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ICNS 2016

AAtS over AeroMACS Technology Trials on the Airport Surface

Rafael Apaza, NASA Glenn Research Center, Cleveland, Ohio
Biruk Abraham, Federal Aviation Administration, Washington, DC
Toshihide Maeda, Hitachi Ltd., Kawasaki, Japan

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Rafael.Apaza@NASA.gov

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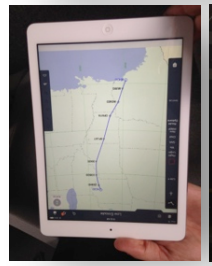
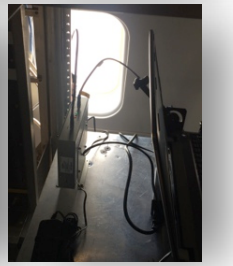
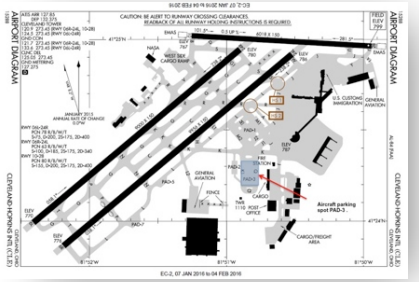
Trial Introduction

- 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





Cleveland Hopkins Int'l Airport (CLE)



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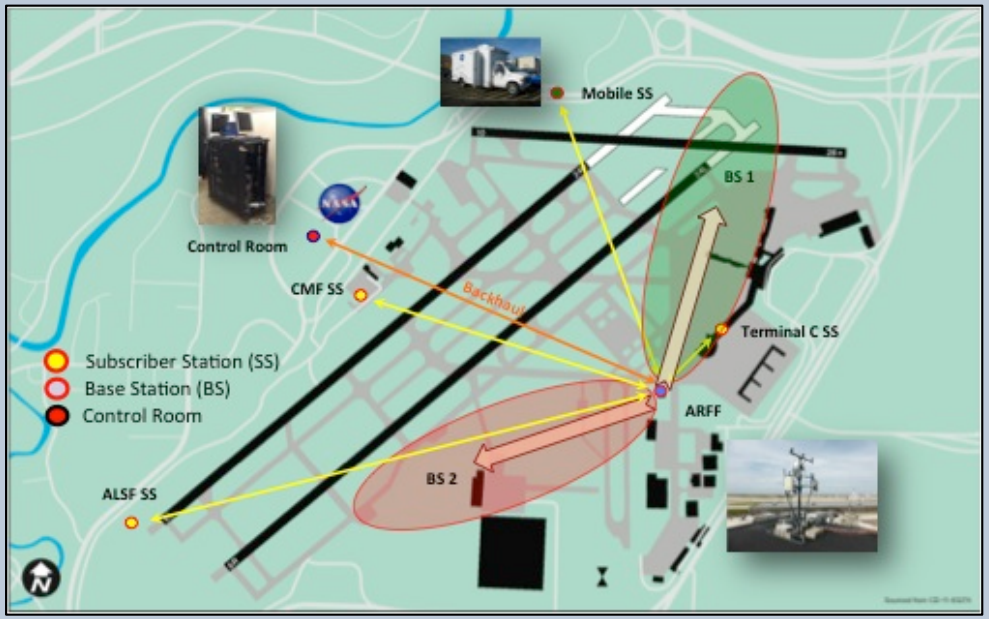
AeroMACS and NASA Test Bed Configuration

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)

