Air Operations

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ICAO/FAA Workshop on ADS-B & MLAT Implementation

ADS-B/MLAT Implementation Experiences

6th September 2011, Mexico

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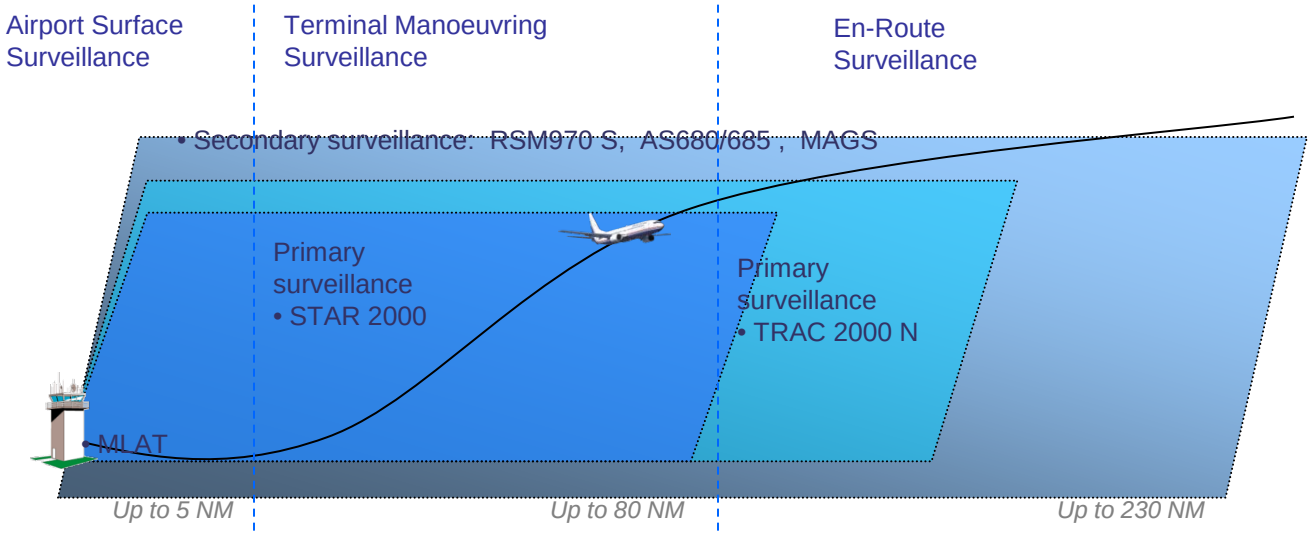
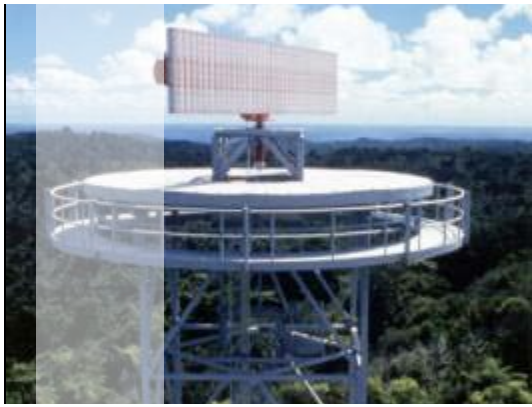
Surveillance Products

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

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MLAT / WAM Implementation

Multilateration

- **Multilateration System Types:**
  - MLAT: airport surface surveillance
  - TMA+ MLAT: airport terminal area surveillance
  - Country-wide WAM: en-route surveillance

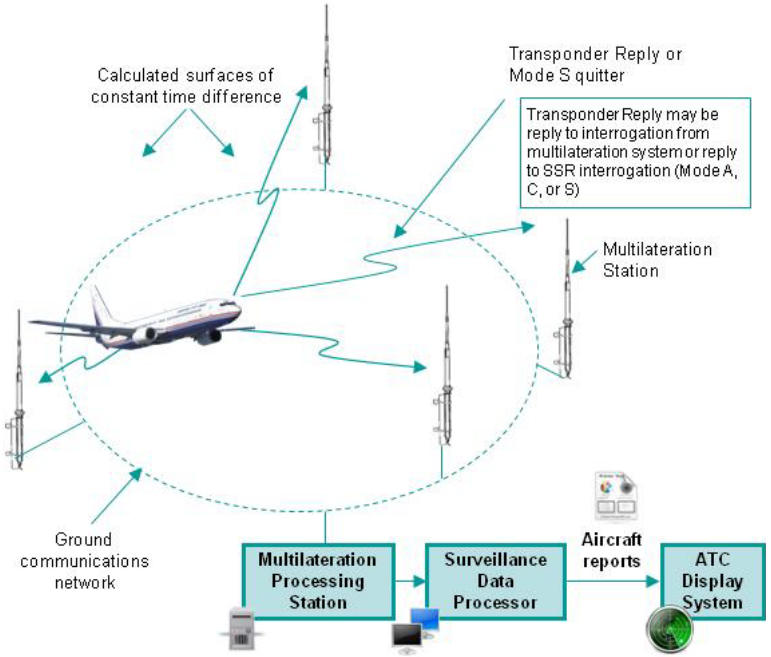
    (wide area multilateration)

Thales Multilateration System: MAGS

MLAT / WAM System Elements

- **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



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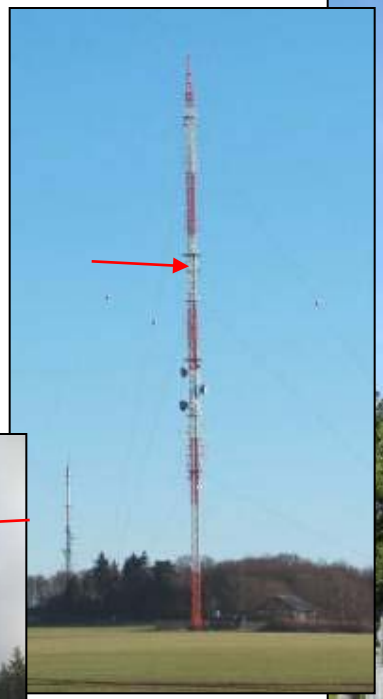
Distributed Sensor Systems

- **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



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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

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Site Selection Task

- **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**

Multilateration Characteristics

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:

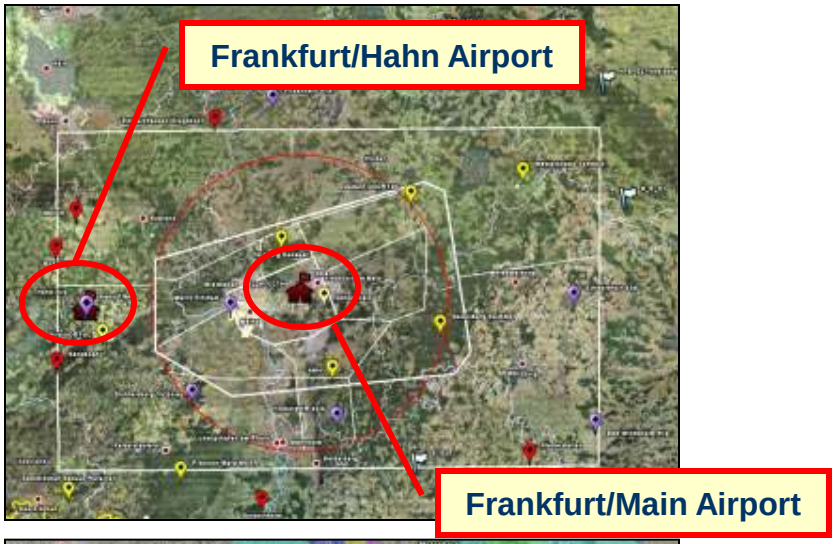
- Many sites required,
- No of sites strongly depend on vertical coverage limit and terrain
- Complex system to manage (many sites, synchronisation across system, multiple interrogators ...)
- Costly (acquisition, operation and maintenance) for large regions
- No ICAO standardization documents available yet

