DSS-1090: The Compact Mode S-ES ADS-B Ground Station

Nadi, Fiji

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Introduction
ERA at Glance

- Founded in 1994 as Joint Stock Company
- Cooperative Surveillance Systems
  - Multilateration Systems for ATC – MSS family
  - ADS-B Systems – DSS family, SQB
  - MLAT Systems for Military (ELINT/ESM and Air Defense)
- Staff with years of experience
- Global partnership on current R&D projects
  - RVSM, EMMA
  - EUROCAE WG-41 (active member)
  - EUROCAE WG-70 (chairmanship)
- Certifications and Standards
  - ISO 9001 Certification
  - CAA Certificates
- Headquarters: Pardubice, Czech Republic
  Production: Pardubice, Czech Republic
  Research Branch: Prague, Czech Republic
Czech Republic

- Central Europe
- Developed industrial country with rich history

![Map of Central Europe showing the Czech Republic](image)
DSS-1090: The Compact Mode S-ES ADS-B Ground Station

Long Experience & Tradition

KOPAC PRP-1
- first generation
- 1 to 6 targets/manual

RAMONA KRTP-81
- strategic ELINT
- 20 targets

TAMARA KRTP-86
- ELINT & Surveillance
- 23 radar + 48 SIF t.

BORAP
- ELINT/ESM system
- Wideband interferometric direction finder

VERA-E
- ELINT/ESM and Air Defense system based on TDOA technique

AP
- Long range Multilateration surveillance system

ASES
- Airportsurveillance system

P3D
- Mid range 3D Multilateration Surveillance System

HME
- Height measurement element

ASCS
- Mid range Multilateration Surveillance System

P3D
- Mid range 3D Multilateration Surveillance System


former TESLA

DSS-1090: The Compact Mode S-ES ADS-B Ground Station
How to classify ATC systems of ERA?

ATC Surveillance Systems

Primary
(Non-cooperative with targets)

Secondary
(Mode A/C/S Cooperative)

ADS
(Cooperative, GNSS dependent)

- Primary Radars
- Surface Movement Radars (SMR)
- Secondary Surveillance Radars (SSR)
- Multilateration Surveillance Systems (MSS)
- Airport
- Wide-Area
- VTS - Vehicle Tracking System
- DSS - Mode S-ES Depended Surveillance System
- ADS (Cooperative, GNSS dependent)
ATC Surveillance Systems of ERA

- Based on Time Difference of Arrival (TDOA) Multilateration of Mode A/C/S Transponders
  - MSS-A – Airport Surveillance Cooperative System
  - MSS-W – TMA and En-route Surveillance System

- Based on GNSS position decoding (ADS-B) and on Mode S Extended Squitter
  - VTS – Vehicle Tracking Systems
  - DSS – ADS-B Ground Stations

Note: MSS are also capable of ADS-B functions.
How to understand their applications?

ACC (en-route surveillance)

APP (TMA surveillance)

TWR, APRON (Airport Surface Surveillance)

MSS-W system
- SSR substitute
- up to 200 NM

DSS system
- up to 250 NM

MSS-A system
- SMR complement
- up to 5 NM
- includes VTS

VTS system
- SMR complement
- surface only

ACC Area Control Center
APP Approach Control
DSS Dependent Surveillance System
SMR Surface Movement Radar (non-cooperative sensor)
SSR Secondary Surveillance Radar (cooperative sensor)
TMA Terminal Maneuvering Area
TWR Tower Control
Relevant References

20 MSS systems in total

- 10 WAM systems (MSS-W)
  - 7 Mil ATC CZ (backup to radar net)
  - 2 ANS CZ (Prague, Ostrava)
  - 1 EUROCONTROL (Linz)

- 4 Airport MLAT systems (MSS-A)
  - Palma de Mallorca
  - Copenhagen
  - Prague
  - Braunschweig

