GROUND STATIONS AND MULTILATERATION

Thales Air Systems GmbH

Security and mobility in a networked world.
Ground Stations
  - Overview
  - Vendor Types
  - General Requirements

Multilateration
  - Overview
  - Characteristics
  - Key Technical Points
  - Installation Examples
  - Combined System Examples
Thales Terms: Two ADS-B System Types:

- Standalone System
- Centralized ADS-B System
  - The determining factor is where the Target Report Data is created.
- The main advantage is how many Target Report Streams the upstream or Data Fusion system must handle.
Thales Terms: Two ADS-B System Types:

- Standalone – Ground Station

- Aircraft use GNSS and/or inertial navigation sensors to determine their own position
- Aircraft broadcast ADS-B messages periodically without being interrogated.

**ADS-B Messages**

- Aircraft reports

**System Output:**

- Surveillance Data Processor
- Track Reports
- ATC Display System

**ADS-B Ground Station**

- ADS-B out
- ADS-B in

**Global Navigation Satellite System**

**ADS-B messages contain realtime data, like:**
- position,
- altitude,
- velocity vector,
- intent.
Thales Terms: Two ADS-B System Types:

- Centralized ADS-B System
  - The determining factor is where the Target Report Data is created.
  - The Whole System of X Stations can be considered a Standalone Ground System.
Many Factors in determining a Surveillance Solution

- A system should fulfill the current requirements and future requirements of the surveillance system.
- Shall be built for expandability not only in Coverage Requirements but also support future technology upgrades.
- And meet your current budget needs and considered Life Cycle Cost.
- We know the advantage of ADS-B is not only its performance, coverage but also Life Cycle Costs when comparing to other surveillance means.
- Thales does provide all the solutions currently available in the market.
  - PSR, MSSR, MLAT, ADS-B and MSPSR…
- We realize the importance of ADS-B in the future of surveillance.
Vendor Types

- Every Vendor out there has a different form factor.
  - 19 inch rack mountable, meaning the unit is based on a U form Factor.
    - (THALES AX680 series is a 2 U rack mounted unit)
  - Ruggedized, the unit is either Wall Mounted, Mast Mounted or can fit with adapters inside a 19 inch rack.
    - These units are usually built to withstand harsh weather conditions without an additional enclosure, besides a Solar Shield.
    - (THALES BX680 series is a IP66, wall mountable, mast mountable unit)
AX680 series

- Industry standard - 19” form factor, indoor equipment
- Hot-swap elements, low prev. maintenance
  - Receiver RXA
  - COTS UPS
  - Large Capacity Battery (24 hours UPS) LXB

BX680 series

- Weatherproof, hermetically sealed
- Maintenance-free
  - Receiver RXB
  - Battery BTB
  - Large Capacity Battery (24 hours UPS) LXB
  - IP66 rated, no dust ingress and sprayed by water for 3 minutes, 100 Litres per minute at 100 psi
Vendor Types

- Selection of the Vendor Type, either rack mounted or Ruggedized.
    - Cost of Site Rental
    - Mounting for Communication Equipment
    - Space Requirements
    - Maintenance Support
General Requirements

- **Maintainability**
  - As much as possible a ground station design should minimize the number of trips to the actual site.
  - A ground station should have low power consumption.
  - Should be able to handle interference, overlapping..
  - Interference is a major threat to robust ADS-B performance and achieving performance at range, 250+ Nautical miles.

- When deploying or selecting a system it is important to understand what will be the life cycle costs for a system.
  - Site Rental Costs
  - Communication System Costs (acquisition versus leased lines.)
  - Power Consumption
  - Trips for Maintenance due to routine or failures
MULTILATERATION
- Based on 1090 MHz signals (Mode A/C/S, 1090 ES)
- Requires less than 4 receivers with line of sight to target
  - Can use Baro-ATL and Ranging Techniques to reduce the number of ground stations to fulfill coverage requirements
- Geometry-dependent – proper site planning is critical
- Transmitter required for Mode A/C compatibility and for systems using Ranging Techniques.

**Multilateration System Types:**
- MLAT: airport surface surveillance
- TMA MLAT: airport terminal area surveillance
- Country-wide WAM: en-route surveillance (Wide Area Multilateration)
- Same equipment - same software
Fundamental Principle of Multilateration

Airport Multilateration (MLAT)  
Wide Area Multilateration (WAM)

MLAT/WAM CPS calculates surfaces of constant time difference

Multilateration Ground Stations (GS)

Ground communications network

Multilateration Central Processing Station (CPS)

System Output: Aircraft reports

Surveillance Data Processor

Track reports

ATC Display System

Aircraft transponders reply to interrogations from SSR or multilateration systems, and emit unsolicited squitters/extended squitters

Signals received and time stamped by Ground Stations

MLAT/WAM CPS calculates surfaces of constant time difference
Advantages:

- Good Performance possible – depends heavily on system geometry
- High update rate – every received signal used to locate target
- Mode S communication possible (downlink of aircraft parameters)
- Same ground stations as for ADS-B – intrinsic ADS-B capability
- Low ground equipment cost – but more sites than ADS-B
- Can provide the gap filler while airframe operators are equipping and certifying their fleet
**Update Interval**

- **ED142 definition**
  - The maximum permissible time interval between successive Target Reports for the same target.
  - Target Report being the reply from the aircraft ... DF0, DF4 ..., and the corresponding report in the Asterix data stream.
  - Update Interval is used to measure the performance of the system against a comparable rotating radar time period.