Test Bed Configuration



Frequency Assignments

BS 1: 5095 MHz **BS 2: 5100 MHz**

Partners

Aircraft Access to SWIM

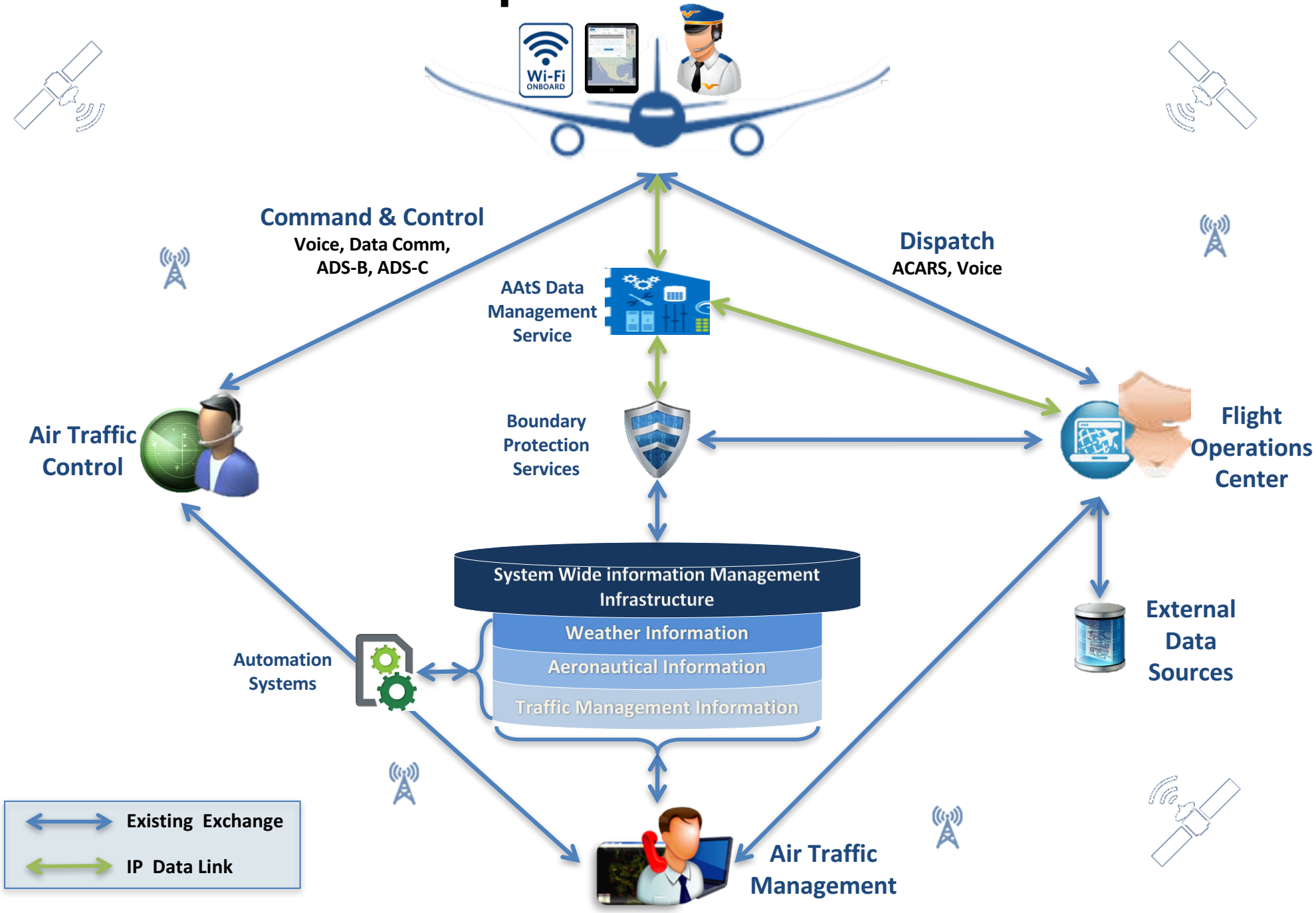
Description:

