data, although future systems will probably solve this deficiency. Consequently, ADS-B position messages from an inertial system are normally transmitted with a statement of unknown accuracy or integrity. Some new aircraft installations use an integrated GNSS and inertial navigation system to provide position, velocity, and quality indicators for ADS-B transmission.

2.1.3 It is foreseen that these navigation systems will have a better performance than a system based only on GNSS, since inertial and GNSS sensors have supplementary features that mitigate the weaknesses of each system. Since ADS-B messages are broadcast, they may be received and processed in any suitable receiver. This receiver may be an “ADS-B ground station” processing ADS-B messages (extended squitter) and generating aircraft reports to be displayed on an ATCO work console.

2.1.4 Figure 1 below illustrates the operation of ADS-B.

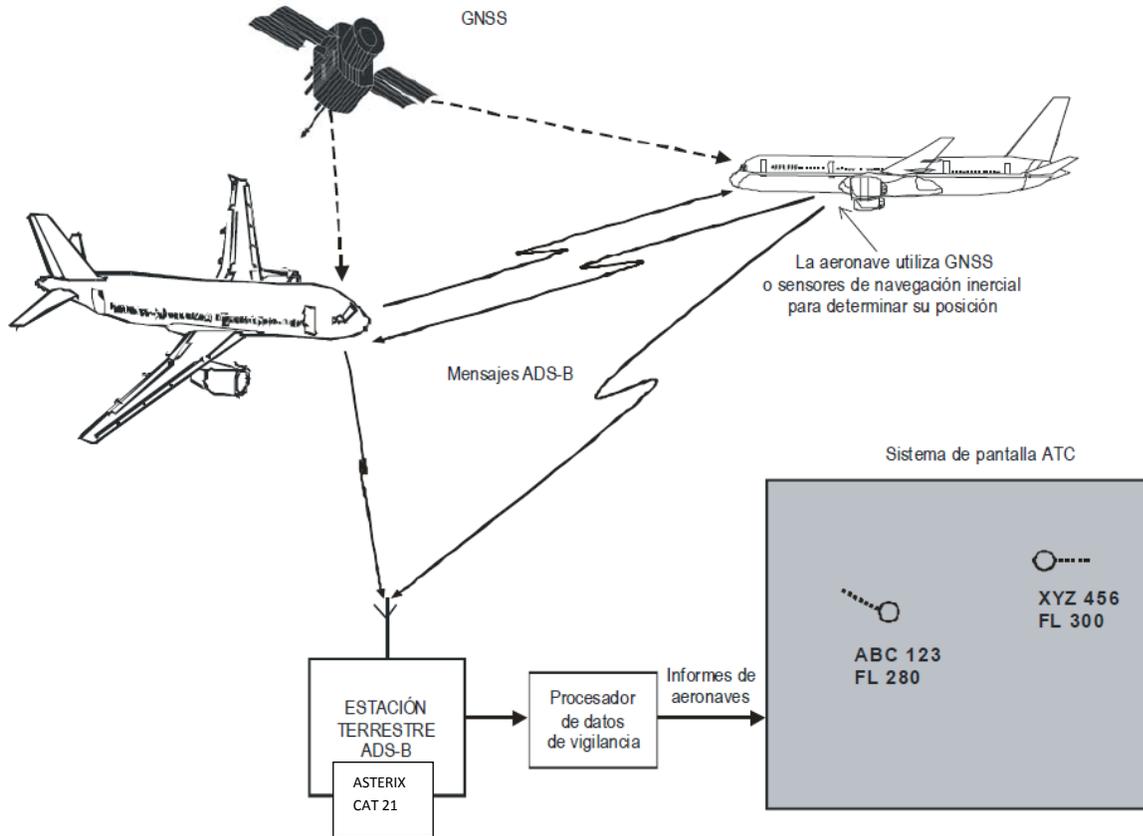


Figure 1: ADS-B schematic

2.1.5 Three ADS-B data links have been developed and standardised for the transport of messages, namely Mode S ES, also known as 1090 ES (Extended Squitter), UAT and VDL Mode 4. Mode S ES has been chosen as the type of link to be used in the SAM Region (GREPECAS Conclusion 12/44 - *Regional CAR/SAM guidance for the introduction of ADS-B data link*. Doc 9871, Technical provisions for Mode S services and extended squitter, provides more details on Mode S ES.

2.1.6 Mode S extended squitter (1090 ES) contains an additional 56-bit data block compared to the conventional Mode S or short squitter (see Figure 2). ADS-B information is broadcast in separate messages, each containing a related data set (e.g., airborne position and pressure altitude, surface position, velocity, aircraft identification and type, emergency information).

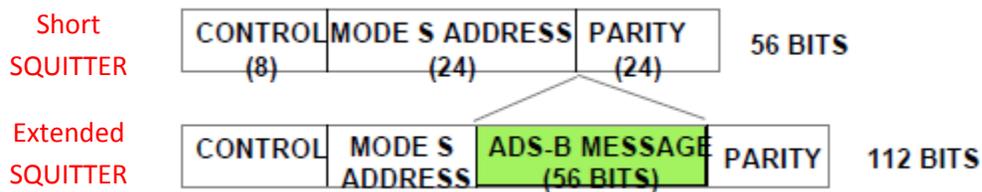


Figure 2. 1090 ES datagram

2.1.7 The first datagram is the so-called 56-bit Short Squitter (SS), which is transmitted once per second. This short squitter is used for surveillance, where the 24-bit MODE S ADDRESS field embodies the selective interrogation of aircraft addresses consisting of 2 sub-fields, a 9-bit sub-field that identifies the country, and a 15-bit sub-field the identifies the aircraft. Each ES transmission contains the aircraft address, which permits an unequivocal association between the data in the various squitter formats and the originating aircraft.

2.1.8 The second datagram is the 112-bit Extended Squitter (1090 ES) that, in addition to the 56 bits of the SS, contains the 56-bit ADS-B message. There are three standards for the ES: RTCA/DO-260, RTCA/DO-260A and RTCA/DO-260B. these standards correspond, respectively, to Versions 0, 1 and 2, to ICAO Doc 9871.

2.1.8.1 The ES provides five types of reports:

- a) Airborne position;
- b) Surface position;
- c) Aircraft identification and emitter category; and
- d) Event-driven.

2.1.8.2 Each of these types is described in Doc 9924 Appendix K item 5 “ADS-B ES messages”. Figures 2A and 2B show examples of ADS-B messages.



