ICAO/FAA Workshop on ADS-B & MLAT Implementation

ADS-B/MLAT Implementation Experiences

6th September 2011, Mexico
Thales has over 50 years experience in the design and implementation of radars and provides a complete multi-sensor surveillance solution.

- **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
- **AS680/685**: ADS-B systems (FAA certified)
- **MAGS**: Multilateration systems (Airport MLAT & WAM)

The largest in-house surveillance portfolio
MLAT / WAM Implementation
Multilateration System Types:

- MLAT: airport surface surveillance
- TMA+ MLAT: airport terminal area surveillance
- Country-wide WAM: en-route surveillance (wide area multilateration)

Thales Multilateration System: MAGS
**Ground Stations (GS)**
- Same ground stations and configurations as ADS-B GS
- Receive-only (GSR, equals to ADS-B GS)
- Receive-transmit (GST = GSR + additional transmitter), acting as
  - interrogator (1030 MHz),
  - synchronisation transmitter (1090 MHz),
  - test transmitter (1090 MHz)

- Test transponders only if requested by customer

- Central processing Station (CPS)

- Control and Monitoring Server (CMS)

- Remote Control and Monitoring System (RCMS) – technical position,

- Local Control and Monitoring System (Maintenance Laptop)

**Do not forget THE NETWORK!**
- Mostly customer-furnished
- Sometimes redundant
- Bandwidth issues to be taken into account
- Monitored elements – remote control
- Thales support: Ethernet, DSL, FO, WIFI
- Re-use of existing sites, hardly any site built from scratch

- Adapt to very diverse constraints for each site
  - Antenna types
  - Sectorisation
  - Comms
  - Packaging
  - Lightning Protection
  - EMC
Good sites do exist, but... many others came before – and they have similar needs

- No space on mast
- Top position occupied
- Strong transmitters
- Harmonics close to the 1090 MHz frequency
- Icefall may impact antenna’s life
- Daily lightning strikes
- **System Performance** depends on geographical distribution of sensors
- **Site Survey** is always required
- **Each site represents cost**
  - Non recurring: planning, procurement, installation, testing
  - Infrastructure cost - mast, power, communication, security
  - Recurring cost: leased lines, power, site rental cost
  - Recurring effort: maintenance/administration, config management
- **The site selection task is thus to minimise site density while preserving required performance**
**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
- Low lifecycle cost

**Drawbacks:**

- Many sites required,
- No of sites strongly depend on vertical coverage limit and terrain
- Complex system to manage (many sites, synchronisation across system, multiple interrogators ...)
- Costly (acquisition, operation and maintenance) for large regions
- No ICAO standardization documents available yet
- Coverage – range affected by fruit, degarbling capability required
- Central Processing of ADS-B reports in GS
- Probability of Detection PD *typ.* 97% @ 4s (1s DFS)
- Horizontal Position Accuracy HPA
  MLAT: 7.5m airport surface/20m aprons (ED-117),
  WAM: 150m TMA, 350m en-route (ED-142) (50m DFS)
- Full remote control incl. remote SW update
- Dual independent synchronisation basis (GPS, RF timing)
- SW certification according to ED109/AL4 (ESARR6)
  (equals SWAL3)
- Low maintenance effort, low power consumption, low comms requirements
  (bandwidth), no air-conditioning
Wide Area Multilateration (WAM) System,
Terminal Area Multilateration System,
Airport Surface Multilateration System

- Frankfurt Terminal Area
  (120 NM x 80 NM)

- Among the heaviest 1090 MHz radio load in the world (according to FAA)

Coverage Simulations

Link Budget Models
Installed WAM Sites

DFS WAM Central Processing Station

DFS WAM Ground Stations
PAM FRA Coverage Area

Required Coverage Area

Actual coverage exceeding requirements

Frankfurt CTR

Required Coverage Area

Frankfurt CTR
High flying ADS-B / MLAT targets have excellent match.

Error $<< 50 \text{ m (typically around 20-30 m)},$
WAM

- DFS PAM Frankfurt
  - upper and lower airspace, TMA, CTR, GND at two airports

- NATS London TMA
  - Upper and lower airspace, TMA, CTR

- Afghanistan country-wide WAM
  - Upper airspace coverage

- Test bed: WAM STR (Stuttgart-Nuremberg Airspace)
  - Upper and partially lower airspace, GND

MLAT AIRPORT

- Lyon St. Exupéry Airport (+4 more)
- Abu Dhabi Airport
- Taipeh Tayouan Airport
- Helsinki Vantaa Airport
- Milano Linate Airport
ADS-B Implementation
When considering operational ADS-B implementation, a number of items need to be defined:

- the scope of ADS-B surveillance: for situational awareness or for separation,
- the type of airspace: en-route, TMA, upper, lower, with or without existing radar coverage, and associated coverage
- the time frame considered,
- Preparation and publication of necessary regulatory material
- Organisation of controller training, users educations,
The ADS-B ground infrastructure must be considered globally, including:

- ADS-B ground stations
  - To receive, decode, format and forward ADS-B data
  - Site monitors to end-to-end test the correct operation of Ground Station
  - Dual station for redundancy

- Data communication network
  - Quality of Service: latency, bit error rate
  - Dual link for redundancy
  (e.g. land line and satcom or 2 satcoms using different satellites)

The ADS-B capable Air Traffic Control system must be able to:

- Receive, process ADS-B data and elaborate tracks
- Possible fuse with radar data.
- Correlate with Flight Plan
- Have Safety nets upgraded to deal with ADS-B
- Display aircraft position (appropriate symbols)
- Possibly, have supporting tools (e.g. RAIM Outage Prediction)
Depending on the targeted application and infrastructure configuration, other components may be required:

- Multiple channel ground station to improve performance in high traffic density areas
- ADS-B Data Dispatcher to collect ADS-B data from several Ground Stations and redistribute to several users with different requirements
- TIS-B system to support air-to-air applications (ADS-B IN)

But also other preconditions are required to use ADS-B

- A sufficiently high population of properly/certified ADS-B equipped aircraft that operate according to standard
- Operational procedures, sustained by a safety case
  - Nominal
  - Fallback
On top of the new surveillance means infrastructure, the ATM system needs modification. Impacted functions includes:

- **Surveillance Data Processor**
  - Front-End
  - Tracker

- **Safety Nets**
  - To be adapted to new means

- **Controller Working Position (HMI)**
  - Symbols
  - New tools (e.g. RAIM Outage for ADS-B)

- **Ancillary functions**
  - By-pass
  - Recording and replay
  - Simulator
One key component impacted by the addition of new surveillance means is the surveillance tracker.

The new generation of surveillance trackers receive data from multiple sources:

- Primary and Secondary Radar (traditional surveillance);
- Mode-S Radar;
- ADS-B;
- Wide Area Multi-Lateration.

These data need to be fused together, forming one “multi-sensor system track” that represents the consolidated estimate of the physical position of the aircraft. Fusion needs to address:

- The update rates of the various sources of data;
- The integrity of the positional data received.

ADS-B and Multi-Lateration Data offers improvements over traditional Radar data in:

- Improved positional data update rate of around 1 report per second
- More accurate position
- Opportunity to use for Parallel Runway Monitoring

ADS-B Data offers additional improvements over Multi-Lateration and traditional Radar data in:

- Direct velocity vector Information (Radar velocity vector can be up to 7 seconds behind the actual aircraft vector)
- Rate of Turn Information
- Rate of Climb/Decent Information
- In the future, Intent Information
Minimum ADS-B architecture in a multi-sensors context
Advantages:

- Accuracy like GPS (same quality independent of range to ground station)
- Coverage like a secondary radar
- High update rate (2 positions/second, 2 velocity/second)
- Intent available (level-off altitude, next waypoint, etc.)
- Low ground equipment cost
- Low infrastructure requirements
- Low lifecycle cost

Drawbacks:

- Requires Equipped Aircraft
- “dependent surveillance” may require external validation or second surveillance layer when traffic density grows
- Coverage – range affected by fruit, degarbling capability required
- Local Processing of ADS-B reports in GS
- Compliance to MOPS DO-260/ED-102, DO-260A
- Full remote control incl. remote SW update
- SW certification according to ED109/AL4 (ESARR6) (equals SWAL3)
- Low maintenance effort, low power consumption, low comms requirements (bandwidth), no air-conditioning
- **XS-950 - Mode S T/R incl. Extended Squitter**
  - For Heavy carriers (Airbus, Boeing)
  - ACSS (THALES/L3-Com joint venture)

- **AS/X-680 ADS-B 1090MHz ground station**
  - Autonomous, low power (50W), remotely configurable and controlled
  - Australia, Europe, USA, Indonesia, Africa, Korea,

- **EUROCAT ATM automation system, A-SMGCS (STREAMS airport system)**
  - Process and display ADS-B tracks
  - Multi-Sensor Tracking System (Radar, ADS-B, WAM)

- **MOSQUITO vehicle locator**
  - 1090 MHz extended squitter
Coverage:
- 27 En Route Service Volumes
- 236 Terminal Service Volumes
- 35 Surface Service Volumes