- 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

AAtS Operational Overview



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

Applications
Mobile Platform

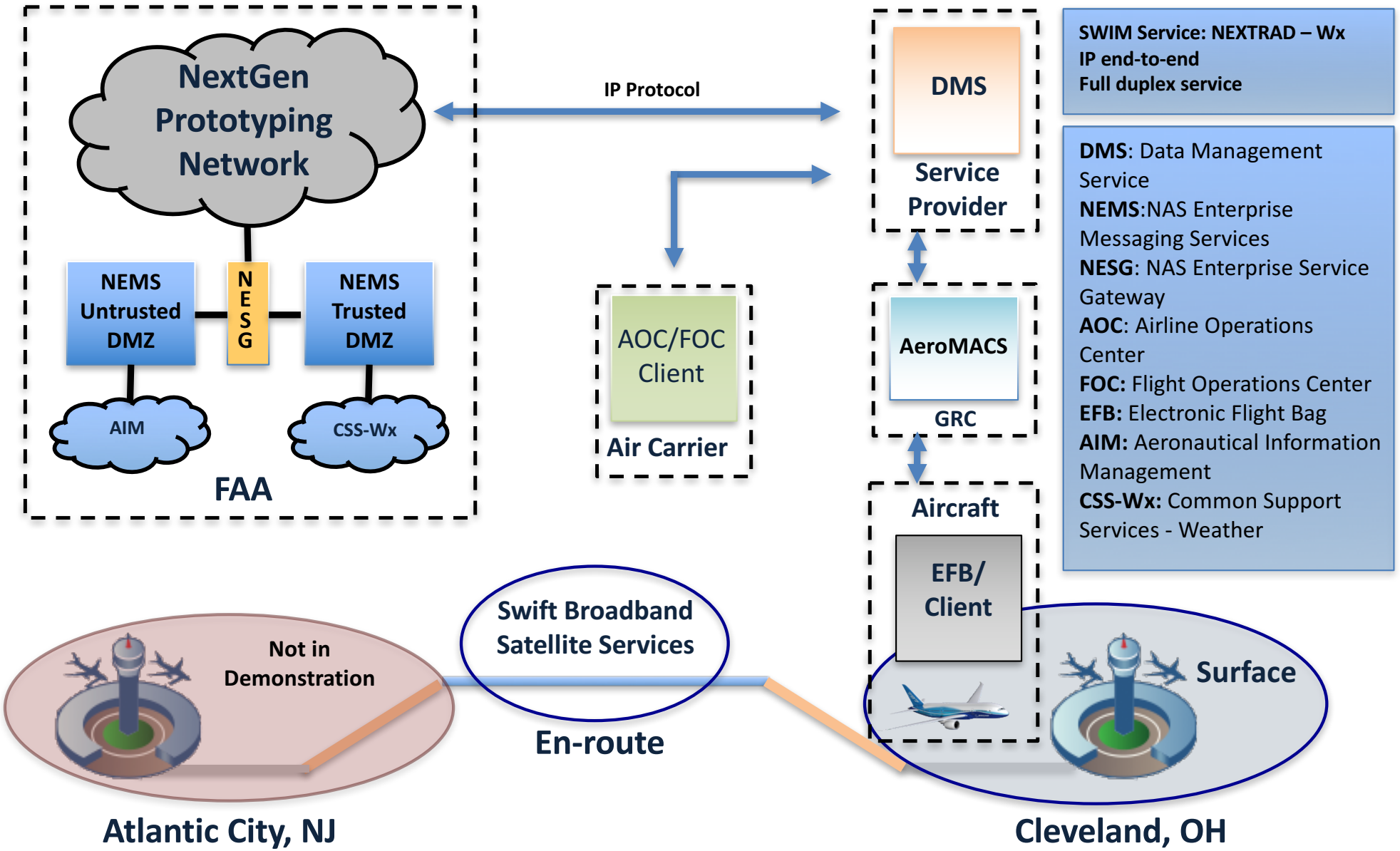
SWIM Data
- Trajectory Options Set
- Weather Information
  - NEXRAD – 2.3 MB
  - PIREP
  - SIGMET
  - AIRMET

Airline Operations - AOC
- Electronic Flight Folder Exchange – EFF
- Message Size DL: 2.0 MB
- Message Size UL: 10.0 MB
- Emulated