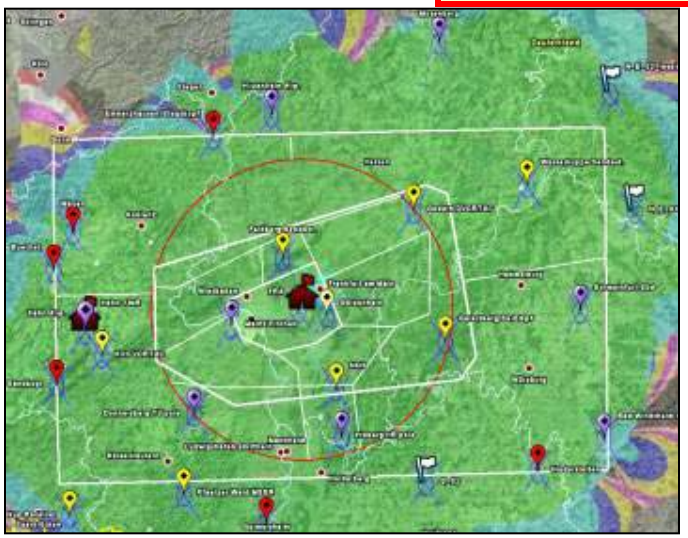
Multilateration Key Requirements

- **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** ✓

MAGS WAM: DFS PAM Frankfurt

Coverage Requirements

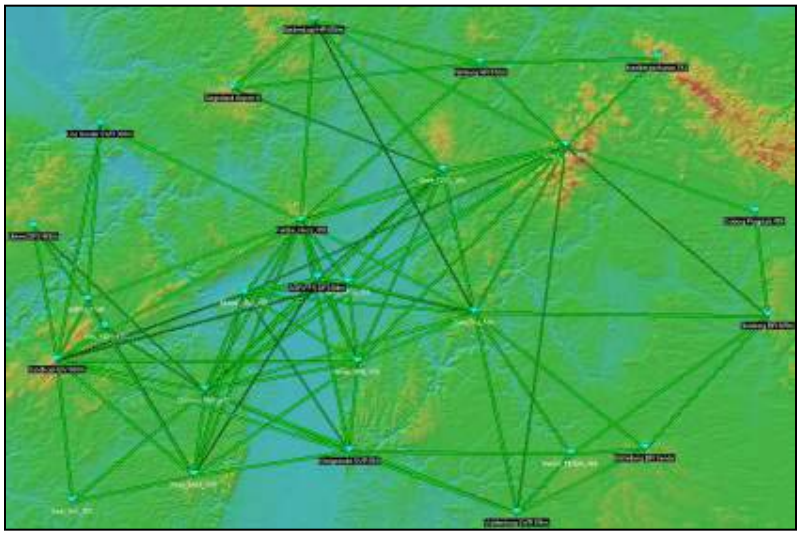




Coverage Simulations

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)



Link Budget Models

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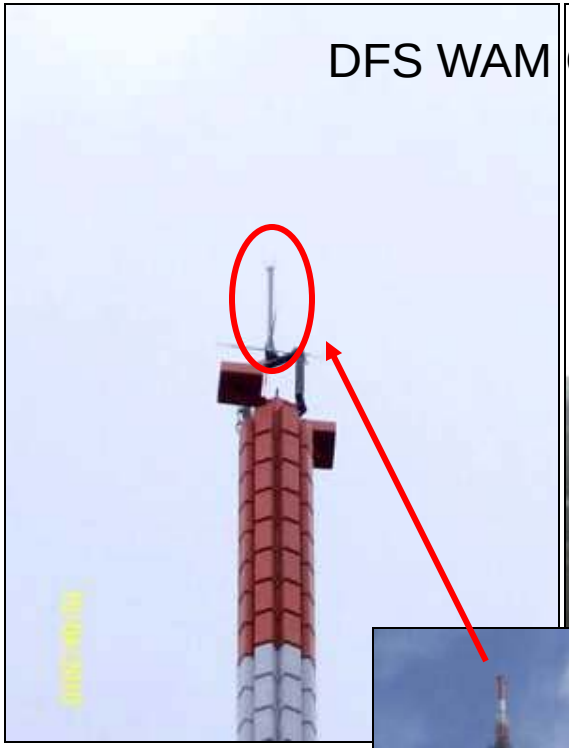
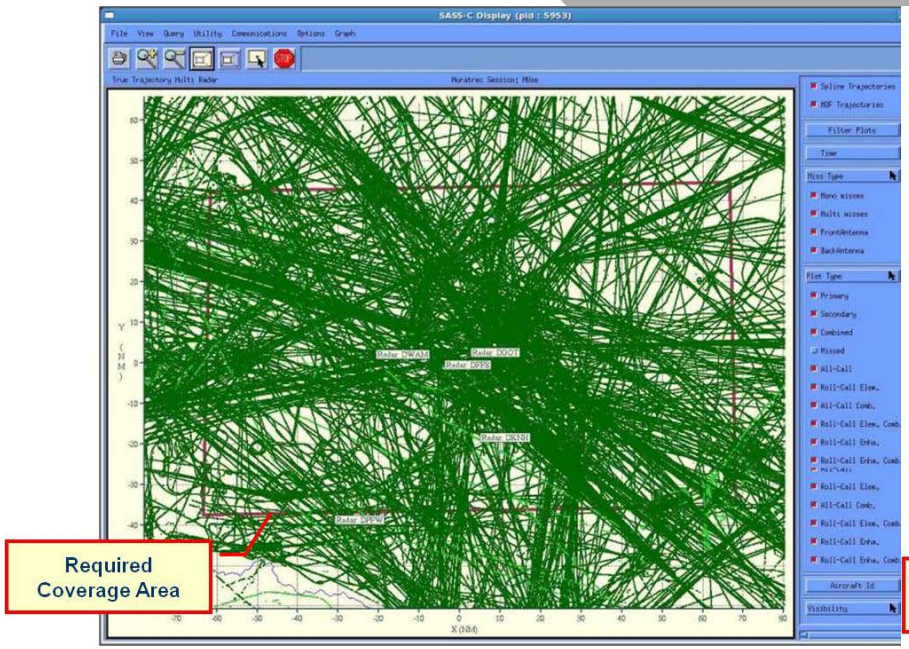
Installed WAM Sites

