Aeronautical Mobile Airport Communications System (AeroMACS) Technical Development Briefing

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Presentation Outline

• Background
• AeroMACS Technology and Applications
• NASA CNS Test Bed
• Development and Trials
• Future Work
• Standardization and WiMAX Forum
• Concluding Remarks
Why Airport Surface Wireless Communications?

Today
Wired Infrastructure
- Aging (40 yrs.)
- Costly deployment
- Rigid
- Costly maintenance
- Buried infrastructure
- Vulnerable
- Limited availability
- Point-to-point
- Noise susceptibility

Tomorrow
Wireless Infrastructure
- Scalable
- Agile
- Flexible
- Affordable
- Implements new protocols
- Supports fixed and mobile nodes
- Networked
AeroMACS Background

**AeroMACS** – a wireless airport surface communications technology based on IEEE 802.16e standard designed to **deliver critical networked communications** services to **mobile** and **fixed systems**

- Airport Wireless Communications (AeroMACS) concept developed by NASA Glenn under Space Based Technologies (SBT) Project 2002-2006.
- After SBT ended, NASA-FAA partnership continued AeroMACS development (SAA 3-978)
- In **2007**, ITU’s WRC07, the extended 5091-5150 MHz MLS for Airport Surface communications (wheels down).
- NASA GRC in partnership with FAA developed AeroMACS prototype system utilizing NASA GRC CNS Test Bed facility
- AeroMACS is part of NextGen and SESAR technology portfolio for airport surface operational improvements
- FAA has initiated the first round of AeroMACS deployments for fixed nodes – 9 airports
AeroMACS Technology Description

AeroMACS is a Digital Broadband Wireless Access system

- Member of “Mobile WiMAX” (IEEE802.16e)
  - Operates in AM(R)S band (5091-5150 MHz, Bandwidth = 5 MHz)
  - TDD/OFDMA
  - Adaptive Modulation and Coding: QPSK, 16QAM & 64QAM
  - Adaptive MIMO Switching - MIMO-A/STC & MIMO-B/SM (Optional)
  - Quality of Service (QoS)
- Enables IP-based “High Speed Wireless Access“
- Downlink/Uplink ratio adjustable: 26:21, 29:18, 32:15 & 35:12
- Provides “Security” using SS/MS Certificate, Security Keys and Encryptions
- Supports “Mobility” (up to 50 knots = 92.6 km/h)
# AeroMACS Applications: Fixed and Mobile

<table>
<thead>
<tr>
<th>Mobile Apps</th>
<th>Air Traffic</th>
<th>Air Carriers</th>
<th>Airports</th>
</tr>
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<tbody>
<tr>
<td>✓ AT Comm.</td>
<td>✓ Surface Mgmt.</td>
<td>✓ Fire &amp; Rescue</td>
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<tr>
<td>✓ AAtS</td>
<td>✓ Fueling</td>
<td>✓ Wild Life Mgmt.</td>
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<td>✓ Gate Clearance</td>
<td>✓ Weather</td>
<td>✓ Mobile Security</td>
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<td>✓ NOTAMS</td>
<td>✓ De-icing</td>
<td>✓ RWY Status</td>
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<tr>
<td>✓ Surface 4 DT</td>
<td>✓ EFB</td>
<td>✓ Coordination</td>
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<tr>
<td>✓ ATIS</td>
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<table>
<thead>
<tr>
<th>Fixed Apps</th>
<th>Air Traffic</th>
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<tr>
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<td>✓ Ramp Mgmt.</td>
<td>✓ Security Gates</td>
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<td>✓ Weather</td>
<td>✓ Flight Ops.</td>
<td>✓ Construction</td>
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<tr>
<td>✓ Navigation Aids</td>
<td>✓ Ramp Services</td>
<td>✓ NOTAM-D</td>
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<tr>
<td>✓ Visual Aids</td>
<td>✓ Baggage</td>
<td>✓ Lighting</td>
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2006 - NASA GRC in partnership with industry and government established the CNS Test Bed in North East Ohio

