



SAM/IG/4  
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**International Civil Aviation Organization  
South American Regional Office**

**FOURTH WORKSHOP/MEETING OF THE SAM IMPLEMENTATION GROUP (SAM/IG/4)  
REGIONAL PROJECT RLA/06/901**

**Lima, Peru, 19-23 October 2009**

**Agenda Item 6:           Assessment of the operational requirements to determine the  
implementation of improvements to communications, navigation and  
surveillance (CNS) capabilities for en-route and terminal area operations**

**FOLLOW UP OF ADS-B TRIALS IN THE SAM REGION - ADS-B TRIAL IN PERU**

(Presented by Peru)

**SUMMARY**

This paper contains information about ADS-B trials carried out in Lima, Peru, as part of the activities of the action plan for the conduction of ADS-B trials, formulated at the SAM/IG/2 meeting. Trials were possible thanks to the collaboration of Thales, which provided the equipment and personnel for the trial, free of charge. There was also active participation of personnel from the air navigation service provider of Peru, CORPAC, and support from the ICAO South American Regional Office.

**References:**

- GREPECAS/13 Conclusion 13/87;
- Report of the SAMIG/2 meeting: Appendix C to Agenda Item 5: Action Plan for the Implementation of ADS-B Trials in the SAM Region; and
- Report of the SAMIG/3 meeting: Agenda Item 6.

**1.                   Introduction**

1.1               The purpose of conducting ADS-B trials in Lima was to acquire hands-on knowledge of the technical aspects related to the installation and operation of an ADS-B ground station and a TSD (Technical Situation Display) terminal, in order to share ADS-B data collection results with SAM States for subsequent analysis in terms of coverage and information validation.

1.2 The trials carried out are consistent with the requirements established in GREPECAS Conclusion 13/87 - *ADS-B TRIAL PROGRAMME IN THE CAR/SAM REGIONS*: “That the States/Territories/International Organisations, in collaboration with airspace users, establish and implement an ADS-B trial programme using the available technology and services with a view to improving ADS-B knowledge and assessing the benefits for air traffic management in the CAR/SAM Regions”.

1.3 The SAMIG/2 meeting agreed to prepare the implementation of an ADS-B trial programme in the Region, as part of the activities of Regional Project RLA/06/901 “*Assistance for the implementation of a regional ATM system, taking into account the ATM operational concept and the corresponding technological support in communications, navigation, and surveillance (CNS)*”, establishing an action plan for the conduction of ADS-B trials and the holding of a seminar in 2009 to provide information on ADS-B technology and share trial results.

1.4 After defining the objectives of the trials, the CNS Officer of the ICAO SAM Regional Office and the rapporteur of the CNS Task Force coordinated with some ADS-B system manufacturers and providers that normally participate at ICAO events in the CAR/SAM Regions to see if they could provide ground equipment for conducting the trials in the Region, at no cost to Project RLA/06/901.

1.5 Of the manufacturers and providers consulted, only Thales ATM GMBH agreed to our request for equipment, assessment time, and support by specialised personnel for the seminar, at no cost to the project.

1.6 The ICAO SAM Regional Office requested the collaboration of CORPAC S.A., the air navigation service provider of Peru, to provide the location and personnel for the installation of the ADS-B equipment, CNS and ATM personnel to participate in the trials, and the facilities of the Civil Aviation Training Centre (CIAC) for conducting a seminar.

1.7 The SAMIG/3 meeting received information about the installation of an ADS-B ground station and a TSD (Technical Situation Display) terminal for the conduction of trials at the Jorge Chávez International Airport of Lima-Peru, at CORPAC facilities.

1.8 These ADS-B trials were carried out from 8 May 2009 to date. The seminar to present the results of ADS-B trials was postponed until next year, on a date to be defined. However, on 3-5 June 2009, at the facilities of CORPAC S.A., THALES ATM carried out a seminar on its ADS-B system for the Peruvian personnel.

## 2. **Analysis**

### *Trial objectives*

2.1 The main objectives of the trial were as follows:

- a) Obtain technical experience on the installation and configuration of an ADS-B ground station and TSD terminal;
- b) Collect radar data; and
- c) Analyse and process the collected ADS-B data.