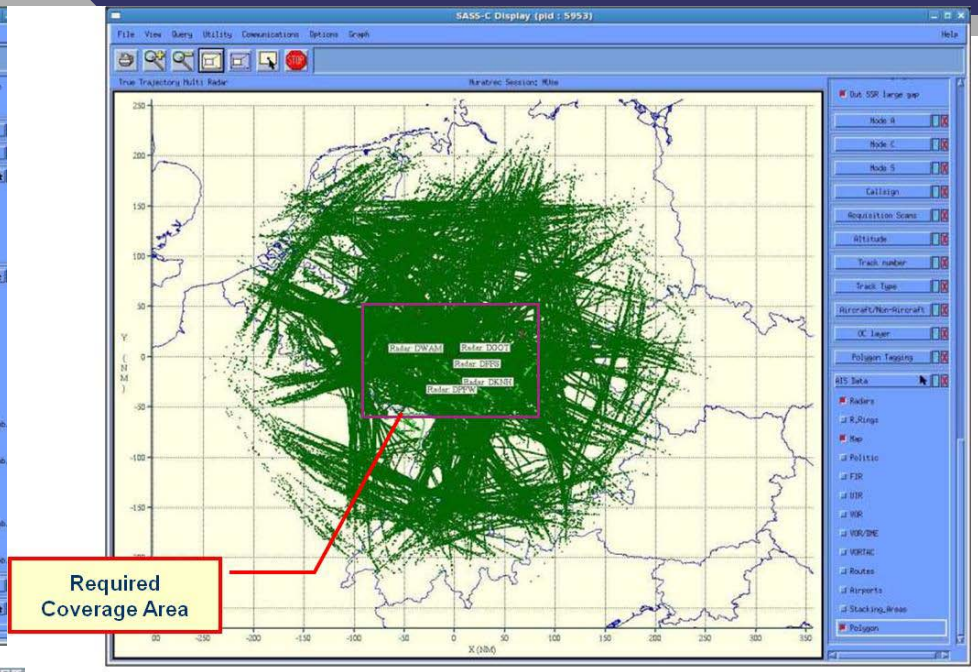
DFS WAM Central Processing Station

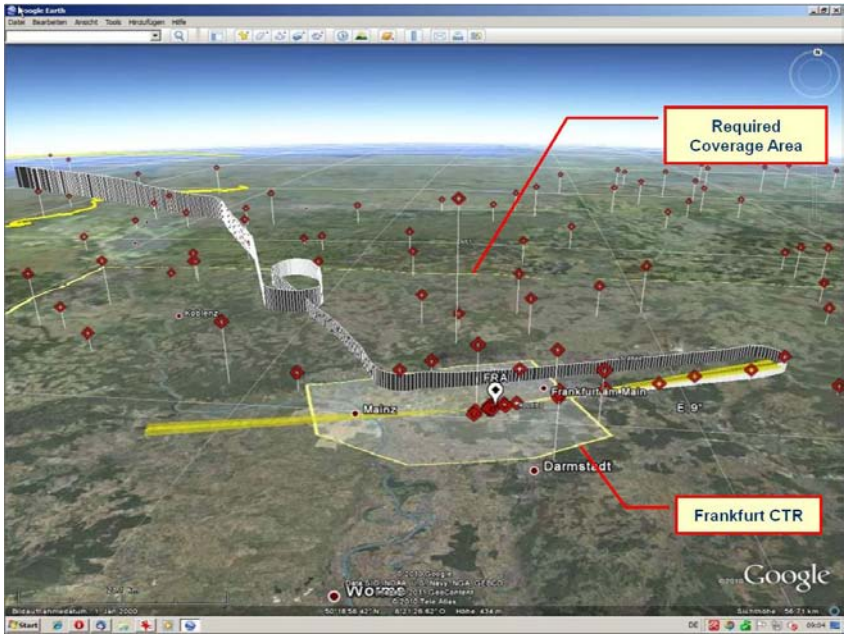


DFS WAM Ground Stations

PAM FRA Coverage Area

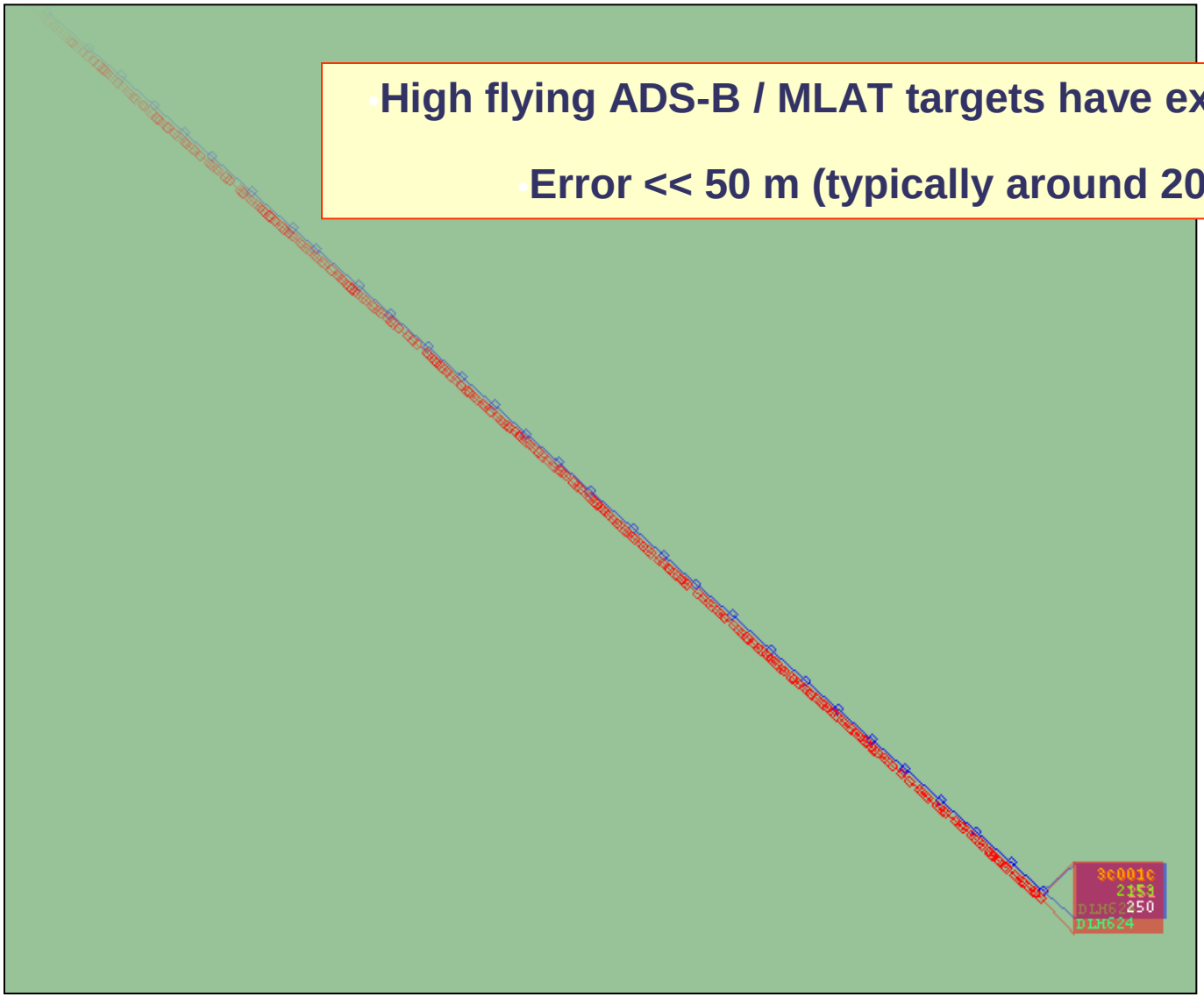






Actual coverage exceeding requirements

WAM: DFS PAM FRA - a closer look



- High flying ADS-B / MLAT targets have excellent match.
- Error << 50 m (typically around 20-30 m),

Blue: ADS-B
Red: WAM

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Thales MLAT/WAM References

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

Implementing ADS-B

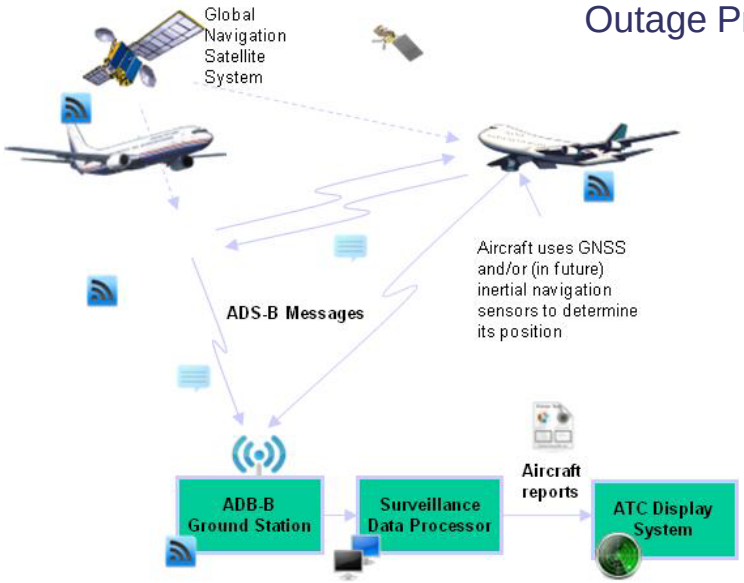
- **When considering operational ADS-B implementation, a number of items need to be defined:**
  - the scope of ADS-B surveillance: for situational awareness or for separation,
  - the type of airspace: en-route, TMA, upper, lower, with or without existing radar coverage, and associated coverage
  - the time frame considered,
  - Preparation and publication of necessary regulatory material
  - Organisation of controller training, users educations,