Figure 2A: ADS-B position message

Identification Message									
TYPE	Transmitter Category	Aircraft Identification (8 characters), formed through the combination of 6 digits							
5 bits	3 bits	6 bits	6 bits	6 bits	6 bits	6 bits	6 bits	6 bits	6 bits
↓									
CAT	15	-> Categoria	21	[ADS-B]					
LONG	0017	-> Longitud	23	bytes					
FSPEC	E98110	-> Espec. Campos	11101001	10000001	00010000				
010	1400	-> Estacion Radar	SAC= 20	[ESPAÑA]	SIC= 0	[??????]			
040	00	-> Desc. Plot	REAL						
28	-> Desc. Plot	ICAO Addr	ARC->25ft						
030	3E3E94	-> Hora UTC	4079252	[x 1/128 Sgds = 31869.156 Sgds]	= 08:51:09.16				
080	3414CB	-> Target Address	3414CB						
210	08	-> Tecnologia	Mode-S-ExtSquitter						
170	242173	-> Identificador	IBE3521						
D72C60	-> de Aeronave								

**Figure 2B: ADS-B identification message**

2.1.9 The initial versions of ES messages are defined in RTCA DO-260 and are known as version ZERO (0) formats. Complete definitions of message structures and data sources for version 0 formats are contained in Doc 9871, Appendix A.

In version 0 formats, the type codes of airborne position and surface position messages can be associated to a navigation uncertainty category (NUC). Version ZERO ES message formats and the associated requirements are suitable for the first implementation stages of extended squitter applications. Surveillance quality is reported in the navigation uncertainty category (NUC), which may be an indication of the accuracy or integrity of the navigation data used for ADS-B. However, it does not specify whether the NUC indicates integrity or accuracy.

2.1.10 The revised versions of ES messages are defined in RTCA DO-260A and RTCA DO-260B known, respectively, as version ONE (1) and version TWO (2) formats. Complete definitions of the data structure and data sources for versions 1 and 2 formats are contained in Doc 9871, Appendices B and C, respectively. Versions 1 and 2 formats and the associated requirements correspond to more advanced ADS-B applications (see Appendix 1 to this document, “ADS-B operational application”).

2.1.11 In the versions 1 and 2, the accuracy and integrity of navigation data are divided into 3 main components, namely NAC, NIC, and SIL (see Appendix 2 to this document, “Introduction of NAC, NIL, and SIL”).

2.1.12 Each ES transmission contains a 5-bit field that identifies a “TYPE CODE” specific to each message. Version 0 formats allow the TYPE CODES of airborne position and surface position messages to be associated to a NUC. Version 1 formats allow the TYPE CODES of airborne position and surface position messages to be associated to a NIC.

### 3. GENERAL CONSIDERATIONS ON ADS-B IMPLEMENTATION PLANNING IN THE SAM REGION

#### 3.1 GENERAL CONSIDERATIONS

3.1.1 As stated in Doc 9924, Aeronautical Surveillance Manual, the following list shows the recommended stages for the planning and implementation of surveillance systems--in this case, of an ADS-B system.

- a) *Define the operational requirements:*
- Select the applications to be supported: This will help determine the required performance.
  - Define the area of coverage: The definition of the volume where the operational service will be supported is very important since it will serve as a basis for system costing. In particular, the correct identification of lower altitude boundaries is very important since it will have significant consequences on the number of sensors to be introduced.
  - Define the type of traffic: for example, IFR flights, VFR flights, local or international flights, civil or military flights.
- b) *Define the local environment (current and future):*
- Current and expected traffic densities, including a description of likely peak hours.
  - Route structure.
  - Type of on-board equipment currently mandatory for the different types of flights (mandatory carriage and actual proportion of equipment).
  - Type of aircraft: commercial, general aviation, helicopters, gliders, ultra-light aircraft, VLJ, military aircraft, and their dynamic characteristics (maximum speed, climb speed, turn rate, etc.).
  - Segregation of the different types of traffic, possible traffic mix, and likelihood of intrusion of aircraft not equipped with means of cooperative surveillance.
  - Specific local RF environment.
- c) *Analyse design options and determine the techniques that may be used:*
- Verify existing surveillance sensors that may be reused.
  - Verify the new sensors and surveillance techniques that may be introduced at a low cost.
  - Determine the number of locations and investigate their availability. Check on-board equipment.
  - Determine the required level of redundancy and fall back operating mode.
  - Determine whether it will be necessary to carry new equipment on board.
  - Determine the impact on operating procedures.
  - Conduct cost-benefit and feasibility studies of the different options, if necessary.
- d) *Conduct a safety analysis of the new proposed system:*
- To demonstrate that the system will provide the necessary performance in its nominal operating mode.
  - To demonstrate that the different failures have been analysed.
  - To demonstrate that it was determined that failures were acceptable or could be mitigated.
- e) *Implement:*
- If new equipment is required on board, prepare the mandate for on-board carriage;
  - The acquisition and installation of the new system.
  - The performance assessment of the new system.

- f) *Establish the operational service:*
  - Transition from the existing to the new system.
- g) *Provide the operational service:*
  - Periodically verify the performance of the new system.
  - Perform regular and preventive maintenance.

3.1.1.1 The following proposals provide practical examples of analyses proposed for the Region, taking into account the participants involved.

### 3.1.2 **Joint work of the CAA and ANSPs**

3.1.2.1 States should consider the following activities prior to the implementation of an ADS-B surveillance service:

- a) Define the operational objective of the implementation.
- b) Define the objectives and goals to be achieved in accordance with the national air navigation plan, the ASBU surveillance roadmap and the SAM regional surveillance strategy, for the development of the ADS-B implementation plan, with the participation of aircraft operators and other users involved.
- c) Services or areas or flight phases that would be under the planning scope.
- d) Analysis of the avionics of the fleet, both Mode-S-equipped and non-equipped, in the airspace concerned; at least the following data should be taken into account:
  - Number of operations or aircraft involved in general aviation, commercial, and military flights. It is recommended that the ratio between the number of aircraft and the operations they conduct be analysed, since, in some cases, commercial aircraft with 1090ES transmission capabilities conduct several operations per day, thus increasing the feasibility of an implementation with a low final cost for aircraft operators.
  - Message standard used for transmission by aircraft (DO-260/DO-260A/DO-260B).
- e) ADS-B message standard to be used in the State.
- f) Type of application in which ADS-B is to be used in accordance with the requirements and the operational concept (ADS-B-RAD, ADS-B-NRA, ADS-B-APT, ADS-B-ADD, etc.) and the types of transponder that they will require (see Appendix 4).
- g) The integration of ES with the SSR system at the existing control centre (if applicable).
- h) Advantages, disadvantages, and limitations of the planned implementation.