- 6 MLAT systems contracted and under progress
  - WAM/Airport Asturias
  - WAM Yerevan
  - WAM Gyumri
  - WAM/Airport Cape Town
  - WAM Czech Republic
  - Airport Riga
Relevant ADS-B References

**VTS**
- Santiago de Chile

**ADS-B GS**
- Integrated with MLAT: Braunschewig, Asturias, Riga, Cape Town, Armenia, Palma de Mallorca, Copenhagen
- 2005: Czech Army

**SQB**
- Prague (96), Copenhagen (31), Santiago de Chile (17), NavCanada (4)
- 2005: Cape Town (16), Amsterdam (31), Copenhagen (25)
ADS-B Programme in ERA

2000
• “Measurement of 1090 MHz Extended Squitter Performance” in Langen near Frankfurt (Germany) in May 2000 – Eurocontrol, FAA and DFS

2003
• VTS contract for Santiago de Chile
• ADS-B processing fully integrated into MLAT systems

2004
• VTS Santiago de Chile delivered
• DSS-1090 trials in Scandinavia
• Integration with VDL-4 station
• Long-term trials in Pardubice and Prague

2005
• SQB type approval by CAA
• DSS-1090 delivered to Czech Army
ADS-B Programme in ERA

2003 – ERA decided to develop an ADS-B Ground Station

Motivation

• Growing market, customer requests
• Design based on existing MLAT Ground Station

Principal Requirements

• Plug-and-Play – easy installation and maintenance
• Low weight and power consumption
• Outdoor and embedded design

2004 – development finished and production started

2005 – production capacity of hundreds of GS / year
DSS-1090: Mode S-ES ADS-B Ground Station
Ground Station

Main features:
- Mode S Extended Squitter (DF 17 and 18, other DF optional)
- Low-cost and compact solution
- Plug-and-Play solution
- Easy outdoor installation
- Open architecture – easy extension
- High reliability (MTBF 38 500 h, MTTR 1 h)
- Low power consumption
- Long range ( > 150 - 250 NM, depending on antenna)
- Multiple Asterix Cat. 21 or Cat. 10 outputs
- Remote monitoring and control
- Optional VDL Mode 4 dual-link ground station
- Suitable for upper- and lower-airspace applications
Compact design
350 x 300 x 270 mm, < 12 kg
Ground Station

- **Main parameters:**
  - Temperature: -40 to +60 °C
  - Power Supply: 24VDC (20V to 28V), other options available
  - Power Consumption: < 30W (up to 250W with heating)

- **The ground station consists of the following parts:**
  - AL2W1090 Antenna (5 dB)
  - SSR Signal Receiver RXSSRP (sensitivity min. -116 dBW, dynamic range min. 70 dB)
  - Target Processor with Measuring Unit (PC/104)
  - Power Supply
  - Optional UPS, GPS receiver, Site Monitor, Management System, Dual Antenna, Dual Station, TIS-B transmitter, VDL Mode 4, MLAT, WAN
Dual Ground Station

SSR Antenna (AL2W1090)

SSR Antenna (AL2W1090)

Coaxial cable

Coaxial cable

SSR Receiving Unit (RXSSRP)

Target Processor (TP)

Ethernet Switch/Router

Power Supply

LAN, WAN

24 VDC

Dual Mode S-ES ADS-B Ground Station
AL2W1090 Antenna

- Narrowband omni-directional two-dipole array antenna with vertical polarization
- Main parameters:
  - Gain: 5 dB
  - Length: 756 mm / 2.5 ft
  - Weight: 1.8 kg / 4 lb
RXSSRP SSR Signal Receiver

Main parameters:

- Sensitivity $S_{0.5}$: min. -116 dBW
- Dynamic Range: min. 70 dB
- Bandwidth: 28 MHz
- Power Supply: 24V (20V to 28V)
- Power Consumption: < 4W
**ADS-B Target Processor**

**Main parameters:**
- Compact solution
- PC/104 industrial computer
- Embedded OS
- SW on Flash
- SW remotely upgradeable, including the Measuring Unit firmware
- NTP or GPS time synchronization
The Target Processor performs automatic evaluation of parameters (aircraft identification, position, altitude, ...).