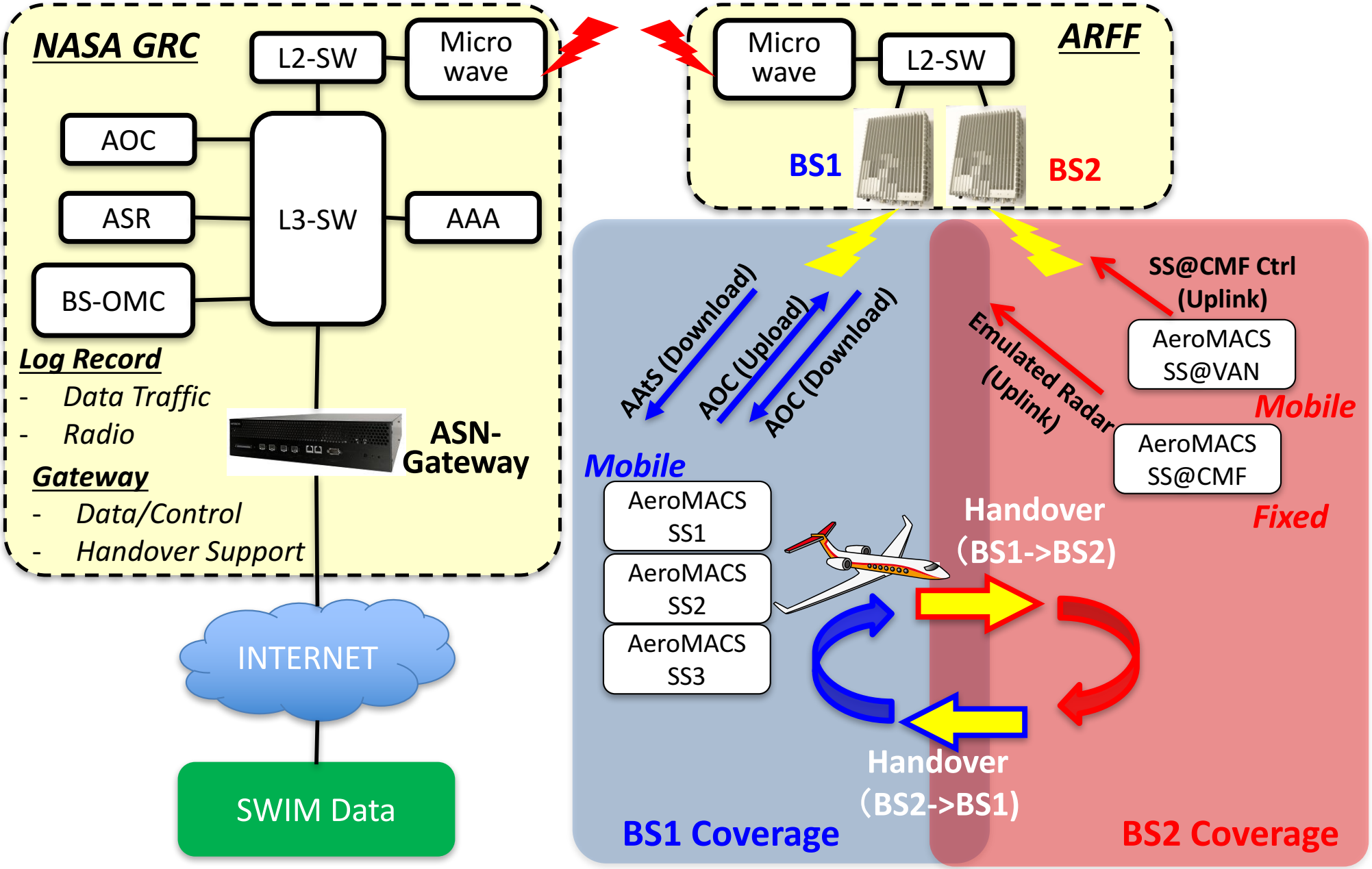
Fixed Platform

Airport Surveillance Radar (ASR)
- Airport Surveillance 11
- Terminal Airspace Surveillance
- 14 Kbps Throughput
- 25 FPS
- Emulated with iperf
- Source: FNT Airport

Trial Architecture



AAtS over AeroMACS Demonstration Architecture



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

Antenna Coverage

Antenna Coverage

SS-3 Ant (Radome)