- i) Type of data merging (multi-tracker) of the existing and future SDP serving the ATM automated system.
- j) Training of ATCOs and crews on ADS-B, its use, advantages, operational procedures to be used, applicable separation minima, delegation of functions, responsibility limits, etc. Specifically in the case of ATCOs, they shall be warned and trained with respect to the possibility of FLP correlation failures in on-board interfaces due to ACID input errors.
- k) Operational risk assessment (in case of failures, navigation data quality degradation, etc.) and ADS-B message performance trials (Doc 4444, 2.6.1.1; 2.6.1.2)
- l) Testing and establishment of procedures in case of:
  - Contingencies, especially in case of interruption of the receiver autonomous integrity monitoring (RAIM) in accordance with Annex 11, 2.30, and Doc 4444, 8.8.4 and 8.8.5.
  - Validation of risk mitigation.
  - Independent and joint simulations with pilots.

### 3.1.3

#### **Civil aviation authorities (regulatory bodies)**

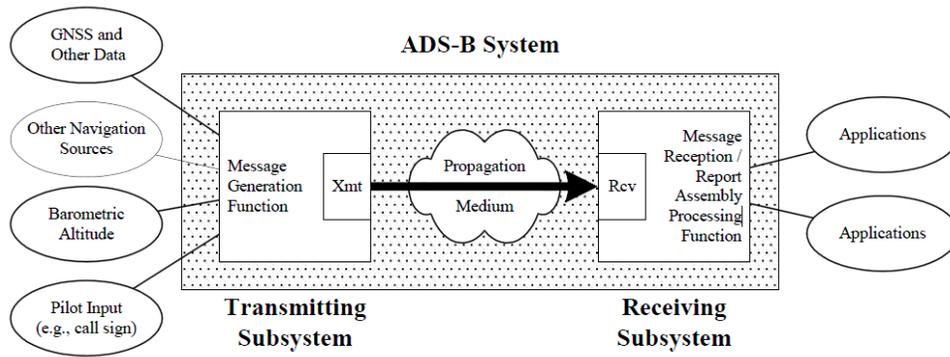
- a) Define the minimum performance and technical/operational characteristics of on-board navigation equipment that will feed ADS-B OUT.
- b) Analysis, selection, and validation of quality and integrity parameters in ADS-B message formats in the State.
  - Chapters 1, 2, 3 of DO-260A and 2, 3 and 4 of DO242A describe in detail the technical and operational tests and aspects to be taken into account for these processes.
- c) Once the testing and parameter selection have been completed, they could be validated as follows:
  - The integration of ES with SSR data in a control centre may be a direct way of obtaining ADS-B benefits while maintaining the independence of SSR surveillance. This is based on the use of active interrogation to validate ES surveillance.
  - The technique may be used in ground ATC and ACAS surveillance applications. Active surveillance is used for validating the surveillance reported by ADS-B and replacing it if an aircraft loses its navigation capability.
  - If the validity check at the beginning of tracking turns out positive, the aircraft may continue in ADS-B with periodic monitoring to ensure the proper continuous operation of the navigation system. If the check turns out negative at any given point in time, tracking can be maintained through active surveillance.

- Another method of validating ADS-B data consists of installing ADS-B with multilateration. The advantage of this option is that it maximises the use of ground infrastructure since multilateration receivers can receive and decode ADS-B messages. This option has the advantage of being completely passive.
- Publication of the respective technical standard as the authority may deem appropriate, highlighting to the ATM community those aspects that crews and aircraft operators (including technical crews on the ground) must take into account when entering data in the on-board interface. (See Appendix 3 – “Proposed publication of a national technical standard.”)
- Drafting of advisory circulars (CA) establishing ADS-B approval requirements for aircraft and operations in the corresponding airspace.

#### 3.1.4

#### **For Operators**

- a) Equipment with ADS-B message generation and transmission functions. Additionally, for CDTI (Cockpit Display Traffic Information) applications, ADS-B message reception, assembly, and processing functions should be available (in both cases, the data link mode will be ES Mode-S), as well as an appropriate number of interfaces, depending on operational applications, approved by the appropriate ATS authority (see Figure 3).
- b) On-board transponders should have the transmission/reception capabilities for the class of transponder (see Appendix 4 “Tables of classes of ADS-B transmitters and receivers”) that corresponds to the ADS-B application to be used, approved by the appropriate ATS authority.
- c) The equipment associated to on-board ADS-B may include:
  - Secondary sources for navigation data backup and interfaces (for example, redundant GNSS, Loran, FMS / RNAV or INS)
  - GNSS augmentation processing
  - Interface with applications that support CDTI for visualising other aircraft
  - Interface for entering data in the cockpit.
- d) Training of crews on ADS-B concepts, the interaction of flight data in ATC applications, the use and procedures of the applications to be used, as well as the contingency plan.
- e) Checklists for ADS-B applications to be used, taking into account the importance of correct entry of flight identification in the on-board interface, to be considered for drafting the corresponding technical regulation. Appendix 5, “Aspects to be taken into account by operators when operating an ADS-B transponder”, highlights the importance of this requirement.



**Figure 3: Schematic of ADS-B for operational applications**

### 3.2 ADVANTAGES OF ADS-B

3.2.1 In addition to local, governmental, regional, or global ATM and CNS implementation guides, it is important that the parties responsible for ADS-B implementation planning clearly establish the objectives, advantages, disadvantages, and considerations that this surveillance system entails for the ATM community as a whole, in accordance with its own reality.

3.2.2 In general terms, significant short-, medium-, and long-term safety improvements are achieved (see Appendix 6, “ASBU surveillance methodology roadmap”) both on the ground and on board:

- a) Enhanced situational awareness in airspaces with radar surveillance or multilateration, through the provision of more information, between IFR, IFR and VFR flights, between VFR flights with electronic VFR IMC function, between uncontrolled flights, to ATC, etc.
- b) Enhanced warning (prediction and resolution) systems both in flight as well as on the ground (between aircraft and between aircraft and ground airport operation vehicles), reducing runway incursions, AIRPROX, ATC safety net warnings, long-term warnings for conflict management, etc.
- c) Shorter airborne segments.
- d) Reduced ATC workload, enabling the delegation of separation responsibilities to certain flights.
- e) Different operational applications and functions using a single system
- f) Increased airspace capacity, etc.

