AeroMACS - WiMAX Forum®

- **Industry-led**, not-for-profit organization that certifies and promotes the compatibility and interoperability of broadband wireless products based on IEEE Standard 802.16 across various industries from Telecommunications (WiMAX) to Energy (WiGRID) and **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 WiMAX Forum Members such as the **EUROCONTROL**, **FAA**, and **ICAO** participate in our aviation-centric events in which industry leaders, experts and technology providers are able to collaborate and share real-world experience, focused specifically on the deployment of standardized and secure broadband networks for the aviation industry.
AeroMACS at a Glance

Globally standardized datalink, offering high capacity and secure communications on the airport surface.

Operation in a regulated spectrum (5GHz) offering protection from interference.

Supports Air Traffic Control, Airline Operations Communications, & Airport communications using single technology.

Part of wider aviation communication infrastructure approved to support the safety and regularity of flight.
AeroMACS Applications
AeroMACS Evolution

1. Standards
2. Security
3. Certification
4. Deployment
Global Coordination & Harmonization

ICAO Aeronautical Communications Panel, Recommendation Future Communications Study

ITU WRC-07 approved spectrum allocation for 5091-5150 MHz for AeroMACS

AeroMACS profile based on IEEE 802.16e - 2009 standard

- FAA and EUROCONTROL
  - TSO-C207a – AeroMACS Airborne Mobile Station (AMS) Equipment

- RTCA SC-223 and EUROCAE WG-82
  - DO-345/EUROCAE ED-222: AeroMACS Profile
  - DO-346/EUROCAE ED-223: AeroMACS MOPS
  - EUROCAE ED-227: AeroMACS MASPS

- ICAO Aeronautic Communications Panel Surface Datalink Working Group (WGS)
  - ICAO Doc 10444 – AeroMACS Technical Manual
  - ICAO ANNEX-10, Volume III, Chapter 7: AeroMACS SARPs

- ARINC AEEC AeroMACS Working Group
  - ARINC 766: Aeronautical Mobile Airport Communication System (AeroMACS) Transceiver and Aircraft Installation Standards
Over a Decade of Standardization

Future Communications Study
Make recommendation

Spectrum Allocation
Define spectrum

Requirements
Ensure compliance and interoperability

Compliance
Test, implement and manage SARPs compliant system

Characteristics
Certify, build and approve AeroMACS systems
AeroMACS Spectrum Allocation

AeroMACS SHALL support 5 MHz channels in the 5091 MHz – 5150 MHz band

- 5091 MHz – 5150 MHz: Internationally allocated by ITU at WRC-07 in 2007 (Co-primary AM(R)S allocation)

- 5000 MHz – 5030 MHz: possible national allocations
The channel spacing is 5 MHz without a guard band between adjacent channels.

The frequencies listed are available for AeroMACS operation after registration with, and assignment by, the Channel Manager.

*SOME level of Radio Regulatory coordination will be advised in all countries as potentially competitive users will seek to acquire spectrum.*

### Lower AeroMACS Sub-Band (5000 MHz to 5030 MHz)

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>Channel Center Frequency ($f_c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5005 MHz</td>
</tr>
<tr>
<td>2</td>
<td>5010 MHz</td>
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<tr>
<td>3</td>
<td>5015 MHz</td>
</tr>
<tr>
<td>4</td>
<td>5020 MHz</td>
</tr>
<tr>
<td>5</td>
<td>5025 MHz</td>
</tr>
</tbody>
</table>

### Upper AeroMACS Core-Band (5091 MHz to 5150 MHz)

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>Channel Center Frequency ($f_c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5095 MHz</td>
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<tr>
<td>7</td>
<td>5100 MHz</td>
</tr>
<tr>
<td>8</td>
<td>5105 MHz</td>
</tr>
<tr>
<td>9</td>
<td>5110 MHz</td>
</tr>
<tr>
<td>10</td>
<td>5115 MHz</td>
</tr>
<tr>
<td>11</td>
<td>5120 MHz</td>
</tr>
<tr>
<td>12</td>
<td>5125 MHz</td>
</tr>
<tr>
<td>13</td>
<td>5130 MHz</td>
</tr>
<tr>
<td>14</td>
<td>5135 MHz</td>
</tr>
<tr>
<td>15</td>
<td>5140 MHz</td>
</tr>
<tr>
<td>16</td>
<td>5145 MHz</td>
</tr>
</tbody>
</table>
# Why AeroMACS

