Agenda

- Evolutionary Deployments
  - North America
  - International

- Surface Surveillance Applications (A-SMGCS)
  - North America
    - FAA
  - Worldwide
    - Operational
    - Planned

- Wide Area Surveillance
  - North America
    - Operational
  - Worldwide
    - Operational
    - Planned
Evolutionary Deployments

- **North America**
  - FAA Technical Center
  - Atlanta Hartsfield
  - Dallas Fort Worth (ATIDS)
  - Gulf of Mexico (HITS)
  - Toronto - Lester Pearson Airport

- **International**
  - London Heathrow
  - Frankfurt
FAA Technical Center (Atlantic City, NJ) 1992-95
  - FAA and MIT Lincoln Labs sponsored tests to determine feasibility of transponder multilateration on airport surface.

Atlanta – Hartsfield International Airport 1995-97
  - FAA, MIT and NASA sponsored
  - Limited coverage of airport
  - Further performance analysis of surface MLAT
  - Included first WAM trials (PRM)

Dallas Fort Worth Airport (ATIDS) 1998-2000
  - FAA contract for major evaluation of surface MLAT
  - FAA used to develop/verify system requirements
  - 6 sensors coverage of East side of DFW
  - Resulted in inclusion of MLAT for ASDE-X

Toronto – Lester B. Pearson Int’l (2000-01)
  - NavCanada evaluation of surface MLAT
Gulf of Mexico (HITS) 2001 – 2005
- NASA sponsored R&D program
- WAM for low level helicopter operations to oil platforms
- Sensors installed on platforms and shore based
- Coverage area > 15,000 sq miles @1500 ft
- MLAT Performance compared to ATCBI-6 SSR
- London Heathrow 1996-97
  - Commissioned by NATS (National Air Traffic Services)
  - Limited deployment (5 sensors) focused on performance in gate/stands area (multipath & accuracy).
  - Successful and resulted in first ATC operational MLAT system worldwide.

- Frankfurt 1997-98
  - Sponsored by Fraport
  - Limited deployment for technical evaluation
  - Successful and resulted in 2nd operational system
Examples of Multilateration Based Surveillance Systems

Advanced Surface Movement Guidance & Control Applications

Wide Area Surveillance (WAM)
MLAT for ASMGCS

- ASDE-X (U.S. FAA)
  - Atlanta Hartsfield
  - Milwaukee

- International
  - London Heathrow (Operational)
  - Vienna (Operational)
  - Sydney (Planned)
Summary of Requirements

- **Coverage**
  - Movement area on the surface and extending to a height of 100 meters above the surface and the airspace used by arriving & departing traffic to a distance of 5 nm

- **Accuracy**
  - 7.5 meter, 95% confidence, runway, taxiway and apron centerlines; 12 meter, 99% confidence
  - Stands to within 20 meter averaged over 5 seconds
  - Airborne targets – 20 meter, 95% @2.5 nm; 40 meter, 95% @5 nm from threshold.

- **Probability of MLAT detection (active Mode S)**
  - 99.9% within any 2 second period on runway & taxiway
  - 99.9% within any 5 second period in the stands

- **False Targets (False detections) PFD**
  - <10^-4 defined as any spurious output or any position report >50 meter from true position

- **Update rate**
  - 1 per second minimum average for any target in the coverage area, based on squitter rate of Mode S transponders.

Source: Eurocae ED-117
**FAA /International Comparison**

- **Coverage area**
  - FAA systems do NOT require gate coverage
  - Most international require gate coverage
  - More sensors required

- **Transponders**
  - FAA requires tracking of older Mode A/C
  - Most international are Mode S only, European Mode S mandate.
  - Compatible with ADS-B (Mode S ES)

- **Interrogation**
  - FAA requires interrogation of older transponders
  - European prefer to minimize interrogations however addressed Mode S used for Mode A and Mode C.
Typical ASDE-X System Architecture
ASDE-X System at Atlanta International Airport
Commissioned June 7, 2006
- Surface Movement Radar (2)
- Multilateration System (MDS)
- Multi-sensor Data Processor (sensor fusion)
- Safety Logic (Conflict detection and alerts)
- Remote Monitoring & Control System (RMS)
- Display Processors
- Controller Displays (8)