3.2.3 Regarding economic benefits, savings can be obtained for:

- a) ANSPs: lower cost of installing, maintaining and acquiring an ADS-B antenna versus PSR or MSSR, less logistic problems and architecture complexity if compared to multilateration, for example, for broad area; permits the expansion of ATS surveillance service in low traffic density areas where the installation of radar may not be justified, etc.
- b) Air users: cost and fuel savings because it enables more direct and optimum routes, less delays and restrictions (with procedures for delegation of responsibilities and tracking, sequencing, and separation functions), etc.

3.2.4 With respect to safety, ADS-B data may be used also for automated monitoring of resolution advisories (RAs) received from collision avoidance systems (TCAS). This functionality may be an additional benefit for States that implement ADS-B coverage in their areas of responsibility, mainly with respect to safety management systems (SMS), since at present RA assessments are normally done using manual processes based on hazard reports sent to the State by the operators.

### 3.3 DISADVANTAGES OF ADS-B

3.3.1 ADS-B performance and operation standards are still under development. GPS continues to be the main positioning source, still lacking official backup. The additional use of sensors such as DME-DME, INS, etc. as positioning sources is foreseen.

3.3.1.1 The avionics of the fleet that operates in the SAM Region is not homogeneous, and thus some ES-capable flights transmit messages in version 0 and others in version 1.

3.3.1.2 The cost of acquisition of the equipment required for ADS-B is still high, especially for general aviation, which, in many cases, still lacks the necessary FMC/FMS for data processing. The same happens for the ADS-B IN function.

3.3.1.3 Accordingly, it is likely that exclusive airspaces will need to be implemented in the Region.

3.3.1.4 Most control centres lack the capacity to receive ASTERIX category 21ed. 1.8 data or to process and merge data in accordance with the recommendations proposed in this document for the SAM Region.

### 3.4 SURVEILLANCE STATUS IN THE SAM REGION

The intentions of the States of the Region regarding ADS-B implementation in each country are summarised below, based on CNS plans submitted by each SAM State to the SAMIG.

#### 3.4.1 Argentina

3.4.1.1 Regarding services under the ICAO CNS/ATM concept, Argentina is planning to borrow one or two ADS-B receiver stations to conduct initial trials in this field.

3.4.1.2 Amongst the improvements to be made to surveillance systems for conventional services, Argentina has foreseen the installation in the short and medium term of MSSR radar systems (INKAN from provider INVAP) as conventional services. Plans concerning the new radars are contained in the guide for the implementation of surveillance systems presented at the sixth meeting of the CNS ATM Subgroup (ATM/CNS/SG/6).

3.4.1.3 Regarding services under the ICAO CNS/ATM concept and, specifically, ADS-B plans for the medium term, Argentina contemplates having a sufficient number of ADS-B receivers, which, in addition to the radars foreseen, would ensure the absence of "coverage gaps". Information obtained from the receivers and from RSMA radars will be carried over the ATN to the corresponding ACCs.

#### 3.4.2 Bolivia

3.4.2.1 Bolivia has an MSSR located in the Kuturipa hill, within the Cochabamba terminal area.

3.4.2.2 Regarding services under the ICAO CNS/ATM concept, Bolivia has no ADS-B stations and its implementation is under study.

3.4.2.3 Amongst the improvements to be introduced in surveillance systems for conventional services and based on an operational requirement, Bolivia has plans to implement an integrated 4-radar (MSSR) system in the medium term to achieve 80% coverage of the La Paz FIR airspace. Regarding services under the ICAO CNS/ATM concept, Bolivia has plans to continue performing cooperative surveillance, noting that SSR Mode A/C and SSR Mode S will continue to be the main surveillance elements for approach, en route and terminal areas.

### 3.4.3 **Brazil**

3.4.3.1 During the past years, DECEA has promoted radar modernization programmes, in addition to complementing the coverage with the installation of new stations. The result of these initiatives is that the radar network in Brazil is considerably new and the secondary radar coverage is complete for the whole of the Brazilian territory (over FL250).

3.4.3.2 Due to this infrastructure, the criteria for the application of minimum horizontal separations in the Brazilian airspace is in conformity with ICAO dispositions, varying in accordance with the available ATS surveillance, the structure and the complexity of the airspace where this is applied.

3.4.3.3 Surveillance system implementation plans are contained in FASID Table CNS 4A. The plans for the new surveillance systems are contained in the guide for the implementation of surveillance systems submitted to the sixth meeting of the CNS ATM Subgroup (ATM/CNS/SG/6).

3.4.3.4 Regarding improvements to be introduced in surveillance systems, it may be noted that Brazil is contemplating the replacement of radar sensors of conventional surveillance systems for other radars in the short and medium term. Actions foreseen are contained in Annex J to its Plan.

3.4.3.5 Regarding services under the ICAO CNS/ATM concept, ADS-C service was implemented in the Atlantico FIR in 2009.

3.4.3.6 The high precision and updating rate of the information provided by the ADS-B has the potential to increase safety upon applying aircraft separation at the current environments covered by radars, as well as reduce the great separations applied to aircraft at non-radar environments, which installation of this type of surveillance is not justifiable under the cost/benefit point of view.

3.4.3.7 In the short term (2013), ADS-B will be introduced for offshore operations at Bacía de Campos. Likewise, a wide area mutilation (WAM) system will be implemented at the TMA- VT by 2014.

3.4.3.8 In the medium term, ADS-B implementation all over Brazilian continental airspace will be completed in 2018, followed by the elimination of secondary radar coverage overlaps for en-route operations (this requires users to be duly equipped with ADS-B).

### 3.4.4 **Chile**

3.4.4.1 Regarding the services under the ICAO CNS/ATM concept, Chile has implemented an ADS-C system at the Océánico control centre, which is used for flight surveillance in areas under its jurisdiction in the South Pacific.

3.4.4.2 Amongst the improvements to be introduced in surveillance systems for conventional services, Chile has plans to renew its equipment, reinforcing the southern area of the country. Regarding services under the ICAO CNS/ATM concept, and with respect to ADS-B, there are plans to study the possibility of implementing an ADS-B system at some airports of the country.

### 3.4.5 **Colombia**

3.4.5.1 Regarding services under the ICAO CNS/ATM concept, Colombia has not implemented any ADS-B system.

3.4.5.2 Amongst the improvements to be introduced in surveillance systems for conventional services, Colombia has plans to update its PSR/SSR radar systems and to install a new MSSR radar system at San Andrés in the short term. Regarding services under the ICAO CNS/ATM concept, and with respect to ADS-B, there are plans to expand the MLAT in the medium term to achieve WAM for both terminal area and en route.