*Considerations prior to the installation of the equipment*

2.2 The TSD terminal and the ADS-B ground station were installed at the premises of the air navigation service provider of Peru, CORPAC, at the radar building, in the briefing room and in the FDP radar equipment room (next to the Lima ACC Control Centre). This location was considered appropriate, given its easy access for local ATC personnel and CNS technical personnel and visitors, the availability of local connectivity (LAN), 220 VAC power with UPS, pole for the ADS-B/GPS antenna, and security. It should be noted that the control tower building of the Jorge Chávez Airport is an obstacle for this location.

*Technical description of the equipment used for trials*

2.3 The make of the ADS-B equipment installed was Thales, AS-68X family, AS680 series, consisting of:

- a) ADS-B receiving antenna;
- b) GPS antenna;
- c) Antenna amplifier unit;
- d) Signal processing unit (AS 680 SPU);
- e) Remote control and monitoring system (RCMS) of the ADS-B earth station;
- f) Local control and monitoring system (LCMS); and
- g) Technical Situation Display (TSD) terminal.

2.3.1 **Appendix A** illustrates the equipment used in the ADS-B trials, and contains an extract of the equipment data sheet.

*Activities carried out during the trial*

2.4 The activities carried out during the trials were the following:

- a) Installation of the ADS-B ground station and antennas (ADS-B and GPS);
- b) Installation of the TSD terminal;
- c) Operational tests;
- d) Practical training of CORPAC CNS and ATM personnel on the operation of the station;
- e) Development of a format for recording data;
- f) Data collection;
- g) Data analysis; and
- h) Presentation of results at the CORPAC seminar.

*Coverage of the ADS-B trial*

2.5 **Appendix B** illustrates the theoretical coverage (line of sight) of the station located in Lima, and the targets of both the radar system and the ADS-B ground station installed at the Jorge Chávez International Airport.

2.6 The coverage obtained during the ADS-B trials was:

- a) To the North-West: up to 260 nautical miles;
- b) To the North: up to 250 nautical miles;
- c) To the South: up to 240 nautical miles;
- d) To the South-East: from 180 up to 200 nautical miles; and
- e) To the East: up to 80 nautical miles.

#### *Data analysis*

2.7 The data provided by the TSD terminal are in ASTERIX CAT-21 format, edition 0.23 (EUROCONTROL). All of the information collected below corresponds only to aircraft operating within the coverage of both surveillance systems (ADS-B, secondary radar).

2.8 The analysis of the collected data revealed the following:

- a) **General data:** The following table shows the total data assessed and the daily averages.

	TOTAL	DAILY AVERAGE
Flights detected by RADAR	7956	306
Flights of aircraft equipped with extended Mode S	3925	151
Aircraft detected by ADS-B	1397	54

- b) **Comparison of data on speed and level:** Based on data collected on 11-29 May of this year, information on speed and level of the selected aircraft, provided by both surveillance systems (radar and ADS-B), at specific times or positions, was recorded and compared. The final averages of these data are summarised below:

AVERAGE OF DIFFERENCES BETWEEN THE TWO SURVEILLANCE SYSTEMS	
of recorded speeds (GS)	+/- 13 knots
of flight levels, between modes C and S	+/- (221 feet)

In the case of the average of recorded speeds, comparisons were not always possible because Mode S sometimes transmitted the true airspeed (TAS); speed fluctuations were between 1 and 40 knots.

The differences in the results of recorded flight level averages were in some cases nil. However, on other occasions, differences of 100 to 200 feet were recorded. The most outstanding case was that of an aircraft that showed a difference of 510.25 ft, which we assume to be the result of a series of errors (altimetry, transponder, rate of climb or descent, information update time), *inter alia*.

- c) **Identification errors:** The most frequent aircraft identification errors are shown below:



DESCRIPTION	QUANTITY	%
Number of flights with identification errors	597	15
Number of flights with an ID spontaneously changed by the software (apparent avionics – B744)	16	0.41
Number of flights with correct ID	3328	85
Number of flights analysed	3925	100

Of the 3,925 aircraft (with extended Mode S) analysed, 597 (15%) had flight identification errors.

It was noted that identification errors can be caused by an incorrect entry of, or failure to enter, the flight identification by the crew, an equipment or software error, as occurs with some B744s, which spontaneously transmit a “U” at the end of the assigned field. This letter appears only for a few seconds (9 to 10 seconds in most cases). However, especially in the case of errors generated by the crew, these problems can be corrected by providing proper training and information on this issue to the operators.

