Precision Approach Monitoring - Frankfurt

PAM-FRA

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Security and mobility in a networked world.
Recapitulation: Surveillance Technologies

Surveillance Technologies

- Centralised
- Distributed

Radar
- PSR
- SSR

ADS
- ADS-C
- ADS-B

ADS-C
- Mode A/C
- Mode A/C/S

ADS-B
- 1090 ES
- UAT
- VDL-4

MSPSR
- PCL
- MSPSR

Multilateration
- Passive / Active

WAM = Wide Area Multilateration

WAM/MLKAT Training Thales Shawnee - Part I Dec 1, 2011

THALES

WAM = Wide Area Multilateration
Fundamental Principle of Multilateration

MLAT/WAM CPS calculates surfaces of constant time difference

Multilateration Ground Stations (GS)

Ground communications network

Transponder Reply or Mode S quitter

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

Signals received and time stamped by Ground Stations

System Output: Aircraft reports

Surveillance Data Processor

Track reports

ATC Display System

Multilateration Central Processing Station (CPS)
Multilateration

- Based on 1090 MHz signals (Mode A/C/S, 1090 ES)
- Requires >4 receivers with line of sight to target, or, at least 3 receivers + baro altitude
- Geometry-dependent – proper site planning is critical
- Transmitter required for Mode A/C compatibility

Multilateration System Configurations:

- MLAT: airport surface surveillance
- PAM and TMA MLAT: precision approach monitoring or airport terminal area surveillance
- Country-wide WAM: en-route surveillance (Wide Area Multilateration)
- Same equipment - same software

Thales Multilateration System: MAGS
(Multilateration Air/Ground Surveillance System)
Customer

- DFS

Main Task

- Provide Multilateration Surveillance within 128x80 NM coverage region around Frankfurt International Airport

Source: Fraport AG
Main Parameters

- Output Probability of Detection: PD ≥ 97%
- Up to 500 targets Mode A/C & S in coverage at any one time
- Reporting interval: 1 second,
- Direct plot output (no coasting, extrapolation or smoothing)
- Horizontal Position Accuracy: HPA ≤ 50m RMS (150 m for ED-142)
- Probability of Code Detection: PCD ≥ 97% (Mode A), ≥ 96% (Mode C)
- Altitude Timeout 1s
- Dual synchronisation required (GPS and RF Time Beacon)
- N-1 redundancy

Main constraints

- High Radio Frequency environment (most loaded 1090 MHz environment)
- High traffic load (>500 WAM targets seen in physical coverage)
- Difficult traffic mix (gliders, ultralights, helicopters, military, air transport,...)
DFS concluded a comprehensive initial site survey presenting a selection of more than 80 sites for tenderers to choose from.

Thales identified 34 sites (12 of these for airport GND alone) and their respective role:

- Main driver: low level visibility, rather than power budget
- Re-use existing sites as far as practical
- Requires system adaptability: antenna types, EMC, communication, packaging, lightning protection, etc.
- Confirmed findings in final site survey
Site selection: 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
Siting Model

Position Performance Model
RF Sync Performance Model

Also modelled:
- all N-1 cases
- all performances
- Various target altitudes

Selected Sites
Interrogation Performance Model
Typical PAM FRA Ground Station Sites
WAM Sensor Equipment

AX680 Receiver

- Digital, software-defined radio
- 1090 ES ADS-B Decoding
- Hot-swap elements

Small Indoor Cabinet

Regular Indoor Cabinet

Outdoor Cabinet

WAM Ground Stations

Central Processing Station
System Integration

Primary ATM System

Fallback ATM System

PAM FRA Overview - WAC February 2013 - HN
WAM Data used by DFS

Performance everywhere to Spec

Screenshots taken 30NOV2012 – hardly any GA
WAM Data seen by the System

Performance not everywhere to Spec

Seen on summer weekend: >520 targets

Screenshots taken 30NOV2012 – hardly any GA
All Data seen by the System

Blue = ADS-B

Screenshots taken 30NOV2012 – hardly any GA
**Low Level G/A aircraft test flight (EDFH)**