### 3.4.6 **Ecuador**

3.4.6.1 There are 3 radars located in Guayaquil, Quito and Galápagos. Regarding services under the ICAO CNS/ATM concept, Ecuador has no ADS-B or ADS-C system.

3.4.6.2 Amongst the improvements to be introduced in surveillance systems for conventional services, Ecuador has plans to install PSR and MSSR radar systems in the short and medium term, as well as MLAT. The plans for the new radars are contained in the guide for the implementation of surveillance systems submitted to the sixth meeting of the CNS/ATM Subgroup (ATM/CNS/SG/6). Regarding services under the ICAO CNS/ATM concept, and with respect to ADS-B, Ecuador has no implementation project.

### 3.4.7 **Guyana**

3.4.7.1 Guyana has no radar systems. Its CNS Plan specifies that they will “seek the necessary information for radar data sharing”.

3.4.7.2 In addition, Guyana has scheduled the implementation of an ADS-B system in the short term.

### 3.4.8 **Paraguay**

3.4.8.1 At national level, Paraguay currently has only one secondary radar Mode S operating in Asunción.

3.4.8.2 Likewise, regarding services under the ICAO CNS/ATM concept, Paraguay foresees that the use of ADS-B in continental area will gradually increase in the air navigation system.

### 3.4.9 **Peru**

3.4.9.1 At present, Peru has 7 Mode S radar systems at national level, 1 Mode S radar in Lima, and 1 PSR/MSSR radar system in the city of Lima.

3.4.9.2 In 2009, Peru tested an ADS-B station. In the medium term, (2011-2015), there are plans to conduct tests with the ADS-B system, and the first ADS-B stations based on Mode S ES receivers will be implemented at national level. Currently, an ADS-B system has been implemented in Pisco (210 km south of Lima) but has not been commissioned yet. This system would initially be on trial and then integrated into the Lima ACC.

3.4.9.3 In the long term (2015-2025), the existing Mode S SSR radars will not be renewed and will be replaced at the end of their useful life (around 2020) by ADS-B ES systems.

#### 3.4.10 **Suriname**

3.4.10.1 Suriname has no air surveillance systems. Amongst the improvements to be introduced in surveillance systems for conventional services, Suriname is planning to introduce PSR and SSR soon at the Zanderij/J.A.Pengel international airport.

3.4.10.2 Regarding services under the ICAO CNS/ATM concept, Suriname has no plans for their implementation and, thus, does not foresee the implementation of ADS-B.

#### 3.4.11 **Uruguay**

3.4.11.1 Currently, there are 2 radar locations: Carrasco and Durazno.

3.4.11.2 For the time being, there are no plans to implement ADS-B, only ADS-C for the oceanic sector in the next five years. Regarding services under the ICAO CNS/ATM concept, Uruguay has no ADS-B systems.

3.4.11.3 Amongst the improvements to be introduced in surveillance systems for conventional services, Uruguay has plans to replace the system in Carrasco for a new ASR.

3.4.11.4 Regarding services under the ICAO CNS/ATM concept, Uruguay has no plans to implement ADS-B for the time being, only ADS-C for the oceanic sector in the next five years.

#### 3.4.12 **Venezuela**

3.4.12.1 Venezuela has radars, whose location and characteristics are described in the FASID table.

3.4.12.2 Regarding services under the ICAO CNS/ATM concept, and with respect to ADS-B, Venezuela has foreseen its implementation after 2015.

#### 3.4.13 **Summary of the current status in the SAM Region**

Country	No. of radars	Plans to install ADS-B (*)	Defined area
Argentina	12	YES	Radar coverage gaps.
Bolivia	1	NO	N/A
Brazil	75	YES	Bacia de Campos (oil producing area)
Chile	11	YES	Some airports of the country

Country	No. of radars	Plans to install ADS-B (*)	Defined area
Colombia	15	YES	Multilateration (MLAT) to obtain wide area coverage (WAM) with ADS-B functionality at selected airports.
Ecuador	3	NO	N/A
Guyana	0	NO	N/A
Paraguay	1	YES	N/A
Peru	9	YES	Pisco. Radar coverage gaps.
Country	No. of radars	Plans to install ADS-B (*)	Defined area
Suriname	0	NO	N/A
Uruguay	2	NO	N/A
Venezuela	10	YES	After 2015. Not yet defined.

(\*) Information obtained from CNS improvement action plans of the States and provided by the States at the SAM/IG/10 meeting. When the State has not specified its plans to implement ADS-B, it is assumed that it has no plans.

### 3.4.14 Radar coverage diagrams

3.4.14.1 Appendix 7, “SAM radar coverage diagrams” shows the estimated line of sight of the various radar systems in the SAM Region, at 25,000 feet.

3.4.14.2 To calculate coverage, use was made of software that automatically calculates coverage, using NASA SRTM (Shuttle Radar Topography Mission) data as terrain data, considering a radar tower height of 15 m, and also taking into account the curvature of the earth for a flight level of 25,000 feet. Brazil and Colombia provided their respective coverage diagrams.

3.4.14.3 The diagrams show that the area with the least radar surveillance coverage is located in Bolivia, Paraguay and along their boundaries with Argentina, areas in which implementation could start at regional level.

## 4. CONSIDERATIONS FOR THE INSTALLATION OF AN ADS-B SYSTEM AND THE TRANSFER OF ITS SIGNAL TO AN AUTOMATED CONTROL CENTRE

### 4.1 General

4.1.1 Although an ADS-B system can be considered as a technology easy to install, it requires consideration of aspects related to electric facilities, air conditioning, and security, just like any other aeronautical facility, except that its requirements will be minimal.

4.1.2 Consequently, it is important to conduct a site study of the facilities before defining where the ADS-B will be installed.

4.1.2.1 This study must cover:

- a) Electric supply
- b) Civil infrastructure
- c) Environmental conditions. Suitable environment in terms of temperature and humidity
- d) Security

- e) Assessment of electric power characteristics at the site
- f) Connectivity platform
- g) Analysis of the site, clearway, and cone of silence
- h) Radio electric study of the site to avoid possible interference

4.1.3 If all this were available (installed capacity for integrating ADS-B Indoor and Outdoor to the locations), cost savings would be obtained in terms of UPS, power generator, lightning rod, grounding, castle or mast, security system sensors, the security system itself, etc. Likewise, a connectivity platform with the electric characteristics required to link the physical interface of the ADS-B radar data processor with both the system GUI and the control centre to which it is to be integrated will avoid the need to contract media for only the ADS-B service.