Antenna Coverage

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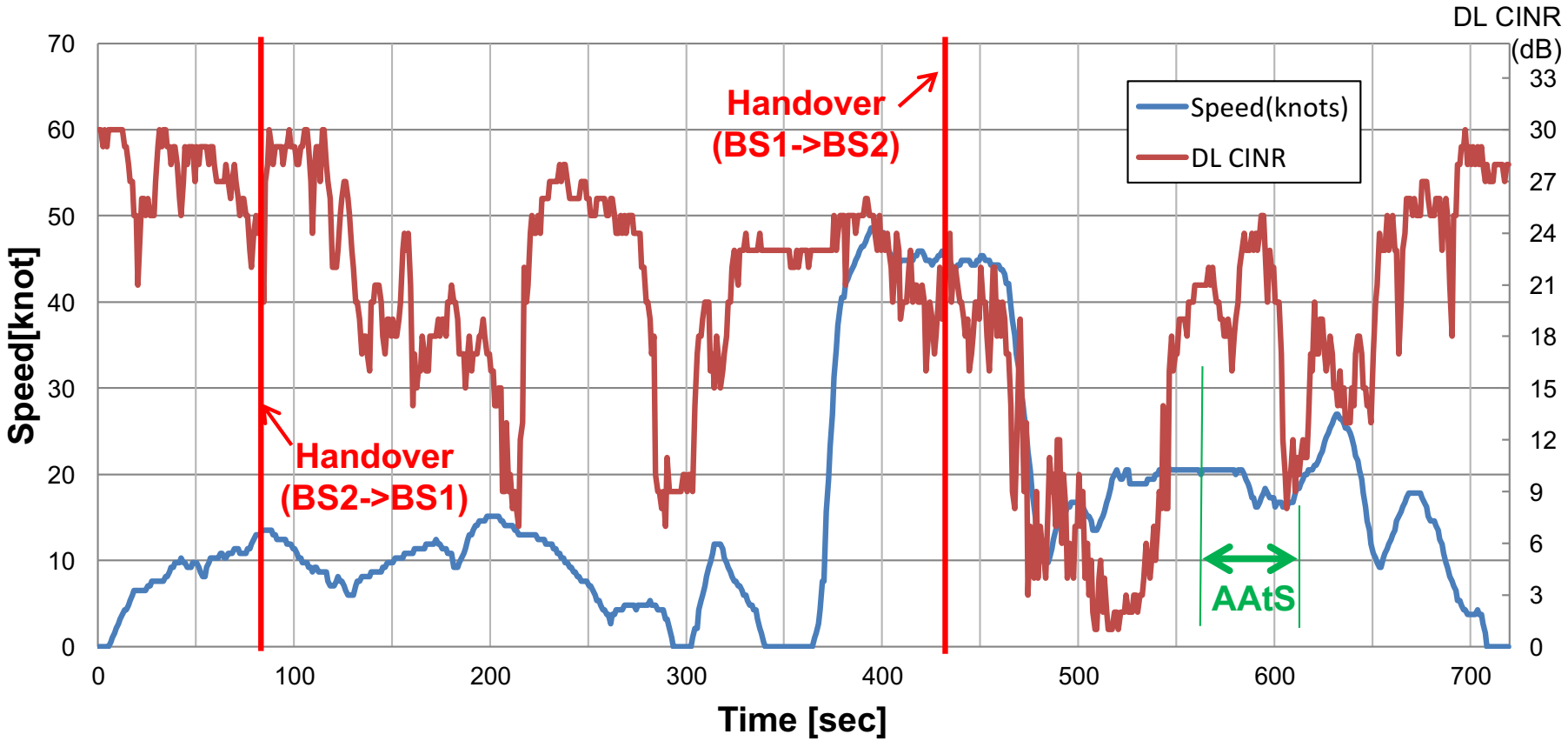
AeroMACS Configuration and Results
Test Case 1: Speed & DL CINR (SS-2)