Two ADS-B “links” or Frequencies Approved by the FAA
- Mode S “extended squitter” (1090 MHz)
  - Used for most commercial aircraft
- Universal Access Transceiver (UAT) (978 MHz)
  - Typically used for other aircraft and vehicles
- Re-Broadcast Capability enables users to see each other

Services:
- ADS-B RX, TIS-B TX on 1090 ES
- ADS-B RX, TIS-B TX, FIS-B TX on UAT
- ADS-R TX Crosslink

Service volume requirements result in a total of 794 ground station sites (mostly dualized)
Solar-powered, satellite comms, passive cooling

16 Ground Station Sites in full NRA Operation

28 duplicated Sites

ADS-B Coverage

Radar Coverage

Thales AS680 ADS-B Ground Station

Image courtesy Airservices Australia
Australia Typical ADS-B Sites

- Dual ADS-B Antennas
- Dual VSAT Links
- Solar Power
- Passive Cooling

Courtesy Airservices Australia
27 ADS-B redundant GS

- 18 ADS-B GS (Eastern part) connected to Makkasar Air Traffic Service (MAATS) from Thales
- 9 ADS-B GS (Western part) connected in JAATS-Jakarta from Thales.
- ADS-B NRA where new Radars cannot be justified
- AS682 – dual redundant ADS-B Ground Station
  - 1x Toulouse – DTI Reference, complete
  - 1x Ajaccio, Corsica, complete

- Overseas Departments
  - 3x La Reunion, complete
  - 3x New Caledonia, FAT ok

La Reunion
New Caledonia
La Réunion

Madagascar

La Réunion

La Réunion

La Réunion

St Denis TMA

Pictures Curtesy of DTI
Europe Cascade and Cristal MED

ADS-B Ground Stations

- 10x THALES ATM AS685 Ground Stations
- OTHER
- CASCADE trials countries

Image courtesy Eurocontrol
10 x AS685 including each:
- up to 4 ch. ADS-B and TIS-B
- ADS-B data dispatcher
- Local operator Console
- Battery Backup

Images courtesy DFS
Thales MLAT/WAM/ADS-B Product Family
Modular Product Family, adaptable to many applications, e.g.

- FAA SBSS Multi-Channel Radio and Single Channel Radio
- MAGS1 MLAT / WAM
- ADS-B / TIS-B Ground Station
- ACAS Monitor
- SSR Channel Monitor
- Mode S Datalink Ground Station

- 3 technologies available on same platform: 1090 MHz, 1030 MHz, 978 MHz (UAT)
- Combined Applications (MLAT & ADS-B) using the same equipment

Low Maintenance requirements - low lifecycle cost

Common hardware/software thus mixed solutions possible, e.g. combining strength of ADS-B en route with WAM-based validation in TMA:

MSTS2 allows to derive the best result fusing multiple surveillance sources

Flexibility and Expandability secure the Investment

1 MAGS is the name of Thales’ MLAT / WAM System
2 MSTS is Thales’ Multi Sensor Tracker System
Two Branches are active:

- FAA Surveillance Broadcast Services System (SBSS)
  - Multichannel Radio
  - Single Channel Radio

- Multilateration and ADS-B Ground System (MAGS)
  - single channel Ground Station AX680
  - dual channel Ground Station AX680
  - Transmitter Unit AN1030 – replaced by NSTX in 2011
  - New product BX680 in 2011

Legacy ADS-B Systems based on AS680 are still supported

- UAP Australia
- DSNA French Overseas Territories
- Indonesia
- Remaining stock to be sold off (drawback: no MLAT/WAM)
- Surveillance Broadcast Ground Station (SBGS)
  - New PTM2 GPS timing module
  - New SBC Singleboard computer replaces MCP server
  - Card Cage
  - Backplane development
  - Power and interconnect
  - Outdoor enclosure

- Next Surveillance Transmitter (NSTX)
  - 1090/1030 High-power transmitter – 1kW

- Advanced Multi-Operational Surveillance Transmitter (AMOST)
  - UAT/1090 Low-power transmitter – 200W

- FAA-specific design
- Design originally triggered by DTI (France) request
- Separate boxes for each PCB
- Weatherproof, IP 67
- Additional shading cover

**Modules:**
- RXB – Receiver with SPB3a
- TXB – Transmitter with NSTX
- BTB – Battery module with COTS UPS

**Interfaces:**
- Multimode FO
- Ethernet with PoE
Thales Surveillance references

- **Radars**: 71 countries (since 1995)
- **ADS-B / WAM**: 20 countries
Thank you

Ludmilla Gonzales
Thales Air Operations Business Development Manager
Ludmilla.gonzales@thalesgroup.com