4.1.4 System reliability and availability depends on its quality and structure. Consequently, it is advisable to request dual and/or redundant systems. Redundancy is normally provided at the level of processing channels, data transmission networks, safety, etc.

4.1.5 In the specific case of the Peruvian experience with the ADS-B and installed in Pisco, a series of adaptations have been required. To this end, CORPAC (Peru's ANSP) has made available 2 rooms for ADS-B equipment (one for the sensor and the other for the test equipment).

4.1.6 These premises already had in place all the facilities cited in the previous paragraph, except for the means of transportation and management of the ADS-B radar signal up to the Lima ACC, which is its final destination. To that end, CORPAC personnel used the existing REDAP platform, from which 2 terminals from other services had to be withdrawn in order to have sufficient bandwidth to carry the ADS-B signal from Pisco to Lima. We mention this experience as a reference so as not to neglect any aspect when implementing an ADS-B system.

## 4.2 **Typical equipment in an ADS-B OUT ground station**

4.2.1 Typically, an ADS-B system consists of the following equipment, materials, and accessories:

- a) Antenna array
- b) RF receiving equipment (radio frequency)
- c) Surveillance data processor
- d) Communications unit (link)
- e) Networking units (data communications network)
- f) GUI and ACC interface unit (in general, the ATS destination unit)
- g) Surveillance data display system
- h) ADS-B and processed data maintenance, configuration, and administration management system
- i) ADS-B test transponder
- j) GPS synchronisation unit
- k) RF and electric cabling
- l) Trays, ducts, conduits, and accessories
- m) Grounding points
- n) Lightning arrester
- o) Uninterruptible power supply - UPS
- p) Electric generating set
- q) Security system, involving intrusion, overheating, smoke, and fire sensors; video cameras to record indoor and outdoor environment

- r) Air-conditioning system (at least air conditioning, humidity control, and dust filters)
- s) Static charge prevention or elimination system or materials. Currently, disposable shoe straps are commonly used in electronic environments subject to static damage.

### 4.3 Required infrastructure

#### 4.3.1 Typical ground infrastructure

- a) Normally, 2 cabinets are required (of a type suited to the physical characteristics of the manufacturer's equipment) and a castle or mast to install the ADS-B antenna and the lightning arrester system.

Indoors:

Cabinet 1: Contains:

- ADS-B data processor
- Communications unit
- Networking units
- GUI and ACC interface unit (or, in general, the ATS destination unit)

Cabinet 2: Contains:

- Display unit.
- ADS-B and processed data maintenance, configuration, and administration management unit.

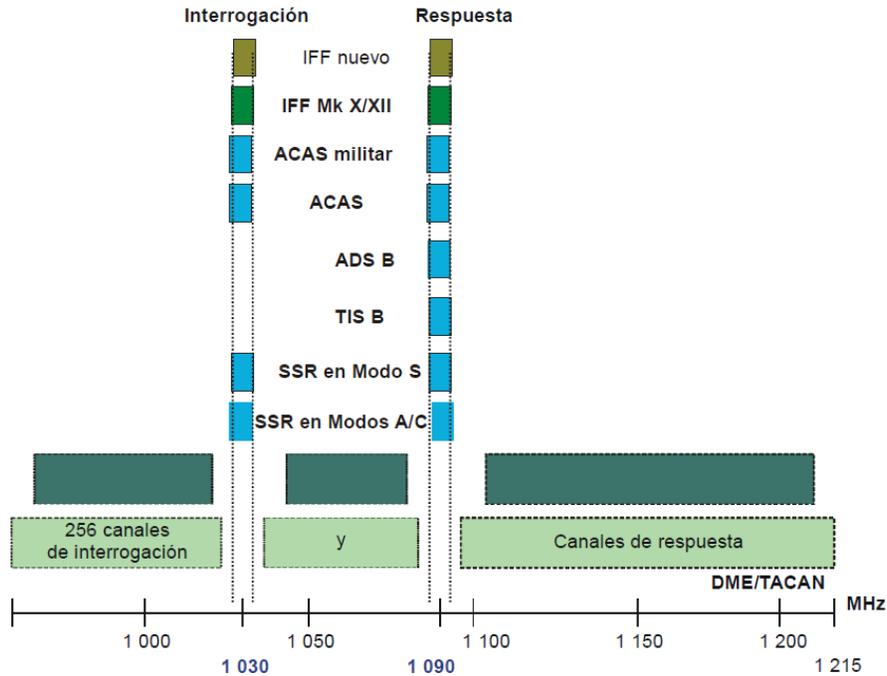
Outdoors:

Mast or castle: Contains:

- Antenna
- RF cabling
- Lightning rod, on top of the castle or mast
- Lightning rod power lines

- b) The location, at a distance previously determined by the provider of the installation in such a way as to avoid losses from excessive cabling, shall have:
  - Lightning rod grounding with resistance values not to exceed 30 ohms
  - ADS –B system grounding with resistance values not to exceed 5 ohms
- c) Aerial trays are recommended for placing the data cables to connect indoor equipment and to connect indoor to outdoor equipment. Data and electric cabling trays must be different in order to avoid electromagnetic interference that will affect data cabling and thus the ADS-B system.
- d) Environmental considerations: Cleaning. Dust is extremely detrimental for the proper operation of equipment; consequently, normal cleaning and general maintenance of the room are essential to avoid problems, especially in connectors and disc units.

- e) Interference and disturbances: Different sources may generate interference and/or disturbances. To solve that, there are some products that may be considered.
- Electric discharges: Rugs and low humidity are two main static generators. The equipment should not be installed in rooms with rugs or similar materials, and the humidity range in the room must be controlled. Low humidity is equivalent to static, thus the importance of maintaining humidity within certain ranges. Accordingly, consideration must be given to installing antistatic floors suitable for technical rooms.
  - Electromagnetic radiation: Data and electric power cables must run on different trays, maintaining the necessary separation to avoid radiation and interference (needless to say, in case of interference, the data cabling will be the most affected).
  - Site assessment: The area to be selected must be as free as possible of obstacles or it must be assured that the terrain model will not be modified in a way that will affect the line of sight of the ADS-B receiver with respect to the air fleet to be served. Likewise, the cone of silence concept must be kept in mind. It is better to foresee a value for the cone of silence than not have any, since, under actual operating conditions, there will be a coverage blind area. Accordingly, a theoretical value between 30 and 90 degrees may be assumed to avoid subsequent surprises.
  - Interference to/from other stations: In the ATC environment, SSR, ADS-B, ACAS and military IFF systems use the same frequencies (1 030 MHz and 1 090 MHz) (see Figure 4). Technical and operational changes in one of the aforementioned systems has consequences on the system itself, on the system involved, on other systems operating on the same frequencies, and even on systems that operate on neighbouring frequencies (*e.g.*, DME). The following figure shows 1 030/1 090 MHz systems as part of the 960 MHz–1 215 MHz aeronautical frequency band. Interference may lead to degradation of system performance, with loss of information or erroneous information. Thus, when selecting the site to install ADS-B antennae, consideration must be given to physical and frequency proximity to other navigation systems at the airport, especially DME systems and surveillance radars.