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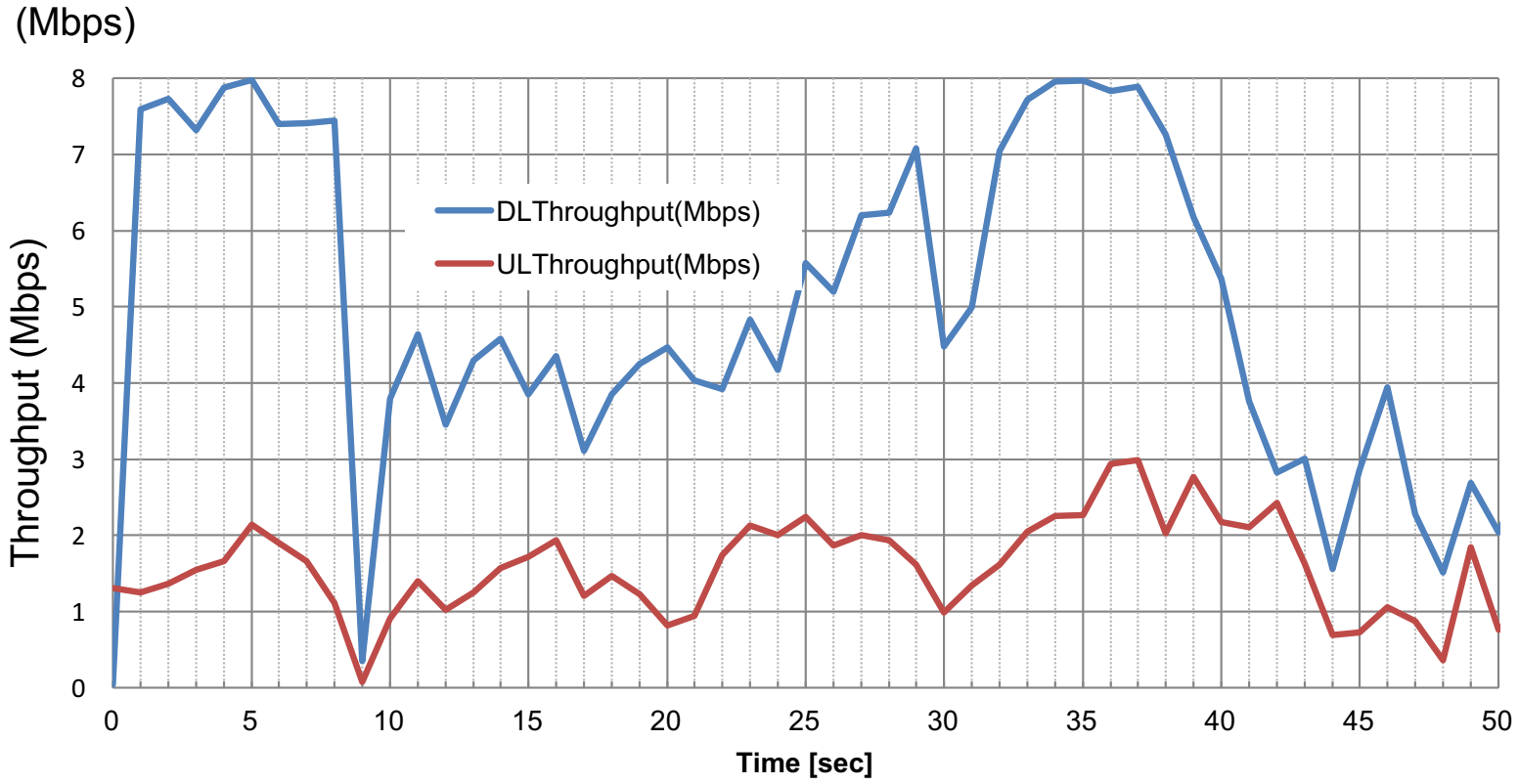
AeroMACS Configuration and Results
Test Case 1: DL/UL Throughput (Access to SWIM)



- **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.**

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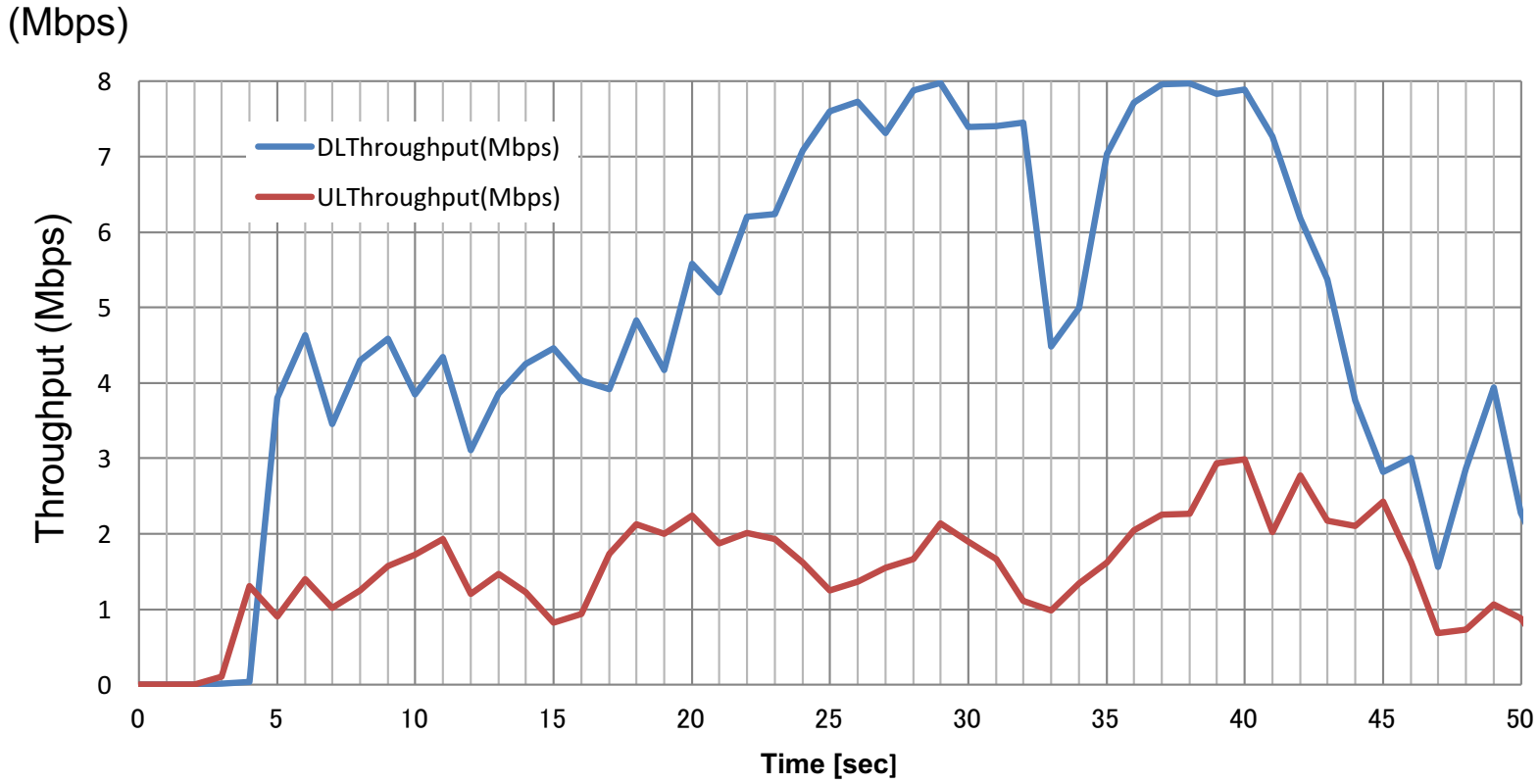
AeroMACS Configuration and Results
Test Case 2: Data Throughput