A particular case occurred on 5 June: an aircraft (IL96) overflying at FL350, with the correct flight identification but with the 24-bit address (assigned by ICAO), with characters that did not belong to that field (9.00E+66). According to the data collected, no other case of error in the 24-bit address field was recorded.

- d) **NUCp values obtained:** Regarding the NUC analysis (4-29 June), and taking into account a theoretical acceptable value of  $NUC > 4$ , the following was obtained:

NAVIGATIONAL UNCERTAINTY CATEGORY FOR POSITION (NUCP) DO-260A							
TOTAL NUMBER OF FLIGHTS WITH							
FOM/PA (0)	FOM/PA (2)	FOM/PA (3)	FOM/PA (4)	FOM/PA (5)	FOM/PA (6)	FOM/PA (7)	FOM/PA (8)
1297	25	18	37	183	2769	2681	1
1377				5634			

Some data transmission losses were recorded (excluding those caused by obstacles), which deserve a more in-depth investigation in order to assess the RAIM.

- e) **Percentage of flights with ADS-B response:** 18% of aircraft has extended squitter Mode S. In average, these aircraft conduct 50% of daily flights.

	DAILY AVERAGE PERCENTAGE
Aircraft with extended Mode S	18%
Flights conducted with extended Mode S	50%

- f) **Shadowing due to location:** Shadowing caused by the control tower building on aircraft in some parts of the movement area and to the North-West (approximately 300 radial of LIM) of the Jorge Chávez airport was confirmed during the tests.



2.9

### Conclusions

- a) First-hand knowledge has been acquired on the operation of the ADS-B surveillance system based on the extended Mode S;
- b) The difference and level of detail were derived from comparing the data provided by the ADS-B and radar surveillance systems;
- c) The large number of flights reported with extended Mode S points to the need for gradual implementation of standards, procedures and equipment for future operational use of ADS-B;
- d) Some problems have been identified, such as incorrect aircraft identification values, that warrant a subsequent analysis in future trials; and
- e) At present, the Peruvian State continues assessing the ADS-B station. It is also considered important to continue carrying out this type of trials in the Region and to share the experience.

3.

### Suggested action

3.1 The meeting is invited to consider the information contained in this paper and to review its **Appendices A and B**, so that they can serve as a reference for any State wishing to conduct ADS-B trials.

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## APPENDIX A

## TECHNICAL SPECIFICATIONS OF ADS-B EQUIPMENT

## AS 68x family

## ADS-B

## System Description

## Description, Operation and Maintenance

Received RF signals are converted into video signals by the RXU's logarithmic receiver, and analyzed by the Signal Processing Board in order to reliably detect ADS-B signals. The decoded data are collected and further processed by the application software of the SBC. The optional GPS Timing System provides a positive system time reference to support the SBC's real time clock. It also provides additional information about GPS status, like position, dilution of precision, number and identity of satellites visible and – optionally – also GPS integrity information in the same way as an ADS-B target (RAIM / HPL). The ground station constantly verifies GPS health by checking the deviation of the measured GPS position versus the configured ground station position.

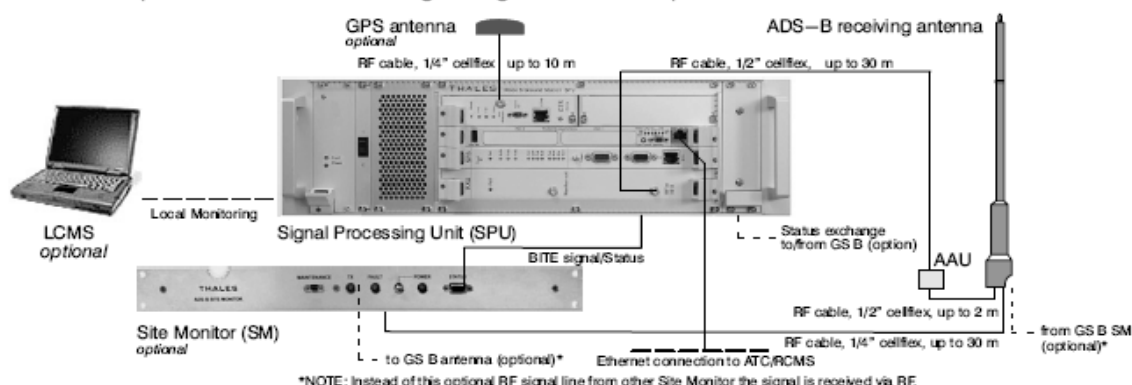


Fig. 1-5 ADS-B serviceable ground station equipment (exemplary view)