**Figure 4. Channels and frequencies in the 960 MHz – 1 215 MHz aeronautical frequency band**

f) **Temperature:** System operation will be more reliable if temperature is kept within a stable range (more conservative than that specified in the manufacturer's manual), the recommendation being between 20° and 25° C. High and unstable work temperatures increase the frequency of circuit failure. However, systems can work for short periods of time at higher or lower temperatures, and it is recommended that ADS-B equipment suppliers be requested to provide the values of the following parameters:

- Operating temperature:
- Minimum temperature:
- Maximum temperature:
- Temperature variations: expressed in T°/ time (° C / hour)
- Instantaneous variations: expressed in T°/ time (° C / minute).

g) **Humidity:** It is recommended that the relative humidity in the rooms selected for the installation be kept between 40% and 60%, with no condensation. Low humidity levels can produce static electricity, while high humidity levels can cause problems in paper feed to printers, as well as fungi problems in magnetic tapes and discs.

The following humidity specifications are recommended:

- Relative air humidity: 40 - 60%, with no condensation.
- Maximum relative humidity: 80%.
- Minimum relative humidity: 30%.

- h) Air conditioning: The air conditioning system shall maintain the temperature and humidity of the room within the indicated specifications.

#### 4.3.2

#### **Installation design structure**

- a) Identification of rooms and sites

Order is important in any facility, even more so in critical systems such as those related to the aeronautical service. Therefore, the establishment of an identification system is the most relevant activity towards the attainment of such order. This will facilitate the task of maintaining and assessing the behaviour of this type of system. It is recommended that system positions be numbered for purposes of identification, giving each system component an identifier, with different prefixes to indicate location, floor, environment, rack, rack level, and the corresponding numbering. Similarly, structured cabling recommendations must be unrestricted. The system supplier must be requested to provide general diagrams of ADS-B connections under the established identification system, as well as of ADS-B LAN cable connections, antennae-rack connections, and connections to the GPS, NTP servers and remote clocks.

- b) Identification cabling

- A checklist must be produced with information on point-to-point cable connections.
- Each rack must have a physical list of the cables associated to that rack.
- Likewise, cable labels must contain all the information associated to the rack.
- Each cable contained in the list is identified by a reference number, which is linked to a list of cable suppliers, with manufacturing details concerning signal/names/functions.
- Each label must precisely indicate the beginning and the end of the cable, as well as where should it be connected within the cabling array.

The types of cables normally installed are:

- Radar cabling between the antennae and the filters, between the filters and radar data processors, between processors and the KVM (keyboard, video and mouse), between GPS antennae and processors. To this end, coaxial cables, such as RG-58, RG-214, RG-179, are normally used. Cable gauges will depend on the distance and the technical details of each manufacturer.
- For indoor cables that connect processors to information output interfaces for radar or data display or management, RJ45 Cat 5E is used as a minimum. It would be even better if a superior category of structured cable is used in accordance with standard T568B.

- c) Required capacity of the national aeronautical network

- The means of transportation of the signal must take into account the protocols and formats of the radar data provided by the ADS-B.

- Due to the nature of the service, ADS-B data must have an IP medium compatible with the Multicast UDP-type transport level protocol. This usually complicates the link between the ADS-B sensor and the ACC, since public service providers normally use the TCP transport layer protocol for their networks and for providing IP services.
- CORPAC has a frame relay network that has been used to link the ADS-B from Pisco to Lima.

#### 4.4 **Receiver autonomous integrity monitoring (RAIM)**

4.4.1 It is expected that the first ADS-B implementations will use GNSS for positioning. In this regard, since the availability of GNSS data has a direct impact on the provision of surveillance services, ATS service providers can choose to use a GNSS integrity prediction service to help determine the future availability of usable ADS-B data.

4.4.2 The service integrity prediction alerts users to a possible future loss or degradation of the ADS-B service in defined areas. With these alerts, the system is warning users that at some point in the future, ADS-B position data may be insufficient to support the ADS-B separation application.

4.4.3 It is advisable that the prediction service be made available to each ATS unit that uses ADS-B for the provision of separation services, to make sure that air controllers are warned before any foreseen degradation of the GNSS service and the resulting reduced ability to provide flight separation ADS-B within the affected area. This is similar to having advanced warning of a planned interruption of the radar system due to maintenance.

4.4.4 ADS-B must not be used to provide separation between aircraft during the period in which it is expected that the integrity of position reports will not be adequate.

4.4.5 If an unexpected loss of integrity occurs (including a crew RAIM alert report), then:

- a) ADS-B separation must not be used by ATC for aircraft until integrity is assured, and
- b) The controller must check if other nearby aircraft have filed RAIM alert reports to see if they have been affected and to establish alternative means of separation if necessary.

4.4.6 More information about RAIM can be found in Appendix 8 to this document.

#### 4.5 **Operational tests**

4.5.1 Once the ADS-B system has been installed, a cabling installation certificate must be requested from the manufacturer or responsible company.

4.5.2 The ADS-B transponder testing system will permit the necessary target adjustment in order to achieve optimum signal integrity. This system is referential.

4.5.3 Regarding operational tests, these must start with a physical level link tests and, if successful, continue with UDP multicast traffic transmission tests from the sensor location to the ATS destination unit. For Peru, the test was conducted from Pisco to Lima (REDAP room node-Lima).

4.5.4 If successful, the next tests are to check if the data received is compatible with the application of the air traffic management system provider, which must be capable of processing data in the ASTERIX CAT 21 ed 1.8 protocol.

4.5.5 Regarding the bandwidth of the means of transportation for Lima, the peak is 18 kbps, but this will depend on the number of aircraft with ADS-B avionics that circulate through the airspace to be controlled. The recommended bandwidth for the means of transportation is no less than 64 Kbps.