To minimize spurious position decoding the globally unambiguous position decoding algorithm is primarily used.

The CPR algorithm for airborne targets is implemented according to RTCA DO-260A.

The CPR algorithm for surface targets is implemented in accordance with standards and recommended practices (SARP’s) for Global Decoding of the ES Surface Format.

3D tracker

- Kalman filter with 4 stages: stationary, straight moving, accelerating, strongly accelerating
- Position validation against 3D region predicted by the tracker
- Target validated after min. 3 plots
Target Processing

Compliant with

- DO-260A MOPS for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services (TIS-B), RTCA, Issued 4-10-03, Prepared by SC-186, Supersedes DO-260
- Surveillance and Conflict Resolution System Panel (SCRSP). Surveillance Systems Working Group-B. WP/B/6-05 SARPs CP for Global Decoding of the ES Surface Format

Available data

- ICAO 24-bit Mode-S address, Identification, Type - aircraft category
- Decoded Latitude and Longitude, Barometric Altitude / GNSS height
- Velocity, Emergency/Priority Status, Target State and Status, Aircraft operational status
Options

Site Monitor
- Allows to independently test the end to end functional performance of the ADS-B System
- Provides system integrity verification – checks performance of the SSR antenna and information on quality of GPS data
- Based on SQB, controlled by the TP

Optional GPS receiver built-in the TP
- Provides UTC time, GS position, and additional integrity information

UPS
- > 24 h backup (24 VDC), outdoor

Dual Antenna; Dual Station
- Improved reliability and flexibility

Various antenna types
- Airport application
- Long-range antennas
Options

- **VDL Mode 4 dual link**
  - Joint product with a partner company

- **TIS-B Transmitter and Mode S Interrogator (100/1600 W)**

- **Multilateration**
  - Independent ADS-B position validation

- **Management System (CMS)**
  - Local and remote monitoring and control
  - Remote upgrade of the software
  - Data recording and post-processing
Options

Site Selection Tool ATOMS
Vehicle Location Unit SQB

- DF18 Mode S extended squitter (for ADS-B, for multilateration)
- Position from built-in GPS receiver
- Powered from the car cigarette lighter
Vehicle Location Unit SQB

**Main parameters:**
- Output power: 16 W (pulse)
- Configurable (Mode S address, callsign)
- Power consumption: < 2 W
- -40°C to +70°C
- +9V to +32V
Vehicle Location Unit SQB
Air Situation Display

Main features

- Displays targets from multiple sensors
- Up to 10 Map windows, 2 Target tables
- Internal target tracking
- Powerful filtering
- Customizable colors
- ICAO 4444 Flight Plans
Air Situation Display

Main Window

- Main menu
- Toolbar
- Target parameters
- Target table

Main map

Info window
Management System

- Remote and local
- Based on standard Simple Network Management Protocol (SNMP)

Monitoring:
- Sensor state and mode, regimes of operation
- Diagnostics, Failure localization
- Integrity check
- Number of tracked targets
- Connection test

Control:
- Restart, start and stop of the system operation
- Adaptation parameters
- Configuration sets
- User profiles

Maintenance:
- Software upgrade and rollback
- Software version check
Management System

DSS-1090: The Compact Mode S-ES ADS-B Ground Station
Samples
GS Installations
SQB trials in Prague

SQB ADS-B

SQB MLAT

160 49E72A gnd
ADS-B trials in Prague
Fiji Demo

Components:
- GS (minimal configuration, without case, short-range antenna)
- SQB (on Airports Fiji Ltd. car)
- Air Situation Display (live and recoded data)
Thank You for Your Attention

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Questions?