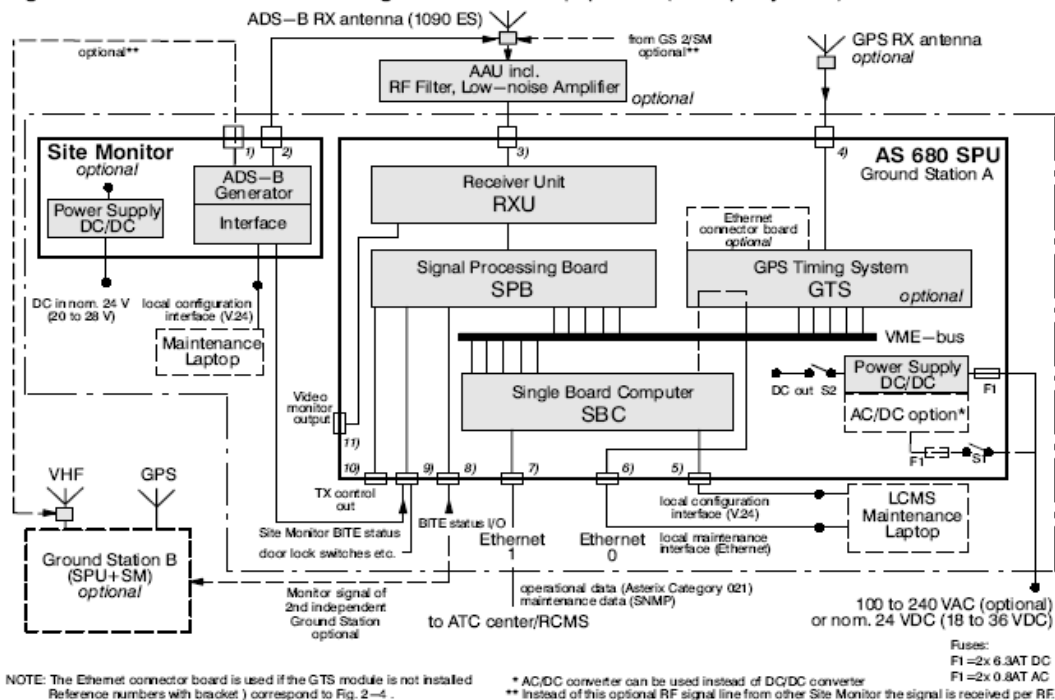


Fig. 1-6 ADS-B serviceable ground station architecture, exemplary configuration

**ADS—B****AS 68x family**

Description, Operation and Maintenance

*System Description***1.5 TECHNICAL CHARACTERISTICS****1.5.1 Dimensions and Weight**

AS 680 basic system:

— AS 680 SPU equipped; HxWxD; weight 19", 3HU; 133x482x250 mm; approx. 7.1 kg

Site Monitor (SM) option; HxWxD; weight 19", 1HU; 43x482x250 mm; approx. 1.0 kg

Configured system versions (optional):

AS 681 with cabinet, equipped; HxWxD; weight 19", 9HU; 600x600x600 mm; approx. 90 kg

— SPU, HxWxD; weight 19", 3HU; 133x482x250 mm; approx. 7.1 kg

— SM, HxWxD; weight 19", 1HU; 43x482x250 mm; approx. 1.0 kg

— Data Switch, HxWxD; weight 19", 1HU; 43x482x180 mm; approx. 1.5 kg

— UPS, basic, HxWxD; weight 19", 2HU; 86x444x410 mm; approx. 19 kg

AS 682 with cabinet, equipped; HxWxD; weight 19", 24HU; 1200x600x600 mm; approx. 150 kg

— SPU, HxWxD; weight (2x) 19", 3HU; 133x482x250 mm; approx. 7.1 kg

— SM, HxWxD; weight (1x) 19", 1HU; 43x482x250 mm; approx. 1.0 kg

— Data Switch, HxWxD; weight (1x) 19", 1HU; 43x482x180 mm; approx. 1.5 kg

— UPS, basic, HxWxD; weight (2x) 19", 2HU; 86x444x410 mm; approx. 19 kg

— UPS, extension, HxWxD; weight (2x) 19", 2HU; 86x444x410 mm; approx. 25 kg

**1.5.2 Peripheral Equipment**

ADS—B RX antenna options:

— Omnidirect. Kathrein, 11.5 dBi, H,Ø; weight max. 3420 mm, 60 mm; approx. 26 kg max.