Surface Movement Radars
- 2ea X-band solid state; 1 on ATCT (352’ AGL); 1 remote tower 90’

Multilateration System
- 16 remote units
  - 8 receiver only
  - 6 receiver + interrogator
  - 2 reference transmitter
ATL Multilateration Accuracy

System Precision (Major axis @ 1 sigma)

Multilateration Precision in feet
MKE – General Mitchell International

- ASDE-X System at Milwaukee
  - Commissioned October, 2003
  - Surface Movement Radar (1)
  - Multilateration System (MDS)
  - Multi-sensor Data Processor (sensor fusion)
  - Safety Logic (Conflict detection and alerts)
  - Remote Monitoring & Control System (RMS)
  - Display Processors
  - Controller Displays (8)

- Surface Movement Radars
  - 1ea X – band solid state

- Multilateration system
  - 10 remote units
    - 4 receiver only
    - 4 receiver + interrogator
    - 2 reference transmitter
MKE MLAT Coverage

System Precision (Major axis @ 1 sigma)

- Not Covered
- Receiver
- RefTransmitter
- Transmitter

feet

22.5
18.75
15
11.25
7.5
3.75
0
LHR Profile - world’s busiest airports

LHR is 3rd busiest airport in the world – in terms of total passengers

<table>
<thead>
<tr>
<th>Rank</th>
<th>Airport</th>
<th>Total passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Atlanta, Hartsfield (ATL)</td>
<td>85,907,423</td>
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<tr>
<td>2.</td>
<td>Chicago, O'Hare (ORD)</td>
<td>75,510,003</td>
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<td>4.</td>
<td>Tokyo, Haneda (HND)</td>
<td>63,282,219</td>
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<td>5.</td>
<td>Los Angeles (LAX)</td>
<td>61,485,269</td>
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<td>6.</td>
<td>Dallas/Ft. Worth (DFW)</td>
<td>59,064,360</td>
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In terms of cargo it is the 17th (MEM is the largest)

Current installation:
- 20 RU MDS system – 10 RO + 7 RT
- 3 Reference Transmitters
- Test system
  - Future T5 expansion
- 6 additional RU
  - Future T4 enhancement
- 2 additional RU
Current LHR Sensor Locations
LHR MLAT Coverage
Vienna MLAT Sensor Locations
VIE MLAT System
- 11 Remote Units
  - 5 RT
  - 6 RO
  - 1 Reference Tx

- Coverage
  - Runways
  - Taxiways
  - Gates
Sensis A-SMGCS for Australian Airports

- Customer
  - Airservices Australia

- Airports
  - Sydney
  - Brisbane
  - Melbourne

- Status
  - Contract Award 6/2006
  - Site Prep 03/2007

- A-SMGCS Architecture
  - Surface Movement Radar
  - Multilateration
  - Automatic Dependent Surveillance Broadcast (ADS-B)
  - Multi-sensor data processing
  - Conflict Alert
  - Tower Displays
  - Remote Monitoring System
  - Data Distribution
  - Aerobahn
  - VeeLo
  - Product Support Facility
Sydney MLAT Coverage

- Sydney MLAT System
  - 16 Remote Units
    - 4 RT
    - 10 RO
    - 2 Reference TX
  - Full coverage
    - Runways
    - Taxiways
    - Apron
    - Gates

Runways & Taxiways
Sydney Gate Coverage

System Precision at Gates
Sydney Airport

Sensis
Detect the Difference
MLAT for Wide Area Surveillance

- North America
  - 29 Palms California (military)

- Europe
  - Innsbruck
  - UK North Sea

- Asia Pacific
  - Tasmania
29 Palms Wide Area MDS System

**Basic requirements**
- Coverage from 100 to 40,000 feet AGL
- Accuracy within 100 m 1 sigma
- Capacity 400 simultaneous targets
- Mode S and Mode A/C
- 1 second update rate w 90% probability
- Track initiate within 5 seconds

**System components**
- 32 Remote Units
  - 14 RO
  - 18 RT
- GPS Time synchronization
- Solar power
- MW data links
29 Palms Wide Area MDS System
The Innsbruck, Austria Challenge