ADS-B Ground Infrastructure (1)

- **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)



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ADS-B Ground Infrastructure (2)

- **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

ATC required adaptations/modifications

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

Surveillance tracker

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 MultiLateration 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 MultiLateration 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

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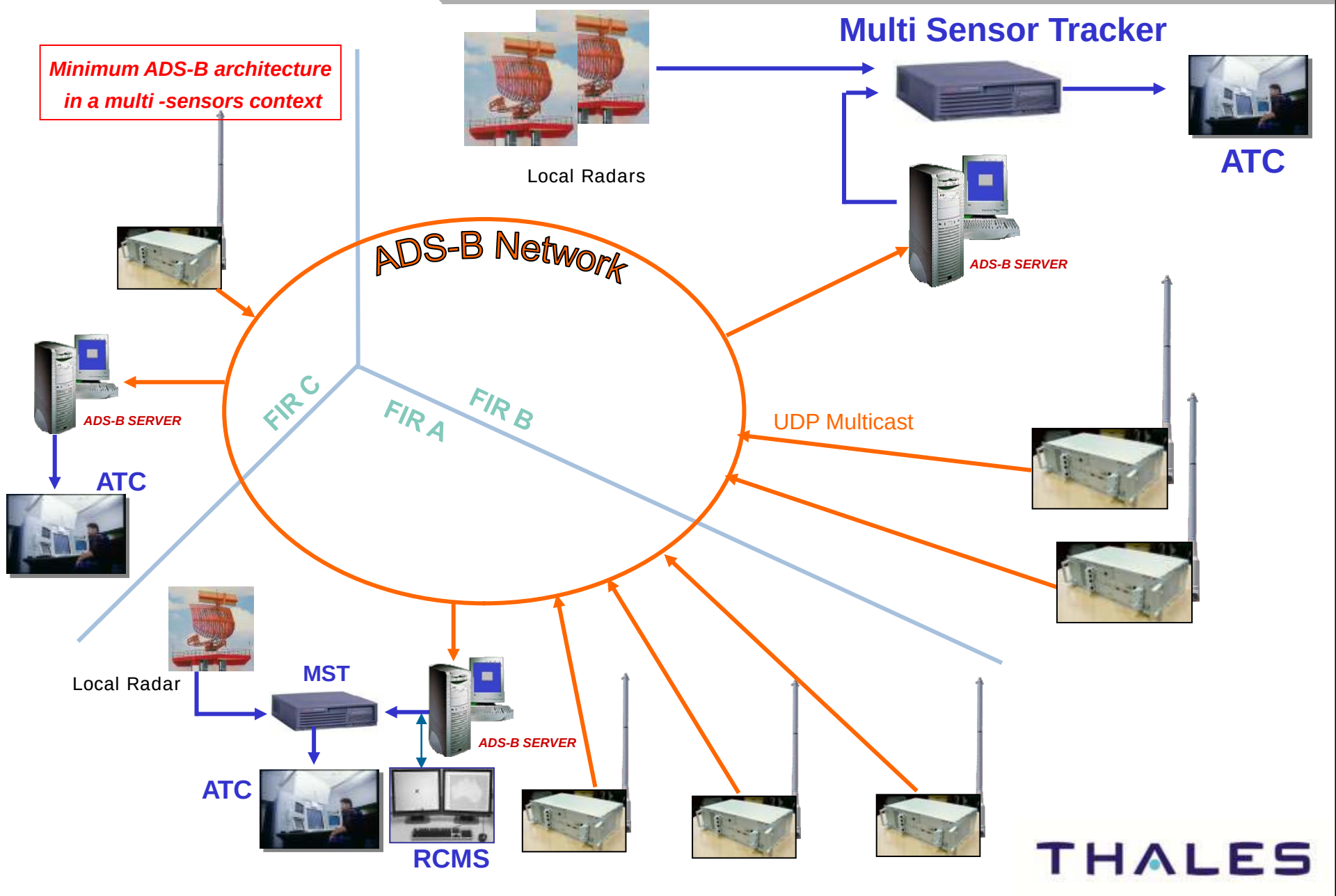
ADS-B Ground Architecture - example



ADS-B Characteristics

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

ADS-B Key Requirements

- 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 ✓

Thales ADS-B main products

- **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

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ADS-B US

Coverage:

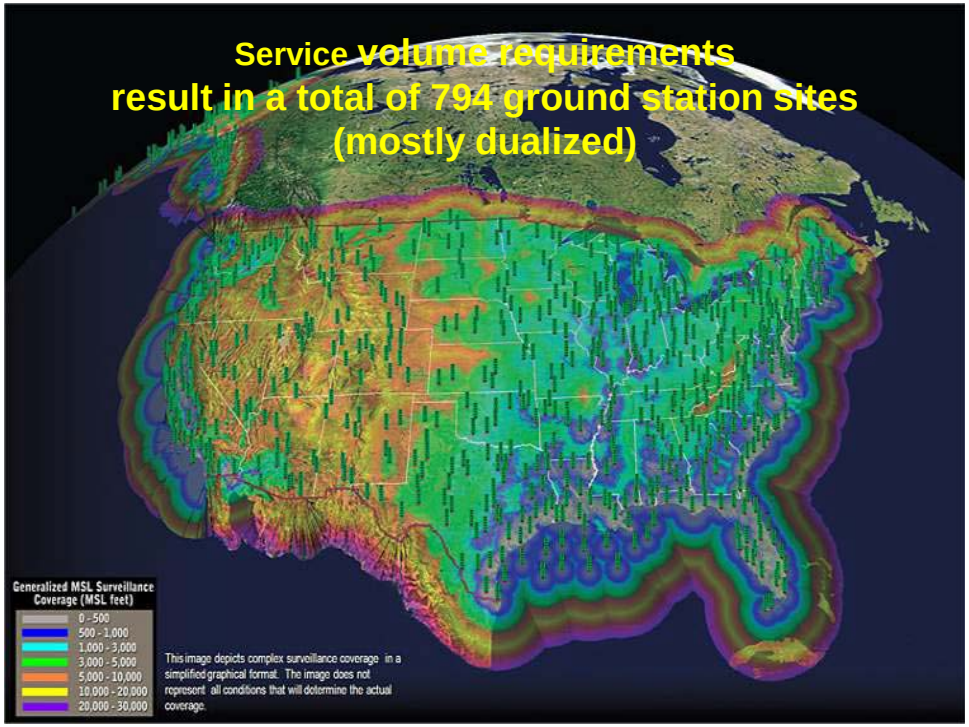
- 27 En Route Service Volumes
- 236 Terminal Service Volumes
- 35 Surface Service Volumes

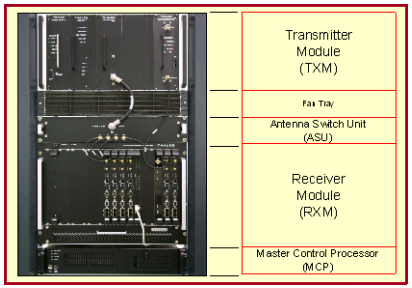
Two ADS-B "links" or Frequencies Approved by the FAA

