AAtS over AeroMACS Technology Trials on the Airport Surface

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Contents

1. Trial Introduction
2. AeroMACS and NASA Test Bed
3. Aircraft Access to SWIM
4. AAtS/AeroMACS Trial – Test Cases
5. Trial Architecture
6. AeroMACS Configuration and Results
7. AAtS Results
8. Conclusion
Collaboration between Federal Aviation Administration (FAA), Hitachi, Ltd. and NASA

Objective: Exchange data between SWIM services and an Electronic Flight Bag deployed onboard an Aircraft

Goal: Evaluate performance of AAtS using AeroMACS data transport technology in a relevant environment

Trial conducted on February 11th, 2016
AeroMACS and NASA Test Bed Configuration

AeroMACS

- 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)
Aircraft Access to SWIM

Description:

• Technology agnostic solution that establishes airborne component of ground based System Wide Information Management (SWIM) Service Oriented Architecture (SOA)

• Facilitates exchange of non-command and control/safety critical information between pilots and other National Airspace System (NAS) users

• Facilitates a commonly sourced/shared aviation information environment for strategic collaborative decision making

• Leverages existing air/ground third party service providers’ infrastructure and technologies without new equipage mandates

• Uses an IP Data Link to perform functions and collaborate/coordinate flight activities

Demonstration Objectives:

• Assess feasibility of commercial services for exchanging SWIM-enabled NAS data

• Validate AAtS concept in cooperation with NAS users/stakeholders

• Provide technical findings and recommendations for future standards development
Demonstration Scenarios

• Weather

• Flight Information Update

• Electronic PIREP Submission

• Aircraft Preference Publication
  • Initial 4DT Preference Exchange
AAtS/AeroMACS Trial – Test Cases

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

• **Test Case 2**
  - This case will exchange AAtS data as in Case 1, but an additional data stream will be activated to emulate airline communications with AOC.
  - Shark-fin antenna evaluation
  - Aircraft runway speed: 55 Knots

• **Test Case 3**
  - This third case is same as Case 2 and adds loading on the AeroMACS communications system to emulate the exchange of radar data from a fixed station to ATCT.
  - Aircraft runway speed: 60 Knots
Trial Architecture

NextGen Prototyping Network

- NEMS Untrusted DMZ
- NEMS Trusted DMZ
- AIM
- CSS-Wx

FAA

AOC/FOC Client

Air Carrier

Aircraft

AeroMACS

DMS

Service Provider

DMS: Data Management Service
NEMS: NAS Enterprise Messaging Services
NESG: NAS Enterprise Service Gateway
AOC: Airline Operations Center
FOC: Flight Operations Center
EFB: Electronic Flight Bag
AIM: Aeronautical Information Management
CSS-Wx: Common Support Services - Weather

SWIM Service: NEXTRAD – Wx
IP end-to-end Full duplex service

Not in Demonstration

Atlantic City, NJ

En-route

Swift Broadband Satellite Services

Cleveland, OH

Surface
AAtS over AeroMACS Demonstration Architecture

**NASA GRC**
- L2-SW
- Microwave
- L3-SW
- AAA
- AOC
- ASR
- BS-OMC

**ASN-Gateway**
- Log Record
  - Data Traffic
  - Radio
- Gateway
  - Data/Control
  - Handover Support
- INTERNET
- SWIM Data

**ARFF**
- BS1
- BS2
- Handover (BS1→BS2)
- Emulated Radar (Uplink)
- SS@CMF Ctrl (Uplink)
- AeroMACS SS@VAN
- AeroMACS SS@CMF

**Mobile**
- BS1 Coverage
- Handover (BS2→BS1)

**Fixed**
- BS2 Coverage
AeroMACS Configuration and Results
SS Antenna Configuration and Coverages

SS-2 Ant-1
GPS Ant
SS-1 Ant-1

SS-2 Ant-2
SS-1 Ant-2

SS-3 Ant (Radome)
AeroMACS Configuration and Results
Test Case 1: Speed & DL CINR (SS-2)

Speed [knot] vs Time [sec]

- Handover (BS1->BS2)
- Handover (BS2->BS1)

DL CINR (dB)

0 10 20 30 40 50 60 70

0 100 200 300 400 500 600 700

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National Aeronautics and Space Administration
AeroMACS Configuration and Results

Test Case 1: DL/UL Throughput (Access to SWIM)

- DL:UL Symbol Ratio = 32:15
- Once associated with a BS, onboard SS could maintain AeroMACS link with high throughput up to 8 Mbps (DL) / 3 Mbps (UL)
- Total Data transferred within 50 seconds were 31.8 MB (DL) and 10.1 MB (UL), which can cover access to SWIM.
AeroMACS Configuration and Results
Test Case 2: Data Throughput

- **DL:UL Symbol Ratio = 32:15**
- **Additional Data Traffic (TCP/iperf) has given no effect to SWIM Data transfer (Additional Data stream from CMF at Test case 3 gave no effect, either).**
- **Total Data transferred within 50 seconds were 30.9 MB (DL) and 9.7 MB (UL).**
- **Required AOC Data Transfer of 10 MB(DL) and 2 MB(UL) were completed within 23 sec (DL) and 16 sec (UL)**
AeroMACS Configuration and Results
Window Antenna (SS-1/SS-2) vs Shark Fin Antenna (SS-3)

- Window Antenna can benefit 3 dB by diversity effect (two elements). Antenna diversity is essential for MIMO-A (& MIMO-B).
- CINR of the Window Antenna drops when the airplane changes its direction parallel to the BS antenna beam.
- Shark Fin antenna gain (incl. cable loss) looks 3 dB lower than that of window antenna (single element), but it works omni directional.
- CINR of Shark Fin antenna looks sensitive to the airplane dynamics (vibration).
All exchanges well within the 400 sec transaction time guideline provided in the AAtS Implementation Guidance Document (IGD) per ICAO’s Manual on Required Communication Performance (Doc 9869)
Conclusion

• Collaboration between Federal Aviation Administration (FAA), Hitachi, Ltd. and NASA
• Goal was to evaluate performance of AAtS using AeroMACS data transport technology in a relevant environment
• Hitachi technology for AeroMACS successfully performed on all test cases and demonstrated high throughput information delivery to AOC and AAtS applications
• ICAO Required Communications Performance was successfully met for all AAtS data exchanged
• Trial successfully completed on February 11th 2016