- Originally test bed consisted of three airports (BLK, CLE and LPR) and the NASA Glenn Research Center (GRC)
- Today’s configuration consists or NASA GRC and Cleveland Hopkins Airport
- Objectives:
  - Prototype
  - Evaluate
  - Measure
  - Reduce risk
- Applied Research
  - Advanced Integrated Surveillance
  - Airport Surface Wireless Communications
  - Secure Information Sharing
  - Staffed Virtual Tower
  - Precise 4-D Trajectory Negotiation

Test Frequencies

<table>
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<tr>
<th>Frequency</th>
<th>MHz</th>
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<tr>
<td>5005</td>
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<tr>
<td>5015</td>
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<td>5025</td>
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<td>5095</td>
<td>5120</td>
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<tr>
<td>5100</td>
<td>5125</td>
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Test Bed Locations

CLE
- CMF
- ASH
- Glycol Tank
- Snow Barn
- ARFF
- Terminal C

GRC
- Bldg. 4
- Bldg. 110

FAA
- ALSF
AeroMACS NASA Trials and Investigation

- Aircraft Mobile Application Testing – AeroMACS testing on Boeing 737-700 corporate aircraft
  - Weather to the cockpit using EFB, System Performance
  - Antenna performance
  - Throughput Validation
  - Partners: Boeing, United Airlines, WSI, ITT, FAA, NASA, CLE Airport Authority
- Surveillance Video Test – First trial using terminal radar video
- RTCA, ICAO, WiMAX standards and technical profile development support
  - US RTCA standards DO-345 and
  - International Civil Aviation Organization SARPS completed
- Standard Compliance Trial – First compliance system test and demonstration with Hitachi Corp.
- World Wide satellite interference analysis
**Hitachi Prototype Testing**

- **Throughput Test:**
  - 5MHz channel can provide total throughput of 11 Mbps (Downlink + Uplink)

- **Quality of Service (QoS) Test**
  - Technical Standard (Network) was validated: the reserved bandwidth is guaranteed.
  - It was validated that a single MS accommodates multiple QoS class communication links

- **Initial Network Entry (INE) Test**
  - INE time depends on scan step and range
  - INE on the Runway succeeded and the necessary INE time was a bit longer (5MHz step: 4.50 sec, 250kHz step: 26.67 sec) because of longer T2 time
  - SARPs requirement (90 seconds) can be realized (maximum 26 sec at the Field Trial)

- **Mobility and Handover Test**
  - Mobility validation: AeroMACS link maintained throughout Runway drive @50/22 knots with handover. Latency: 200 msec.
SWIM Data over AeroMACS

- **Test Case 1**
  - This test case transports SWIM data over AeroMACS.
  - SWIM Accessibility
  - Data Throughput
  - Aircraft runway speed: 45 Knots.

- **Test Case 2**
  - This case will exchange SWIM data plus emulated airline data communications with AOC.
  - Radome antenna evaluation
  - Aircraft runway speed: 55 Knots

- **Test Case 3**
  - This case will exchange SWIM data plus emulated airline data communications with AOC and emulated radar data exchange.
  - Handover performance
  - Aircraft runway speed: 60 Knots
AeroMACS test at Boston Logan Airport

- FAA Airports, FAA Technical Center
- 1\textsuperscript{st} Airport\Airline Operational Use
- Test Representative Uses
  - Radar (Ship or Bird Radar)
  - Video
  - Weather
  - Security\Perimeter Monitoring
  - Airline Use
- Preliminary Site Survey
- MOA with FAA
- MPA/FAA/Airline partnership
- \textasciitilde2-year effort
NASA Future Trial and Testing

- **Interoperability**: Hardware and software subscriber station compatibility
- **Security**: Evaluate different system security concepts and configurations (Authentication, authorization, etc.)