- 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





Thales ADS-B Ground Station

FAA Specific Design

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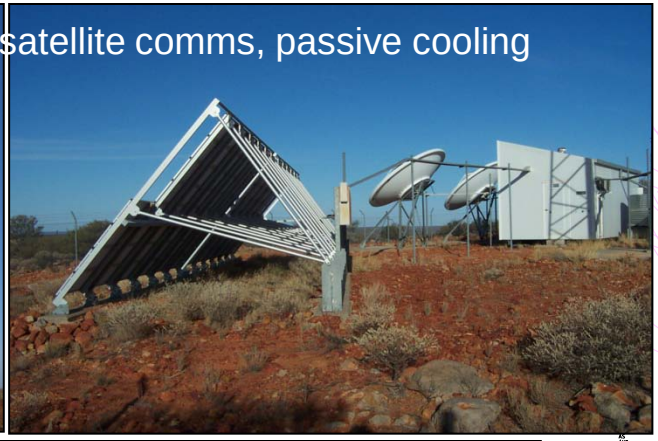
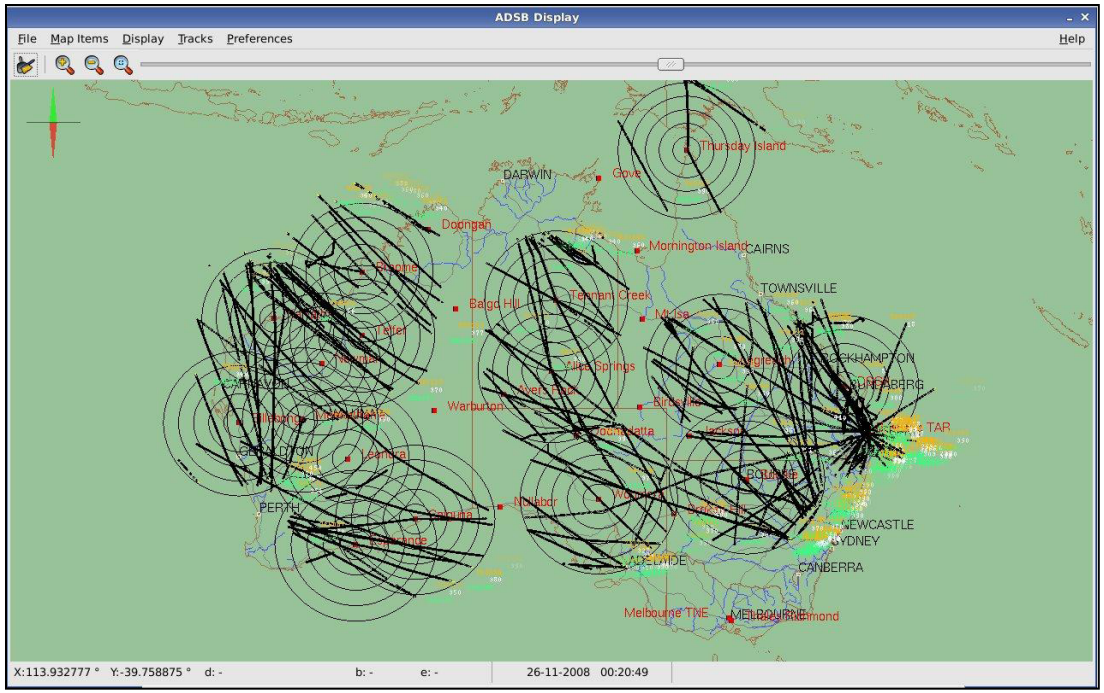
Australia ADS-B UAP



Solar-powered, satellite comms, passive cooling



16 Ground Station Sites in full NRA Operation

28 duplicated Sites

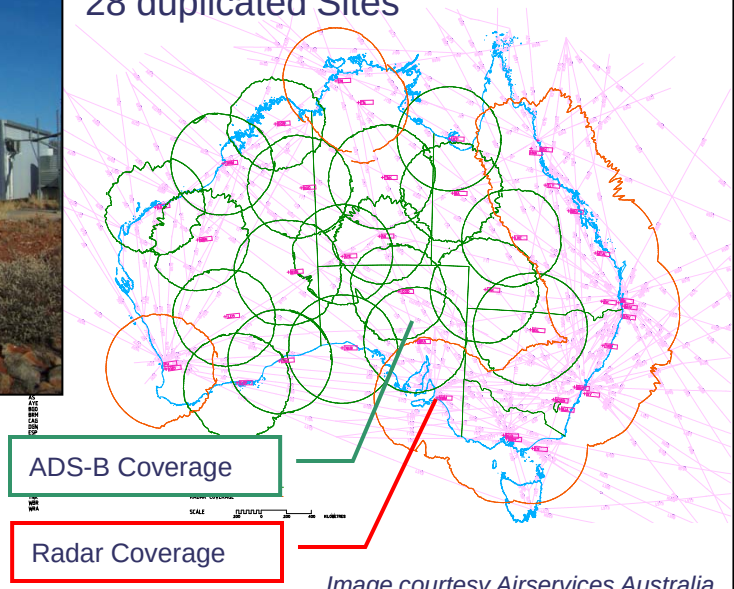


Image courtesy Airservices Australia

Thales AS680 ADS-B Ground Station

Image courtesy Airservices Australia

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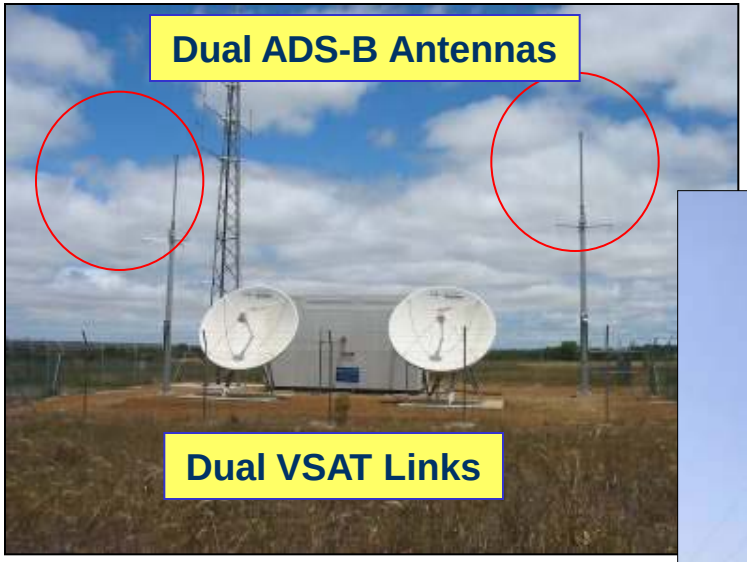
Australia Typical ADS-B Sites