- **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)**

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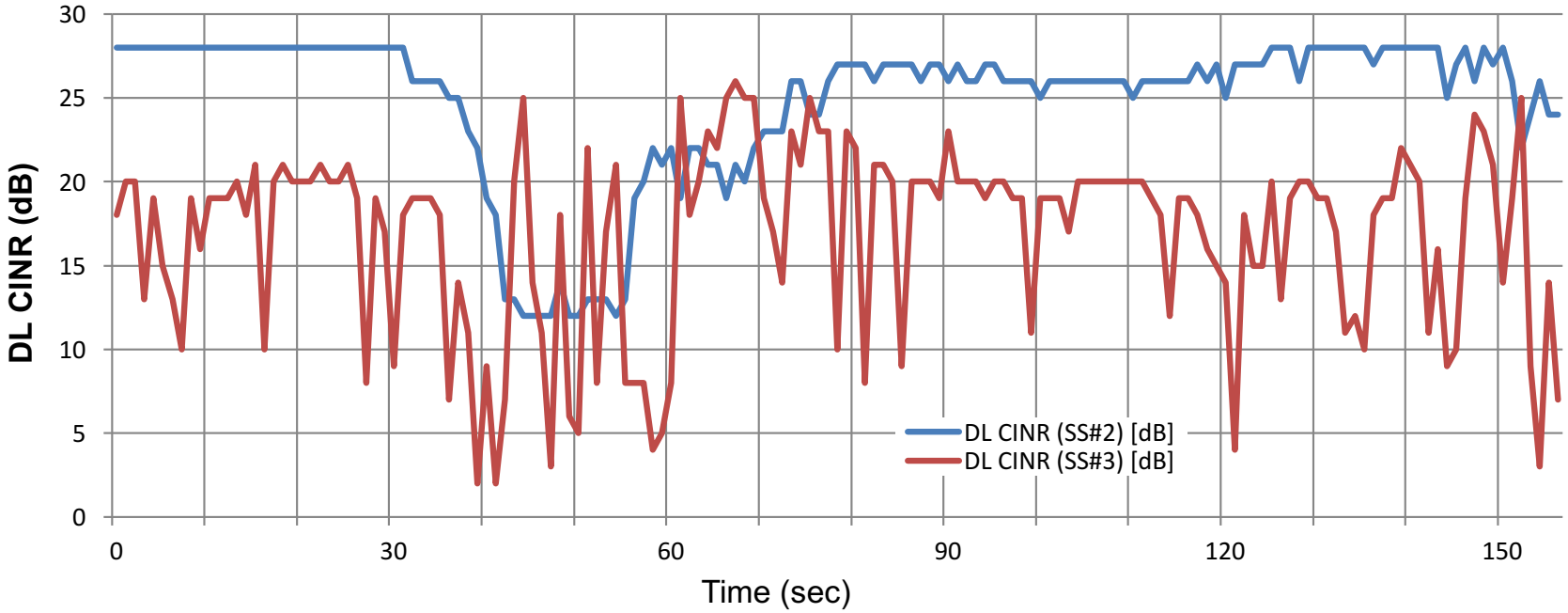
AeroMACS Configuration and Results
Window Antenna (SS-1/SS-2) vs Shark Fin Antenna (SS-3)