- Mountainous terrain surrounding narrow valley
- Traffic mix with 200 daily operations
  - VFR, IFR and glider
  - Charter peaks at 360+ daily
- Off-centerline LLZ/DME approach
- No radar for approaches... one-in/one-out procedures
Austro Control Surveillance Considerations

- Radar implementation deemed technically, logistically and politically difficult
  - Coverage limited by mountainous terrain
  - Highly expensive initial acquisition and lifecycle cost
  - Additional environmental considerations

- Chosen solution... Wide-Area Multilateration with ADS-B

Coverage at 5000’ AGL

Coverage at 1000’ AGL
Innsbruck: MDS Measured Results

<table>
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<tr>
<th>Error Thresh</th>
<th>Pos &lt; Threshold</th>
<th>Track &lt; Threshold</th>
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<tbody>
<tr>
<td>10m</td>
<td>232</td>
<td>14.46%</td>
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<tr>
<td></td>
<td>261</td>
<td>16.27%</td>
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<td>20m</td>
<td>794</td>
<td>49.50%</td>
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<td></td>
<td>868</td>
<td>54.11%</td>
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<td>50m</td>
<td>1535</td>
<td>95.70%</td>
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<tr>
<td></td>
<td>1592</td>
<td>99.25%</td>
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<tr>
<td>70m</td>
<td>1554</td>
<td>96.88%</td>
</tr>
<tr>
<td></td>
<td>1599</td>
<td>99.69%</td>
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<tr>
<td>100m</td>
<td>1575</td>
<td>98.19%</td>
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<td></td>
<td>1601</td>
<td>99.81%</td>
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<tr>
<td>1000m</td>
<td>1604</td>
<td>100.00%</td>
</tr>
<tr>
<td></td>
<td>1604</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Number of Positions: 1604
Test-flight on August 2nd 2004
- **System Requirements**
  - Coverage volume extends from 200 to 2,500 feet above mean sea level.
  - Horizontal position error of the system less than 150 m Root Mean Square (RMS).
  - Target load - simultaneously track at least 200 transponder equipped aircraft inside the coverage volume.
  - Track initiation - initiate a track on a target within 10 seconds of entering the coverage volume at least 90% of the time and within 15 seconds of entering the coverage volume at least 95% of the time.
  - Update rate – 5 seconds
System Features
- 16 Remote Units
- Installed on oil platforms, some not stationary.
- GPS time synchronization
- Central processing located at Aberdeen Center
- Data from Remote units sent over existing communication links.
- Used to monitor helicopter traffic from Aberdeen to platforms and transiting platforms.
- Area beyond shore based radar coverage
- 60,000 square miles @ FL100
- 25,000 helicopter operations per year

Sensor Locations

UK North Sea
TAS WAM Program Overview

- ATC Radar Services from Sensis MDS
  - 150 X 350 NM Coverage Area
  - 150 M accuracy or better
  - Altitudes from GL to 18,000 ft
  - 4 Second Update Rate
  - Mlat and ADS-B Coverage

- Delivery Includes:
  - 19 Remote Units (RT/RO)
  - SSR Site Monitors
  - Remote Monitoring System (Hobart/MEL TAAATS)
  - SSF
  - Training & Program Support

- Status:
  - Completed DDR
  - FAT April 2007
  - Site Installation Begins May 2007
  - Operational February 2008
Tasmania Coverage FL 115
Reference Materials

- ICAO 9830-AN/452 Manual of ASMGCS
- Eurocae MASPS for ASMGCS (ED 87A)
- Eurocae MOPS for MLAT as part of ASMGCS (ED 117)
- RTCA DO 181A MOPS for ATCRBS/Mode S
- ICAO 9688-AN/952 Manual on Mode S Specific Services
- ICAO SARPS Annex 14 Aerodromes
- ICAO 9157 Aerodrome Design Manual
- Operational and Spectrum Tests for ATIDS at DFW Airport; ATC-272, M.L. Wood, MIT/LL, Sept. 20, 1999
- Clarification Mode S Transponder in an Airport ASMGCS Environment; Eurocontrol MODES/SYS/002, Edition 1.1, 3 May 2005