Courtesy Airservices Australia

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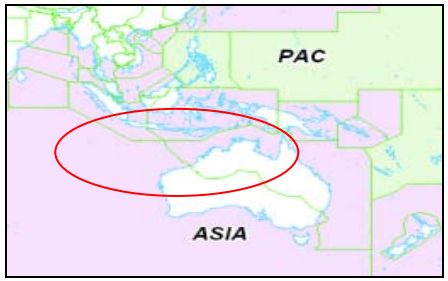
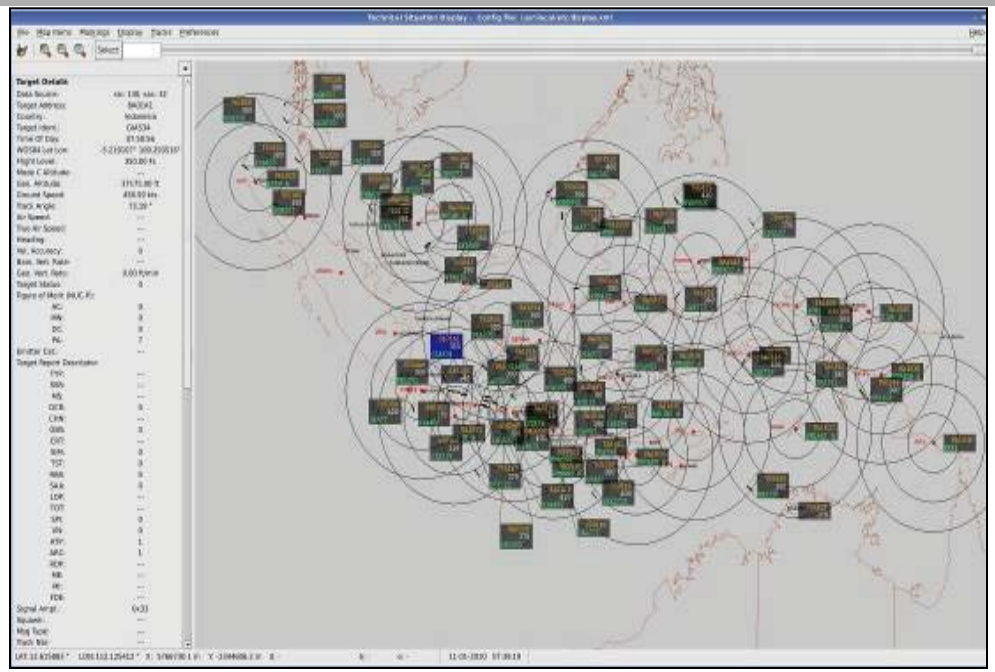
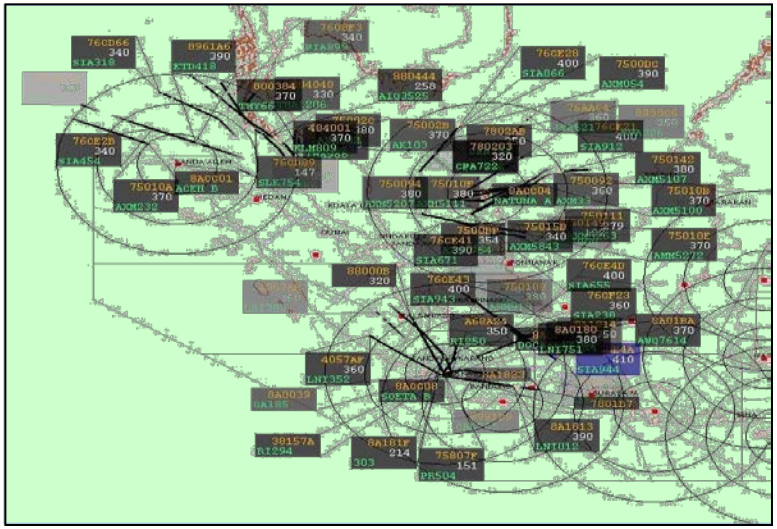
ADS-B Indonesia

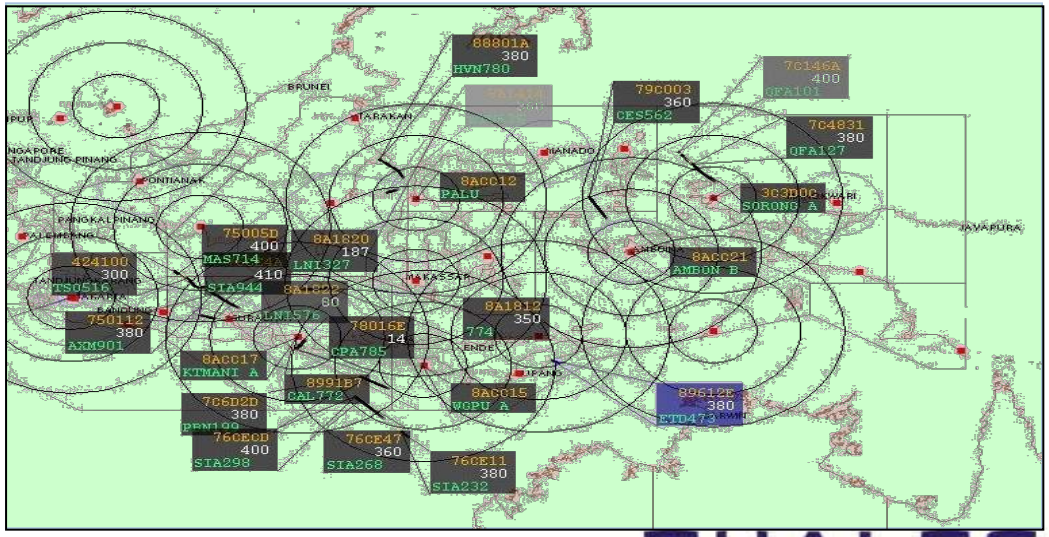


AS682 – dual redundant ADS-B Ground Stations



- **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.





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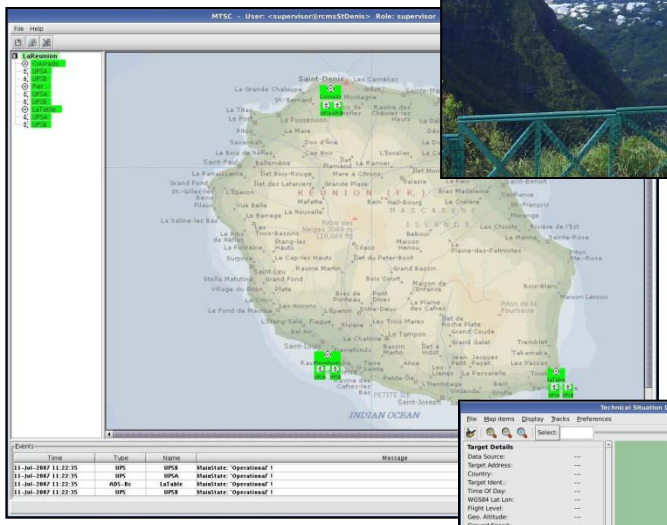
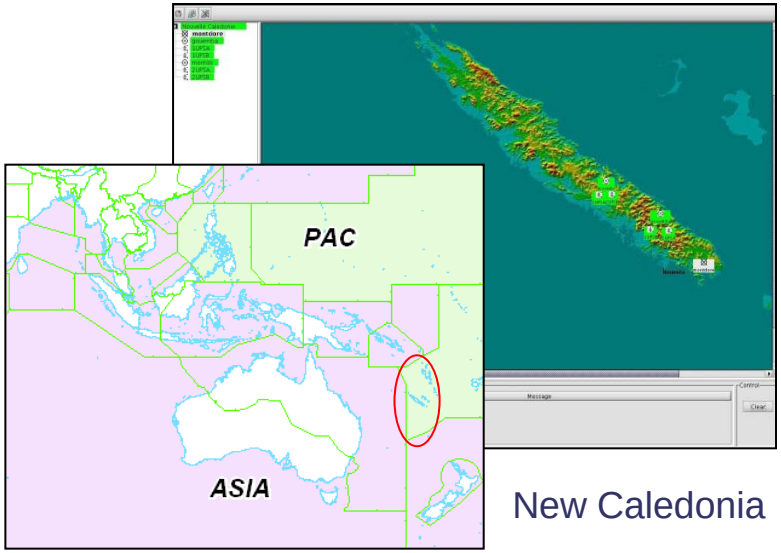
ADS-B France