— Omnidirectional FAN96, 9 dBi, H,Ø; weight max. 2700 mm, 60 mm; approx. 24 kg max.

— Omnidirectional AAN186, 6 dBi, H,Ø; weight max. 1640 mm, 90 mm; approx. 10 kg max.

Antenna Amplifier Unit (AAU), HxWxD; weight 280x180x105 mm; approx. 4 kg

— AAU support and cover, HxWxD; weight 300x255x220 mm; approx. 5 kg

GPS antenna (option), (HxW); weight (2x) 60x100 mm; approx. 0.3 kg

**1.5.3 Power Supply**

SPU

AC voltage input (AC/DC converter option) 100 to 240 VAC, 50/60 Hz, single phase

DC voltage input (DC/DC converter option) nom. 24 VDC, 18 to 36 VDC, max. 4.5 A

Power consumption approx. 55 VA

Site Monitor (option)

AC voltage input via plug—in mains supply 100 to 240 VAC, 50/60 Hz (DC out 24 V)

Power consumption approx. 5 VA

DC voltage input nom. 24 VDC, 20 to 28 VDC, max. 1 A

Data Switch (option)

AC voltage input 100 to 240 VAC, 50/60 Hz, single phase

DC intern 5 V, max. 8 A

UPS type (option)

AC voltage input / max. current RS 1000 with 1 battery extension

AC voltage output 160 to 276 VAC, 50 Hz, single phase / 6.0 A

Power rating 208/220/230/240 VAC / 50 Hz

Batteries approx. 1000 VA (700 W)

Battery extension 3x 12V, 7Ah

Typical battery time (battery mode) in [min] 1

53 (100 % load), 122 (50 % load)

**AS 68x family****ADS—B***System Description**Description, Operation and Maintenance***1.5.4 Environmental Conditions**

## Ambient temperature

Operation indoor (SPU, Data Switch, SM, UPS)	+10 to +40 °C
Operation outdoor equipment (antennas)	−40 to +70 °C
Transport	−55 to +70 °C

## Relative humidity

indoor	max. 90%, non condensing
outdoor	max. 95% (−10 to +39 °C); max. 50% (40 to 70 °C)
non operation and transport	up to 100 % with condensation

## Max. wind velocity optional antennas

Antenna Kathrein (11.5 dBi)	max. 130 km/h
Antenna FAN96 (9 dBi)	max. 150 km/h
Antenna AAN186 (6 dBi)	max. 180 km/h

**1.5.5 System Data Ground Station AS 68x**

## ADS—B System

Ground station with redundant equipment, built by 2 SPU, coupled via Data Switch to ADS—B LAN

## Report generation

ASTERIX CAT 21 reports

## Communication interface

UP/IP, SNMP on UDP/IP, SSH, SCP on TCP/IP

**1.5.5.1 Signal Processing Unit (AS 680 SPU)**

## Receiving signals

1090 ES ADS—B, GPS L1—band 1575.42 MHz

## Coverage range

up to 150 NM at flight level > 300, omnidirectional

## Capacity (GS)

> 250 targets

## Report generation

ASTERIX CAT21 (ADS—B)

**1.5.6 Interfaces**

## AS 680 SPU

## — PC connector \*/\*\*

Serial, SubD, 9 pin, male

## — Data interface connector \*/\*\*

RJ45, Ethernet 10/100Base—T

Serial, V.24, MicroSubD, 9 pin, female

## — Others \*/\*\*

Serial, RS232, SubD, 9pin, female

BITE, RJ45, 8pin;

Status Interface I/O, SubD, 15pin, female

## Site monitor

## — Communication/control \*/\*\*

Serial, RS232, MicroSubD, 9pin, female;