## Installation

- ECONOMICAL, FAST, EASY, SCALABLE

## Turn-key

## Network Management

<table>
<thead>
<tr>
<th>Technical Values</th>
<th>Business Values</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband</td>
<td>No management cost for telephone number</td>
<td>Certification program</td>
</tr>
<tr>
<td>Broad NLoS coverage</td>
<td>Low cost for installation &amp; maintenance</td>
<td>Hardware-based PKI credential</td>
</tr>
<tr>
<td>Data Oriented Architecture – also supports mobility</td>
<td>Simple mobile station ⇒ Easy airworthiness certificate</td>
<td>Multiple Certification Authorities</td>
</tr>
<tr>
<td>Always-on connectivity</td>
<td>Easy IOT due to standardized profile</td>
<td>Revocable and replaceable certificates</td>
</tr>
<tr>
<td>Low failure rate (QoS)</td>
<td>No legacy systems</td>
<td>Certificate Hierarchies</td>
</tr>
</tbody>
</table>
AeroMACS vs. Other Systems

AeroMACS is the only globally standardized aviation technology designed to support the safety and regularity of flight, ATS, AOC and Airport Authority communications simultaneously.

<table>
<thead>
<tr>
<th></th>
<th>ACARS</th>
<th>Wi-Fi Gatelink</th>
<th>Cellular</th>
<th>AeroMACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Reliability</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
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<tr>
<td>Performance</td>
<td>↓</td>
<td>← ↔ → ↑</td>
<td>← ↔ → ↑</td>
<td>↑</td>
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<tr>
<td>Capacity</td>
<td>↓</td>
<td>← ↔ → ↑</td>
<td>← ↔ → ↑</td>
<td>↑</td>
</tr>
<tr>
<td>Global availability</td>
<td>↑</td>
<td>↑</td>
<td>← ↔ → ↑</td>
<td>↑*</td>
</tr>
<tr>
<td>Security</td>
<td>↑</td>
<td>← ↔ → ↑</td>
<td>← ↔ → ↑</td>
<td>↑</td>
</tr>
<tr>
<td>Per-bit cost efficiency</td>
<td>↓</td>
<td>↑</td>
<td>↑**</td>
<td>↑</td>
</tr>
<tr>
<td>Coverage radius</td>
<td>↑</td>
<td>← ↔ → ↑</td>
<td>← ↔ → ↑</td>
<td>← ↔ → ↑</td>
</tr>
</tbody>
</table>

↑ High  ↓ Low  ← ↔ → Medium
* Potential  ** With the exception of roaming traffic

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Network Comparison

Real-World Network Speeds (Kbps)

Approved for Safety Services

Source: Honeywell
The U.S. Federal Aviation Administration (FAA) has identified over 330 AeroMACS applications under 5 categories:

- Air Traffic Control/ Air Traffic Management Applications
- Aviation Information Systems/ Meteorology Applications
- Airline Operations Applications
- Safety Applications
- Airport Infrastructure Applications
AeroMACS Network Infrastructure

Regulators
Ensure that air traffic, security and safety management follow regulation

Air carriers
Support air traffic, security and safety applications on aircraft, and carrier applications

Airports
Support airport operations and any applications mandated by regulators

Suppliers
Provide equipment, services, network applications and management tools

Synergy to share the network infrastructure and its benefits
AeroMACS Security

AeroMACS Public Key Infrastructure (PKI) provides the digital certificates to aircraft, ground device, and servers for strong device to device authentication. This mechanism provides the foundation for application authorization, access control, and data confidentiality.

AeroMACS PKI:
- Minimizes cyber threats
- Provides efficient, reliable, and secure broadband connectivity across the entire airport footprint
- Securely collects data from fixed and mobile terminals
- Securely maintains communications with staff and aircraft
Using Internet and Aviation security standards and in collaboration with the industry, WiMAX Forum started AeroMACS PKI solution development.

WiMAX Forum Alliance with ICAO

- In December 2017, the WiMAX Forum formed an alliance with ICAO to promote effective AeroMACS PKI program to Deliver Secure Networks.

- As the AeroMACS Management Authority (MA), the WiMAX Forum, with the support of Eonti Inc. will implement and manage the AeroMACS PKI.

- AeroMACS Advisory Council (AAC) to provide oversight to the AeroMACS Public Key Infrastructure (PKI) program developed in accordance with industry standards.
AeroMACS PKI Digital Certificates

The PKI provides the digital certificates to aircraft, ground device, and servers for strong device to device authentication. This mechanism provides the foundation for application authorization, access control, and data confidentiality.

A single Root CA system provides a highly secure, trusted, and globally interoperable PKI.
**AeroMACS Certification**

To certify global interoperability for AeroMACS equipment against specific applications and requirements.

### WiMAX Forum Background

- For Mobile WiMAX all testing is performed in WiMAX Forum Designated Certification Laboratories (WFDCL).
- Radio Conformance Testing – RCT.
- Protocol Conformance Testing – PCT.
- Interoperability Conformance Testing – IOT.
- Certification Requirements Status List (CRSL) Defines Tests for specific profiles.
- Protocol Implementation Conformance Statement (PICS) Specifies a list of protocol elements required as a realization of a system profile.