- 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

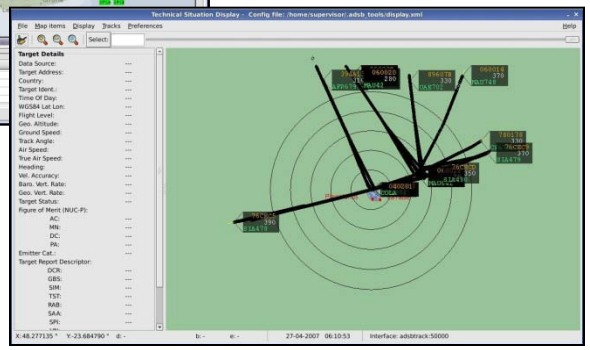
- Overseas Departments
  - 3x La Reunion, complete
  - 3x New Caledonia, FAT ok



La Reunion



New Caledonia



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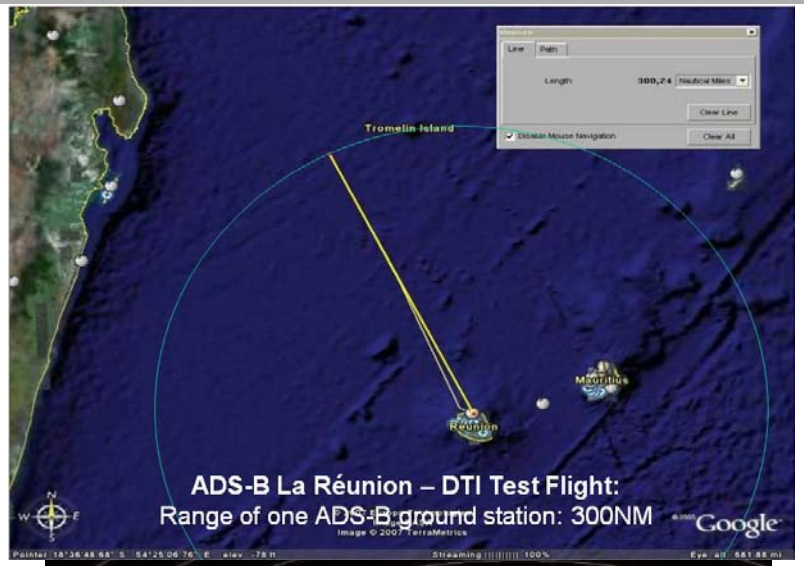
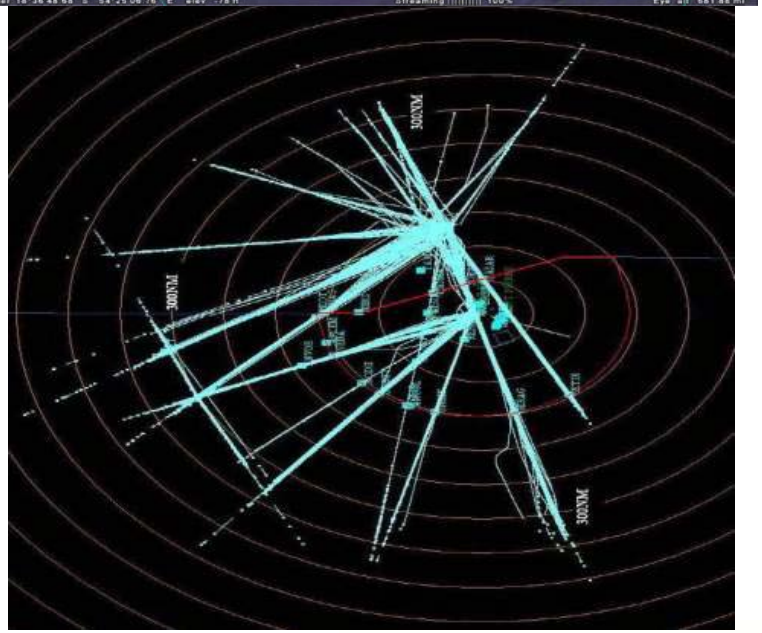
ADS-B La Réunion



La Reunion



La Reunion
St Denis TMA

Pictures Curtasy of DTI

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Europe Cascade and Cristal MED

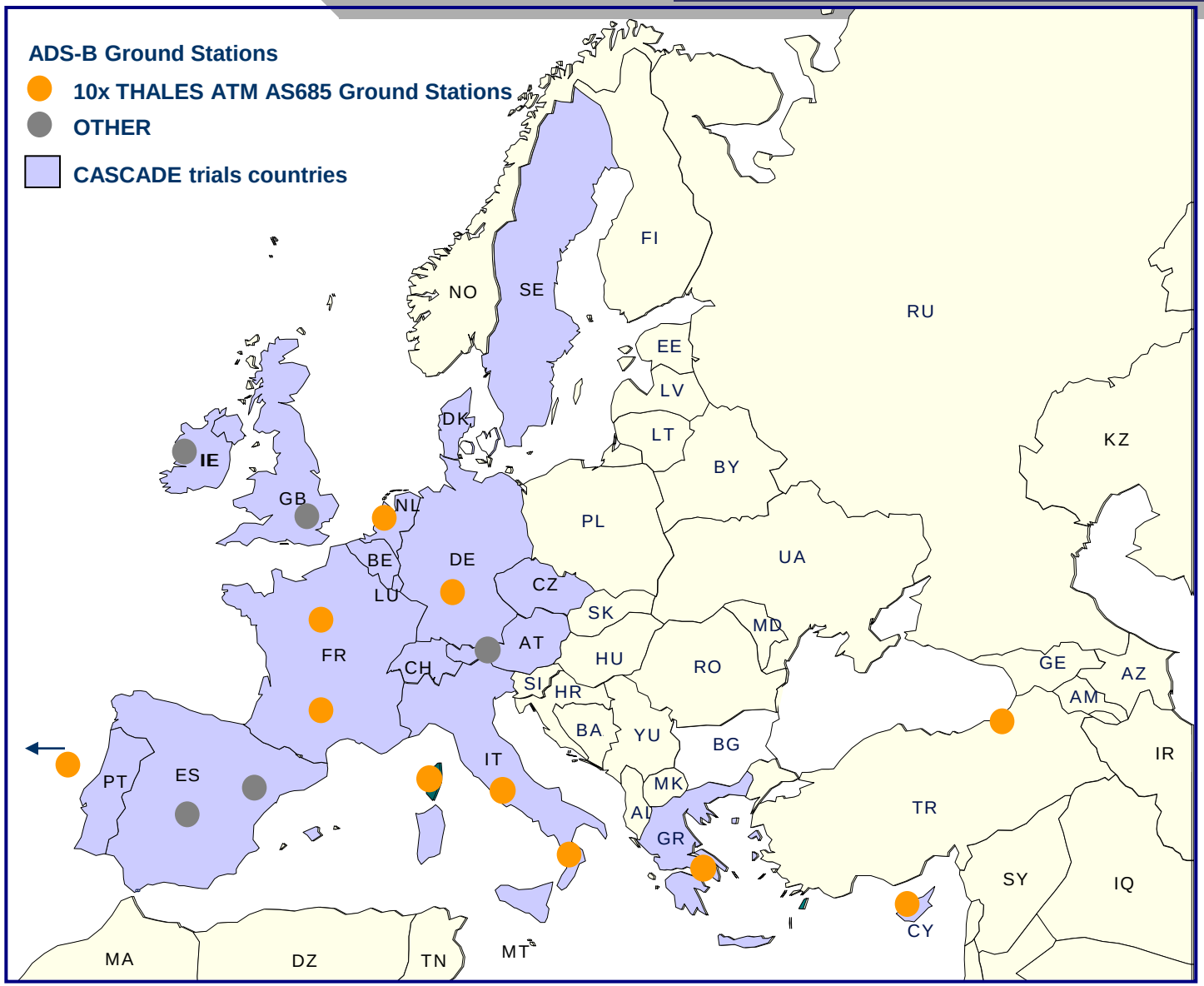

Image courtesy Eurocontrol

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Cascade Sites

10 x AS685 including each:

- up to 4 ch. ADS-B and TIS-B
- ADS-B data dispatcher
- Local operator Console
- Battery Backup

DFS Langen near Frankfurt, Germany

Images courtesy DFS

Athens Intl. Airport

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Thales MLAT/WAM/ADS-B Product Family

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 strenght 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

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Current GS Equipment Types

- **Two Branches are active:**
  - FAA Surveillance Broadcast Services System (SBSS)
    - Multichannel Radio
    - Single Channel Radio

    } new harmonised product in 2011 - SBGS
  - 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)

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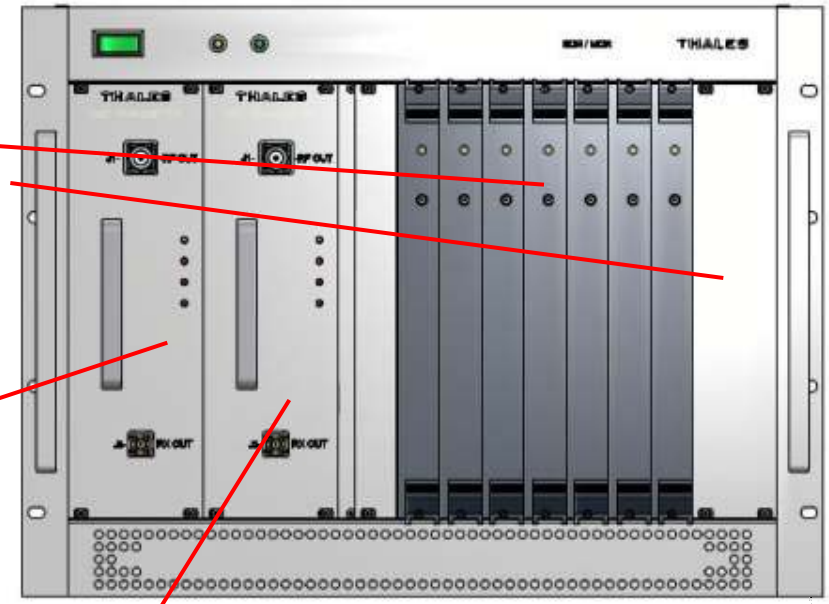
New FAA ground station

- 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

New SBGS MCR Rack Configuration



- 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

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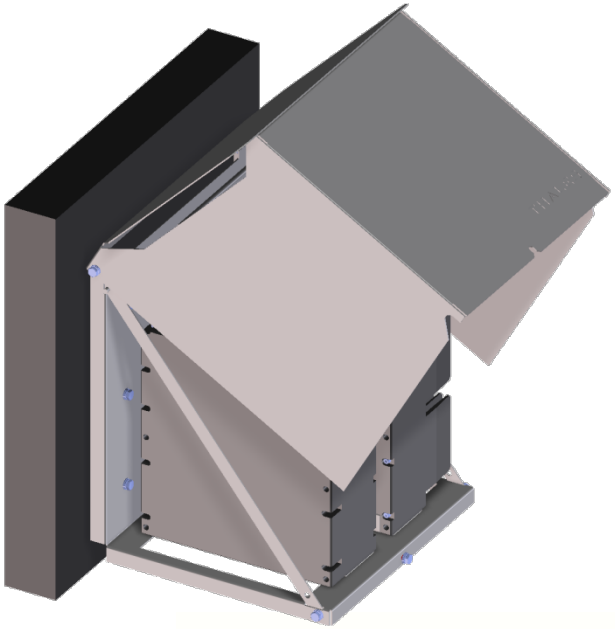
New BX680 outdoor version

- 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



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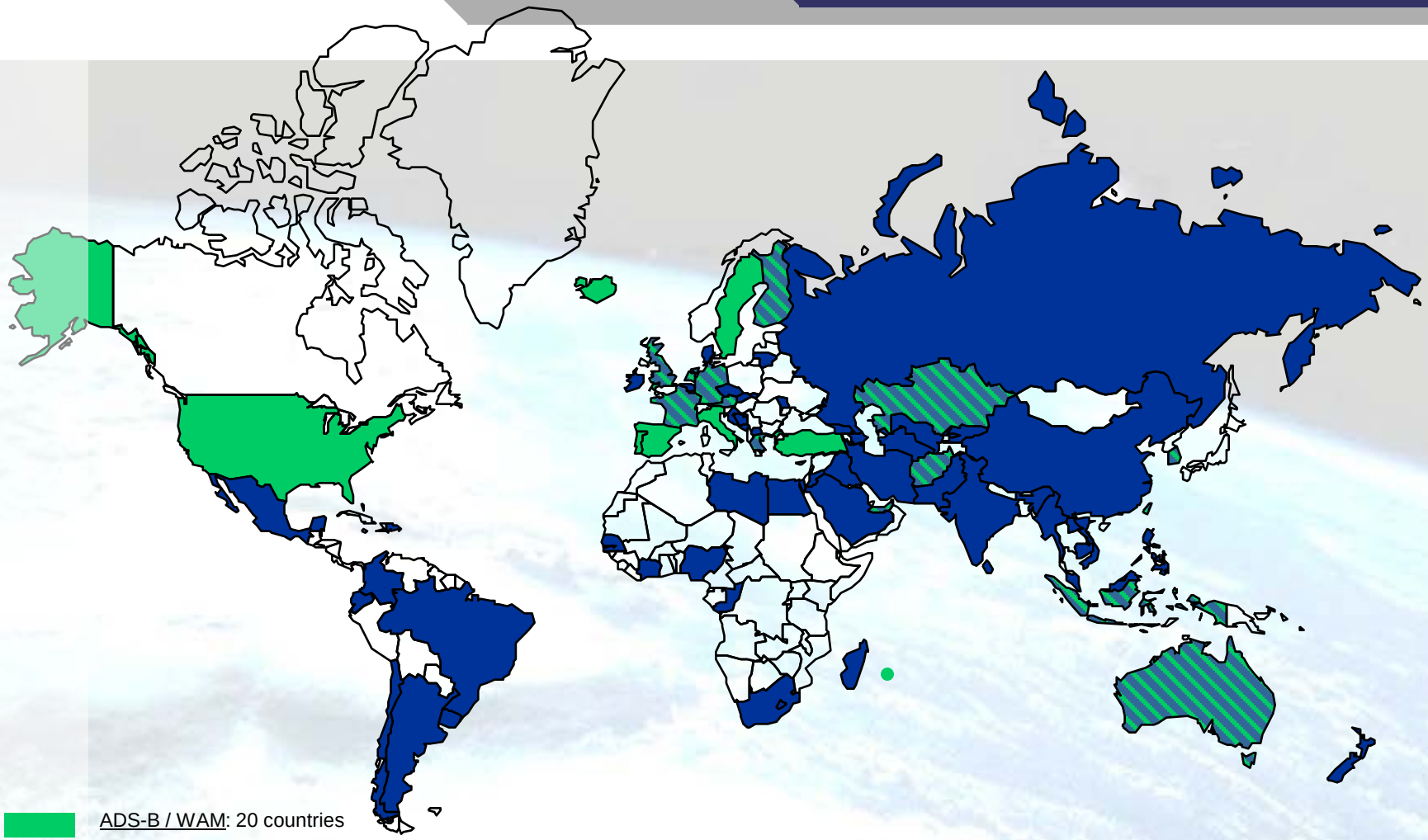
Thales Surveillance references



ADS-B / WAM: 20 countries

Radars: 71 countries (since 1995)

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Thank you

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