- **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)**

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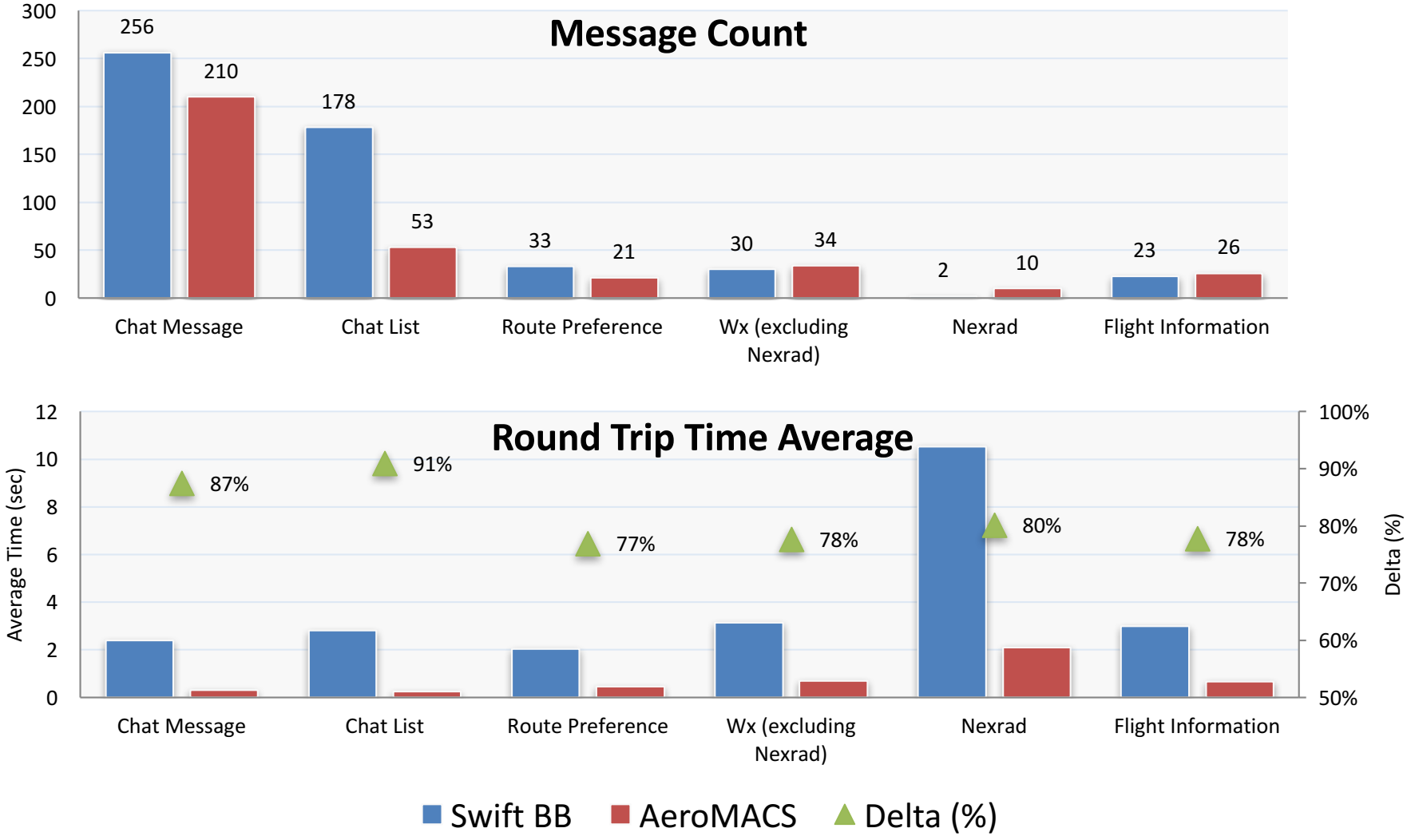
AAtS Results



✓ **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

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