4.5.6 Flight check tests are an integral part of ground-based ADS-B system testing. The aircraft to be contracted must be properly equipped with 1090 MHz Extended Squitter (1090ES) transponders and recording equipment. Flight routes must be established to test both uplink and downlink services within the defined airspace. More information on flight check testing can be found in Appendix P to Doc 9924 - *Aeronautical Surveillance Manual*.

4.5.7 The information required for assessing the ADS-B system through flight tests must include performance parameters, including minimum ADS-B information update interval, volume of coverage over the geographical area where the ADS-B service is to be provided, radar data accuracy, identification data, maximum data latency, and data validation functions.

4.5.8 An important aspect that must be tested is ADS-B interoperability in the surveillance setting of each State, to ensure that ADS-B will not degrade systems already operating in 1090 MHz. This interoperability with other systems in RF frequencies must be one of the objectives of operational tests.

4.5.9 The flight test methodology can be found in WP ASP12-05-Doc-9924 “Change Proposal for Guidance Material on Flight Testing of New Surveillance Systems”.

4.5.10 Another important aspect is the sharing of the means of transportation. Although service integration is what is recommended today, it is important to note that the means should prioritise services. That is, if it is decided that the means of transportation carrying the ADS-B signal will also carry essential services like G/G or G/A speech communications, bandwidth segmentation or assignment techniques should be used to prevent surveillance data information from interfering with speech communications, causing mini voice interruptions (on-line service that admits no delays).

## 4.6 **Training of technical personnel**

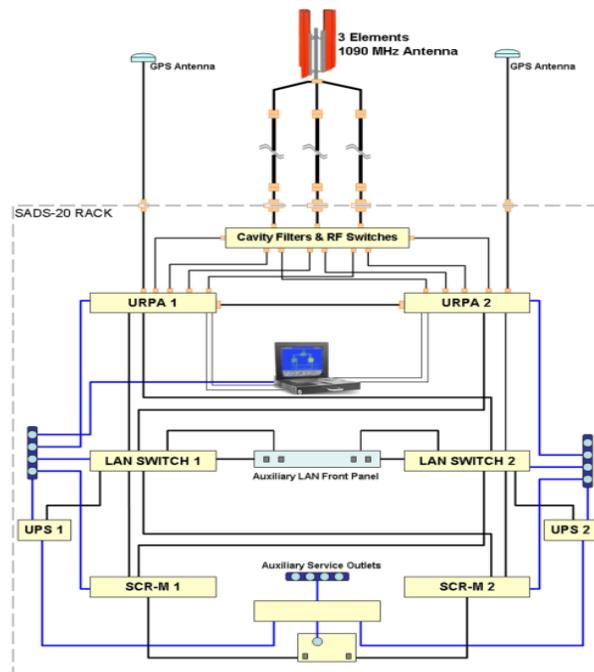
4.6.1 The technical personnel at the sensor site and at the management site of the network that carries the ADS-B signal must be involved in the installation and testing from the beginning. Likewise, they must receive training on the structure of the system, operating characteristics and conditions, radar signal flow, and every technical detail that allows the system to operate under the foreseen nominal conditions.

4.6.2 At the network management site, the bandwidth used for the ADS-B system multicast traffic must be monitored, and the respective changes of processing channels must be coordinated, if applicable, with the resident technician in case remote management or other type of activity is not available.

4.6.3 A final recommendation is that personnel in charge must at all times remember that if the ranges and data specified by the system manufacturer are disregarded, the useful life of the equipment will be degraded and, consequently, reliability will be lost.

## 4.6.4

The ADS-B system model presented below (Figure 5) may serve as a reference.



**Figure 5: ADS-B Architecture Model**

The architecture is composed by the following elements:

- Antenna set:
  - Three independent sectors
- Distribution of RF signals:
  - Set of radio frequency filters and relays
- ADS-B processing receiver unit (APRU):
  - 3 1090-MHz receiver cards
  - 3 processing cards
  - 1 GPS synchronisation card
  - 1 software card (Linux OS)
- Local management system (local control and monitoring)
  - Based on the Unix system
  - System capable of integration with the APRU or any other equipment.
- Communication system:
  - Two (2) redundant LAN networks
  - Routers

5. **FUNCTIONAL RECOMMENDATIONS FOR AUTOMATED AIR TRAFFIC MANAGEMENT SYSTEMS TO BE USED WITH ADS-B IN THE SAM REGION**

5.1 In order to achieve a common interoperability standard for the use of ADS-B in the SAM Region, in addition to that provided for in Chapter 8.2 of Doc 4444, automated air traffic management systems used by ANSPs should have at least the following technical and operational characteristics:

- a) If navigation information is degraded according to the appropriate State ATS authority, the control centre should be able to determine when the reported accuracy and integrity values are sufficient to support a given application (*e.g.*, control with ATC surveillance for 5NM separation). Consequently, it should be capable of entering the allowable information quality and integration (NUC, NIC/NAC/SIL) threshold values that correspond to the ADS-B message version. States should be able to configure these parameters without the intervention of the provider.

**Note:** Reference: Doc 4444 Chapter 8.1.10 and, for more details about these concepts and ES performance, see document DO-260A Chapters 2, 3 and 4.

- b) Appropriate visual alarm display at the ASD in case of deterioration of the minimum value(s) entered as per paragraph a) above, so that ATS units may distinguish between a radar blip, a multilateration blip, and an ADS-B blip (or a combination of these) beyond the limits established for providing separation in the airspace concerned (ref. Doc 4444 Chapter 8.2.5).
- c) For the purpose of analysis and study by the States, it is recommended that automated systems maintain ADS-B plot generation capability, even beyond the established limits mentioned in paragraph “a” above, for non-operational display (technical monitoring). However, these out-of-limit plots should not be taken into account by the multi-tracker for merging with data from other sensors.
- d) Information displayed on the ASD about the type of surveillance sensor used (whether one or several sensors), so as to identify each combination.
- e) Performance of the information on the corresponding parameters received in ADS-B messages (ADS-B-ADD) concerning the safety nets processed by the surveillance system SDP or FDP, as appropriate (see Appendix 1, “ADS-B operational applications”).
- f) Processing of ASTERIX Category 21 edition 1.8 messages (Appendix 9 “Asterix Category 21 Ed. 1.8”)
- g) Capability of processing “version 0” and “version 1” ADS-B messages simultaneously (ICAO Annex 10, Volume 4, item 5.2.4).