**Output Period**

- **ED142 definition**
  - Time between successive Target Reports for the same target.
  - How often a system outputs a target report in the Asterix System.
  - There are three output types and output period is only defined for the two types of periodic output.
  - Periodic Delayed Mode (most common)
  - Periodic Predicted Mode (requires a tracker.)
Periodic Delayed Mode
- The time of applicability is based on the time of last position measurement.
- The report is coasted to the time of output.

Periodic Predicted Mode
- The position is extrapolated to the time of output.
- The time of applicability is updated to the time of output.
MLAT Output Periods, Update Intervals and Data Ages

**Periodic Delayed Mode**
- The time of applicability is based on the time of last position measurement.
- The report is coasted to the time of output.

**Periodic Predicted Mode**
- The position is extrapolated to the time of output.
- The time of applicability is updated to the time of output.

**Data Age**
- Is based on the time the reply containing that data was received by the system.
- The data age can be up to the maximum update interval.

**Interrogation Period**
- To reduce RF loading the Interrogation Period should be based on the Update Interval of the allowable maximum data age.
- If the maximum data age is less than the Update Interval, the maximum data age will be inferred Update Interval.
Example of Installations
Typical ADS-B Equipment

Single/dual channel round station (indoor version)

Rugged single channel single link ground station (outdoor version)

FAA SBS Site
Typical WAM Sites

Re-use of existing sites, rarely site built from scratch

Adapt to very diverse constraints for each site

- Antenna types
- Sectorisation
- Comms
- Packaging
- Lightning Protection
- EMC

Site Survey is always required

Airport Building / Tower  MSSR  TV Broadcast Mast  TV Broadcast Tower
System Examples
<table>
<thead>
<tr>
<th>Programme Name</th>
<th>Date of Commissioning</th>
<th>Nr. of ground stations</th>
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<tbody>
<tr>
<td>Australia (UAP) (Upper airspace not covered by radar)</td>
<td>2006</td>
<td>96 (48 sites)</td>
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<tr>
<td>USA (SBS through ITT) (from ground to FL600)</td>
<td>2010 - 2013</td>
<td>&gt; 1500 stations (796 Sites)</td>
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<tr>
<td>DGAC (France) (Islands – Réunion, Ajaccio, New Caledonia)</td>
<td>2009 - 2011</td>
<td>11</td>
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<tr>
<td>Indonesia (Upper airspace)</td>
<td>2009</td>
<td>27</td>
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<tr>
<td>Afghanistan (Upper airspace)</td>
<td>2010</td>
<td>27 (WAM + ADS-B)</td>
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</table>
High Performance System exceeding Standard Requirements

- Precision Runway Approach system for three airports.
- 3rd busiest airspace in Europe.
- Requirement HPA < 50 m RMS
- Requirement Update Interval of 1 second
- Requirement, GAP is considered anything over 1.5 seconds.
- Requirement Probability of Detection of 97%
- DFS Validated MLAT System Analysis Tool.
- One Single CPS for three different airport environments and ADS-B processing.
  - From Runway Centreline and Threshold to TMA.
### WAM Frankfurt Coverage

**ADS-B (blue plots) and WAM (red plots)**

**required WAM coverage area**

(128 x 80 NM)

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**Link Tech. Ind.:**

- DTI: 0
- MDS: 1
- UAT: 0
- VDL: 0
- OTR: 0

**Signal Ampl.:**

- DBx2D

**Squelch:**

- 3413

**Measured Height:**

- ---

**Target Count:**

- 361

**Plot Count:**

- 91

**Oldest Plot:**

- 68117.013457

**Newest Plot:**

- 68117.924710

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** LAT: 49.186442° | LON: 9.486144° | X: 66892.4 m | Y: -93556.0 m | d: - | b: - | e: - | 04-03-2010 18:56:17**

**Commercial in confidence**
WAM/ADS-B System Topology and Coverage at FL270
WAM Afghanistan: High Level System Architecture

Thales Premises, Stuttgart

Thales Premises, Masar-e-Sharif

MOTCA Premises, Kabul

MOTCA Premises, Kabul

Thales Premises, Stuttgart

Thales Premises, Stuttgart

MOTCA Premises, Masar-e-Sharif

MOTCA Premises, Masar-e-Sharif

remote ground stations

central processing facilities

Maintenance
Central Processing / Remote Control Station

Operational Central Processing / Remote Control Stations

Thales Air Systems January 2012
Thales’s Current Surveillance Products

- STAR 2000: Primary S-Band Solid State Approach Radar
- TRAC 2000N: Primary L-Band Solid State En-route Radar
- RSM 970 S: Mode S Monopulse Secondary Surveillance Radar
- AX/BX680: ADS-B systems
- Multilateration systems (WAM/MLAT)
- TIS-B and ADS-B server
- MSTS: Multi Sensor Tracking System

A complete surveillance portfolio = neutral position
Best use of available technologies for surveillance needs

We are not constrained by only one technology – we are solution focused

Our goal is provide an optimized surveillance architecture that will reduce your surveillance data cost

Thales is fully committed to developing, proposing and delivering optimal and safest global surveillance solutions