### AeroMACS Certification

- AeroMACS Certification encompasses:
  - Radio Conformance Testing,
  - Protocol Conformance Testing,
  - Interoperability Conformance Testing,
  - Security and Network Elements.
- All based on the forum's AeroMACS Certification profile in compliance with the requirements of industry standards.
- AeroMACS Certification will be a requirement of FAA.

### Key Milestones

- Initial Interoperability demonstration (MIDE) event took place in 2015.
- AeroMACS Certification will initially occur in two phases.
  - **Wave 1** – RCT Certification now available in the WiMAX Forum AeroMACS Designated Certification Laboratory (ADCL).
  - **Wave 2** - PCT, IOT, Security and Network testing the ADCL occurring in 2018.
- Siemens and Telrad Networks have received Wave 1 AeroMACS Certification.
AeroMACS Validation
Boeing AeroMACS D-Taxi Tests

Existing VHF blade antenna was replaced by Sensor Systems AeroMACS tests

Aeronautical Application Validation tests were conducted using a Boeing 737-700 aircraft
FAA Bombardier Testbed

NASA’s Glenn Research Center has successfully transmitted route options, weather information and other data via AeroMACS to an FAA Bombardier Global 5000.

The demonstration was conducted at NASA’s Communications, Navigation and Surveillance (CNS) test facility in collaboration with the FAA and Hitachi.
Airbus Aircraft Installation and Rational

Vision of a future globally distributed radio architecture for CNS

Possible Evolution of Communications and Surveillance Systems

A Vision of Architecture for Future Radios and Smart antennas

Digital Interconnection (weight reduction)

Universal Main Radio Unit (Hosting multiple radio software)
Honeywell Portable AeroMACS D-Taxi App

- Future-proof D-Taxi Application is fully compliant with ATN-B2 message set RTCA SC-214/DO-350A EUROCAE ED-228A
- Supports IPS communications over AeroMACS
- Integrates multiple applications on the EFB/iPad: d-Taxi, A-SMGCS with moving map display, baggage handling and airline operations optimization, vehicle management, VoIP, Video
- Conducted safety assessment and mitigation for taxi guidance on COTS iPad
- Prototype AeroMACS portable unit can be used for vehicles, Ramp management staff and for aircraft trials
- ARINC 766 compliant AeroMACS avionics radio under development

Prototype Integrated AeroMACS with iPad EFB – about 1.5” thick
FAA (ASSC)

Airport Surface Surveillance Capability

- Leverages Airport Surface Detection Equipment
- On contract to deploy ASSC at 9 airports, and 3 support systems with options for up to 58 more
  - Completed Site Acceptance Test (SAT) at SFO which is the key site
  - Production activities well underway for the next 8 Airports and the support systems
FAA Hosts Chinese Delegation

CHINESE DELEGATION VISIT FOCUSES ON BENEFITS OF AEROMACS SYSTEM

The FAA hosted a unique gathering from October 24-27, 2017. The visit brought together key representatives from several Chinese government aviation agencies including the Civil Aviation Authority of China (CAAC), Air Traffic Management Bureau (ATMB) and Aviation Data Communication Corporation (ADCC), as well as FAA program specialists and industry representatives.

The visit centered around wireless communication for aviation use. This topic of common interest between the US and China reflects a growing recognition of the power and importance of the Aeronautical Mobile Airport Communication System (AeroMACS). AeroMACS aims to bring wireless, broadband connectivity to airports for surface operations and eventually on the aircraft to interact with avionics systems.

The Chinese delegates presented briefings on the outcomes of their proof-of-concept trial using AeroMACS in the cockpit for the departure and arrival taxi stages at Beijing Capital Airport. The test, conducted from October 1-7, utilized 56 flights from Air China, China Eastern, Hainan Airlines and Shandong Airlines and showed positive results.
Beijing Airport D-Taxi

Air China, China Eastern Airline, Hainan Airline and Shandong Airline attend the D-TAXI assistance system cockpit trial in the period of departure and landing taxi stage via AeroMACS.
AeroMACS D-Taxi Real-Time Mapping

D-TAXI system provides Beijing Airport surface map, guidance and situational awareness of controllers and pilots in the airport surface area.

D-TAXI system via AeroMACS provides real-time guidance according to the approved taxi route by the ATC control tower.
Chengdu Airport D-Taxi and A-SMGCS over AeroMACS
AeroMACS at Haneda Airport
AeroMACS network is demonstrated to be secured.

Test results:
- AeroMACS network is demonstrated to be secured through device certification/authentication.
- ATC traffic is always prioritized to deliver over any other traffics.
- There is no area of “Out of Service” on airport vehicle routes.
AeroMACS is the standardized wireless technology selected to provide safety and regularity of flight on the airport surface globally.

AeroMACS operates in the protected and licensed aviation spectrum band to enable and improve ground communications.
Thank You!

Declan Byrne, President
Declan.Byrne@WiMAXForum.org