**Demonstration**:
- End-to-end service delivery
- Security – key exchange...
- Interoperability
- SMART NAS Test Bed LVC
- AT/AOC Application over EFB
- Mobility

**Partners**:
- FAA
- NASA GRC

**Application** performance test: VoIP

**Internet Protocol** Suite Trial and Evaluation: IPV4/6, Roaming, etc.

**End-to-end** Service Delivery: Latency, Jitter, etc.
AeroMACS Standards Development

- Started in **2009** with the RTCA Special Committee 223 (SC-223) and the European Organization for Civil Aviation Equipment (EUROCAE) Working Group 82 (WG-82). They published a **MOPS** and **Profile** for AeroMACS based on IEEE std 802.16-2009 in **2014**.

- EUROCAE is continuing development of the AeroMACS Minimum Aviation System Performance Standards (**MASPS**).

- ICAO ACP WGS finalized the AeroMACS **SARPS** and completed development of AeroMACS Technical Manual.

- Finally, the WiMAX Forum’s Aviation Working Group (AWG) has been engaged throughout AeroMACS development process, releasing AeroMACS Certification Requirement Status List (**CRSL**) and Protocol Implementation Conformance Statement (**PICS**).
WiMAX Forum

- **Industry-led**, not-for-profit organization, certifies and promotes the compatibility and interoperability of certain wireless broadband technologies across various industries ranging from Telecommunications (WiMAX) up to **Aviation** (AeroMACS) since 2001.

- With regards to Aviation industry, the WiMAX Forum has been instrumental in **all stages** of AeroMACS’ growth, from its initial launch, when we facilitated the development of a system profile, to current global expansion efforts.

- Key authorities such as the **FAA**, **EUROCONTROL**, and the **ICAO** regularly attend Forum aviation-centric events in which industry leaders, experts and technology providers are able to collaborate and share real-world knowledge, focused specifically on the deployment of standardized broadband networks for the aviation industry.
WiMAX Forum Members

Key Members in Aviation

- Aviation Data Communication Corporation, China (ADCC)
- Civil Aviation Safety Authority of Australia
- CelPlan
- ConvergEX Technologies
- DFS Deutsche Flugsicherung
- Embry Riddle Aeronautical University
- EUROCONTROL
- FAA
- Gemtek
- Harris
- Hitachi

- Honeywell
- Leonardo (Finmeccanica/SELEX)
- Metropolitan Washington Airport Authority
- MITRE Corporation
- NASA
- Powertech Labs
- Sequans
- Shinsei Corporation
- Siemens
- Symantec
- Telrad Networks
- United Airlines
WiMAX Forum® AWG has facilitated a number of regional aviation events such as:

- **Aviation Washington**
  September 2013, Washington DC, USA

- **Aviation Brussels**
  Hosted by EUROCONTROL
  May 2014, Brussels, Belgium

- **AeroMACS Track**
  Hosted at Wireless China Summit
  September 2014, Beijing, China

- **Aviation Sendai**
  Hosted by Hitachi, JCAB and ENRI
  November 2014, Sendai, Japan

- **Aviation Madrid**
  Hosted at World ATM Congress
  March 2015, Madrid, Spain

- **AeroMACS Track**
  Hosted at Wireless China Summit
  September 2015, Beijing, China

- **AeroMACS National Harbor**
  Hosted at ATCA Congress
  November 2015, National Harbor, USA

WiMAX Forum® AWG AeroMACS programs in process:

- AeroMACS Certification
- AeroMACS X.509 Public Key Infrastructure (PKI)
- AeroMACS FCC Service Policy Petition
- AeroMACS Seminars
WORLDWIDE CONTRIBUTIONS

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Concluding Remarks

- AeroMACS is a standardized broadband wireless communications technology for use on the airport surface.
- Design to securely meet operational needs of mobile and fixed platforms.
- Operates in protected AMR(S) spectrum: 5091-5150 MHz and 5000-5030 MHz
- Federal Aviation Administration initiated AeroMACS deployment to transport Airport Surface Surveillance Capability sensor information
- Investigation and trials taking place in different countries around the world
- AeroMACS opens up new information exchange possibilities for stakeholders operating on the airport surface