<table>
<thead>
<tr>
<th></th>
<th>Mean:</th>
<th>SD:</th>
<th>RMS:</th>
<th>Min:</th>
<th>Max:</th>
<th>Assumed:</th>
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<tbody>
<tr>
<td>Total Deviation:</td>
<td>18.9 m</td>
<td>27.9 m</td>
<td>33.7 m</td>
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<tr>
<td>Across Track Deviation:</td>
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<td>25.6 m</td>
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<tr>
<td>Along Track Deviation:</td>
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<td>21.9 m</td>
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<td>Latency:</td>
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<td>0.0 s</td>
<td>0.0 s</td>
<td>0.5 s</td>
<td>0.0 s</td>
</tr>
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</table>

**EDFH low approach (100 ft GND)**
**EDFH traffic pattern (500-1000 ft GND)**
**Reference: GPS tracker**

**Evaluation by DFS (S. Stanzel) and Eurocontrol (D. Lambers / J. Steinleitner)**

**Mode S Antenna**
Source: planepictures.net
Calculated by DFS comparing WAM to ADS-B across track error using known good ADS-B aircraft (DLH, BA, RYR)

Across track error eliminates latency effects of ADS-B
Main Features:

- Main performance parameters for MLAT/WAM
  - PD / PFD / Gaps
  - PCD / PFCD
  - HPA
  - Latency / Data Age

- Usage of different data sources
  - ASX CAT10, 20, 21, 48, 62

- Evaluation considering site specifications
  - Coverage area / Airport layout & GS position
  - Configurable requirements & evaluation volumes

- Flexible analysis options
  - Overall or track based analysis
  - Graphical and numerical result presentation
  - Result documentation via automatic reporting function
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Type approval by regulator, SAT passed: MAGS is compliant to PAM FRA Requirements
Global Surveillance
Technologies: A dilemma for ANSPs…

Conventional Surveillance Technologies: PSR, SSR Mode S

Highly mature, continuously improving, widely deployed technologies, cornerstone of CNS infrastructures

New Surveillance Technologies: WAM, ADS-B

Maturing solutions, more & more proven references and increasing operational deployment
The answer: a Global Surveillance approach

Made of the best mix of MLAT, ADS-B & Radars

Find the composite surveillance solution best matching ANSPs needs
Implementing Global Surveillance requires

- A “common language” applicable to any surveillance technologies:
  - Requirements
  - Solution description
  - Performance
  - Costs

- An Integrated Tooling Suite supporting this common language:
  - Requirements capture
  - Solution design & sitting
  - Performance assessment
  - Solution costing

An improved mutual understanding between ANSPs & industry
Enablers for global surveillance implementation (1)

1- Capture of operational requirements

First focus on needs, not on solution…
2 - Solution design & Siting

- Airport Surface Surveillance
- Terminal Manoeuvring Surveillance
- En-Route Surveillance

- Primary surveillance: STAR 2000
- Primary surveillance: TRAC 2000
- Secondary surveillance: RSM970 S, AS680/685, MAGS
- MLAT

Products installation constraints

Products features

Terrain

Explore multiple trade-offs, exploit opportunities & meet constraints....
3 – Operational performance assessment

**Common set of Figures of Merit**

- **Accuracy**
- **Robustness**
- **Detection**

Validated, jointly agreed models providing a reliable performance assessment
Enablers for global surveillance implementation (4)

## 4 – Costing & solution global valuation

### Cost models

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Value (M€)</th>
<th>Total value</th>
<th>Thales share</th>
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<tbody>
<tr>
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<tr>
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</table>

### Global satisfaction criteria

- High
- Medium
- Low

### Priorities weighting

- Costing & solution global valuation
- Cost models
- Global satisfaction criteria
- Global solution rating

### Credible valuation models based on ANSPs & industry references
Conclusions

Acceptance of the PAMFRA WAM System
Thales demonstrated its capability to deliver a high performances Multilateration system in very stringent conditions

Modelling and validation capabilities
Thales has developed technical and economical modelling tools needed to offer safe and optimized surveillance solutions