## — Status \*/\*\*

Status Interface I/O, SubD, 15pin, female

## — Data interface connector (ADS—B LAN) \*/\*\*

2x RJ45, dual port Ethernet, 1000Base—T

## Data Switch (ADS—B LAN) \*/\*\*

2x 8 connectors RJ45, Ethernet, 1000Base—T

\* according IEC60950    \*\* SELV—circuit (Safety Extra Low Voltage)

**1.5.7 Conformity and Licensing Approval**

The AS 680 ground station SPU is compliant to ICAO Annex 10 and to current European Regulations for human health (low voltage directive) and electromagnetic compatibility (EMC). It complies with the requirements of EC Guideline 89/336/EEC in its implementation. It also fulfills the requirements of the following EMC Guidelines:

- Emission Test: EN 55022 (1998); EN 61000—3—2 (1995); EN 61000—3—3 (1995)
- Immunity Tests: EN 55024 (1998); (EN 61000—4—2 (1995); EN 61000—4—11 (1994))



ADS-B antenna



Panorámica del mástil y Antena ADS-B



ADS-B ground station

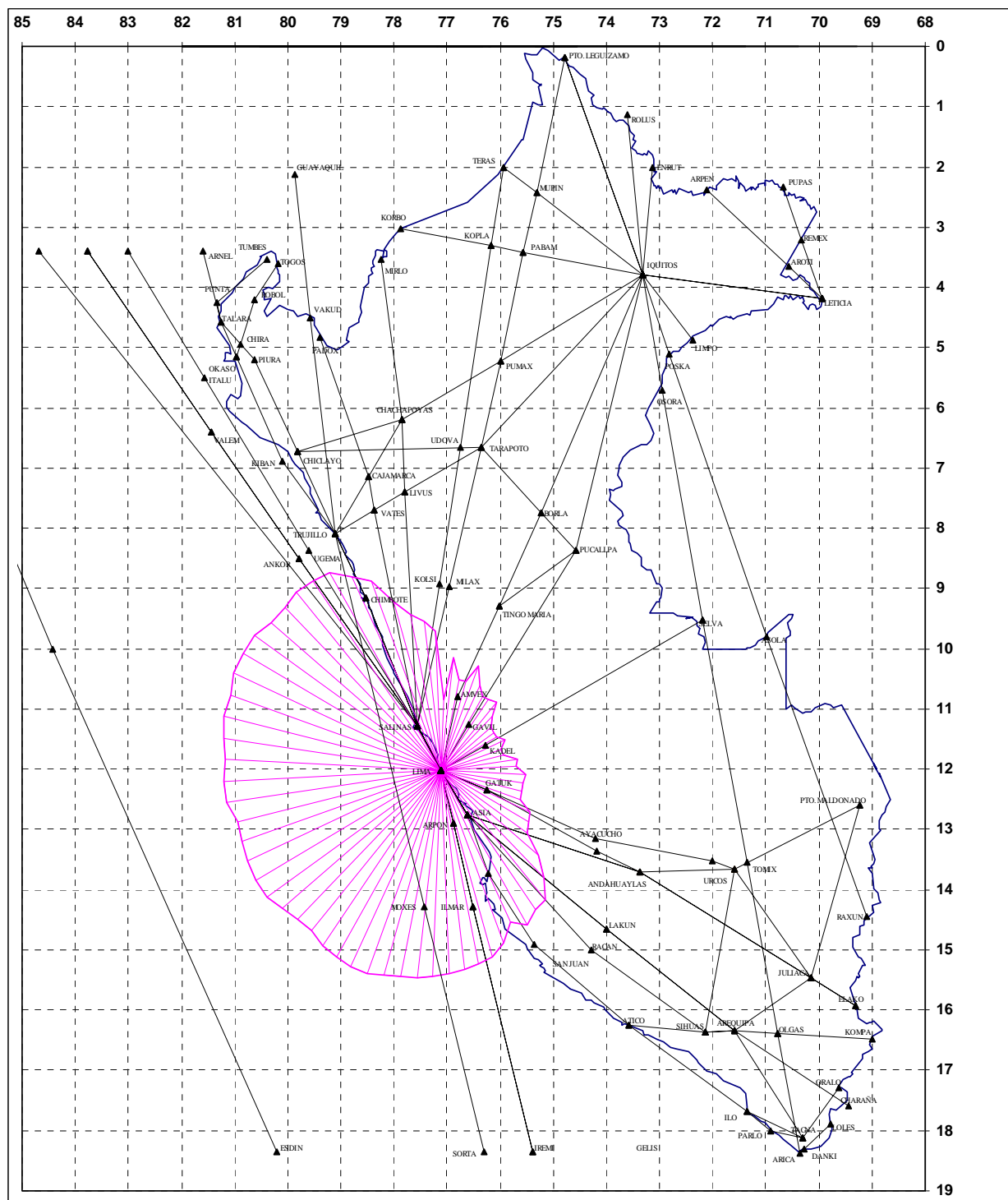


TSD  
(Technical Situation Display)  
terminal



View from the ADS-B antenna  
North of the Jorge Chávez airport

## THEORETICAL COVERAGE OF THE JORGE CHAVEZ AIRPORT - LIMA

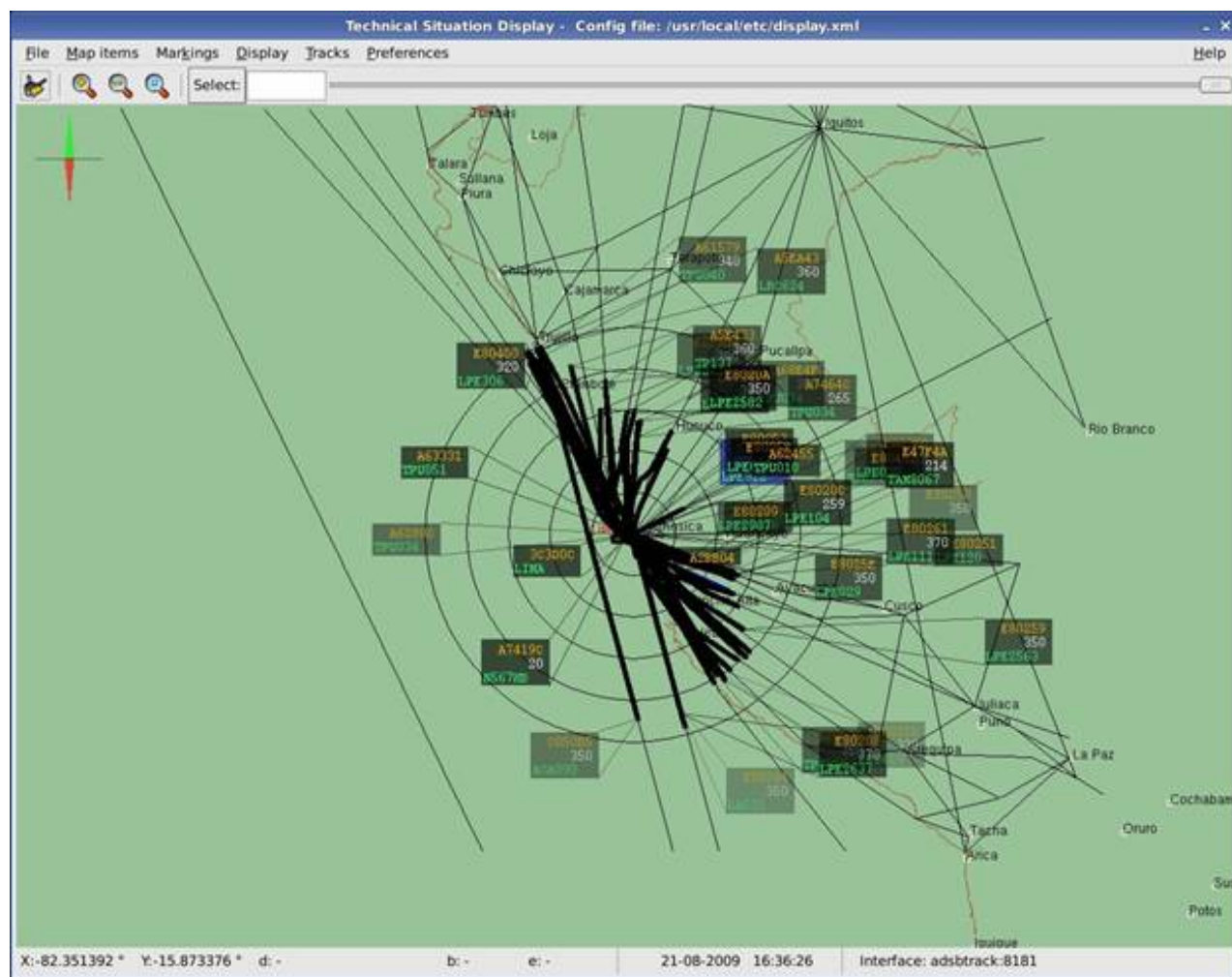


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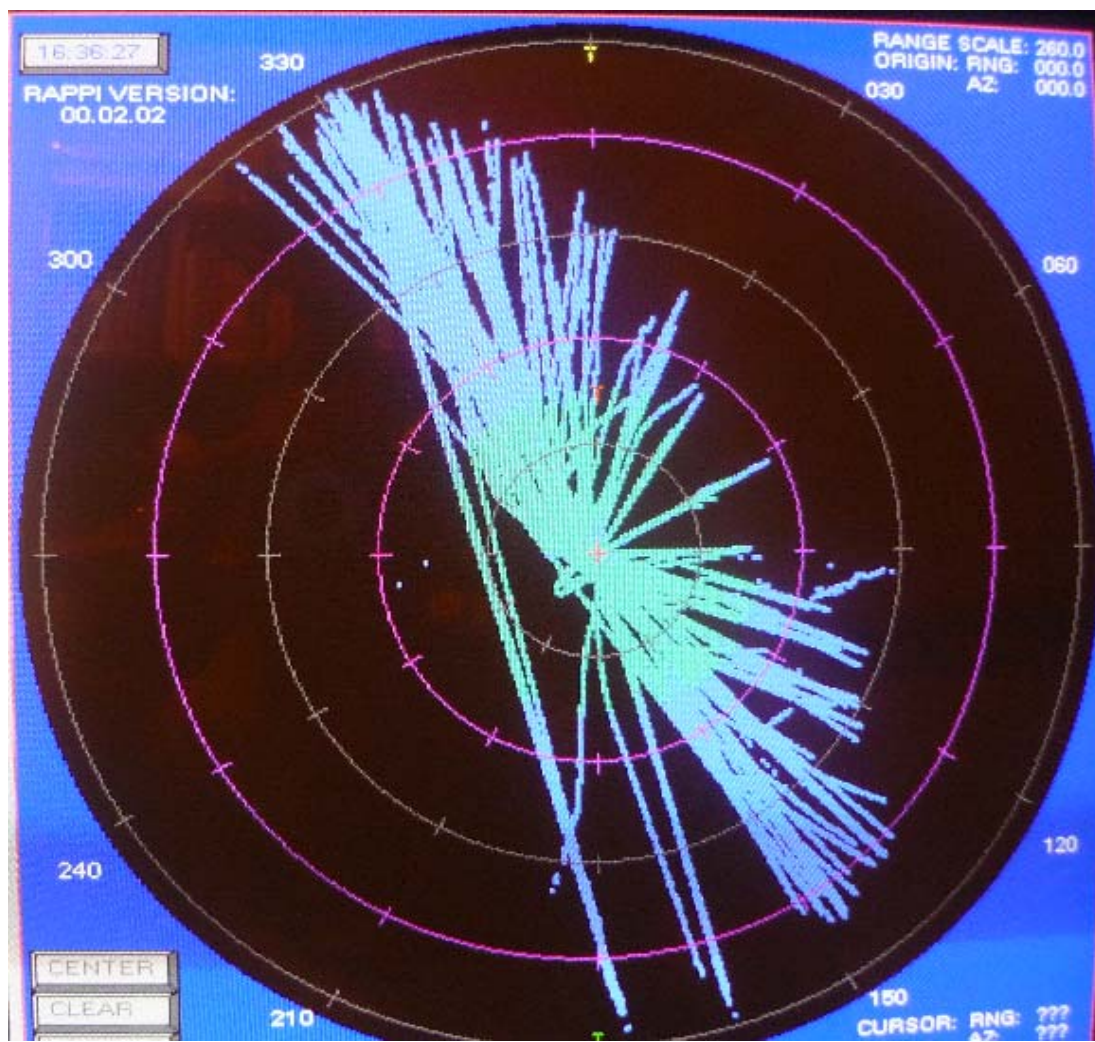
## APPENDIX B

### COVERAGE OBTAINED FROM THE ADS-B SYSTEM





**COVERAGE OBTAINED FROM THE RADAR SYSTEM  
(RAW DATA)**



- END -