

Modeling and Simulation of Proposed New Surveillance Technologies in Alaskan and Gulf of Mexico Airspace

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Outline

- **Introduction**
 - Initiative
 - Technology Overview
- **Comparative Analysis Process**
- **Performance Metrics**
- **Modeling Environment (SLAP)**
- **Scenario Results**
- **Summary**



Introduction

- **The FAA's Surveillance and Broadcast Services (SBS) program is currently deploying ADS-B and WAM surveillance infrastructure into the NAS**
- **JHU/APL has modeled these new technologies to support ATC, two examples covered in this presentation:**
 - Wide Area Multilateration (WAM) w/ Microprocessor En-route Automated Radar Tracking System (MEARTS) in Juneau, Alaska (JNU)
 - Automatic Dependent Surveillance – Broadcast (ADS-B) deployment in late 2009 in the Gulf of Mexico (GOMEX)
- **Goal is to assess the end-to-end performance of various permutations of surveillance technologies (i.e. MSSR-to-MSSR, MSSR-to-WAM, WAM-to-WAM)**
- **Comparative analysis with Monopulse Secondary Surveillance Radar (MSSR)**

Comparative Analysis Process

- **Intent is generic separation approval for surveillance system plus automation at any location deployment (similar to installing radar at new site)**
- **Generate error models for MSSR and alternative surveillance technologies**
- **Model assumptions are conservative and are designed to bound expected performance in general scenarios**
 - Worst case assumptions for ADS-B/WAM, general case for MSSR
- **Model generic flight scenarios designed to capture performance trade-offs**
 - Holding Pattern, Orbital In-Trail, Radial In-Trail, Parallel Radial/Tangential, “normal” flight scenarios
- **Conduct Monte-Carlo Simulation to capture end-to-end performance variability**
- **Compare various performance metrics (primarily separation error)**

Performance Metrics

- **Total Statistics**

- Statistics include Histograms, Cumulative Distribution Functions (CDF) and calculations of Average, Standard Deviation, 5% and 95% values for various parameters including, but not limited to:
 - Position Error
 - Update Interval
 - Separation Error

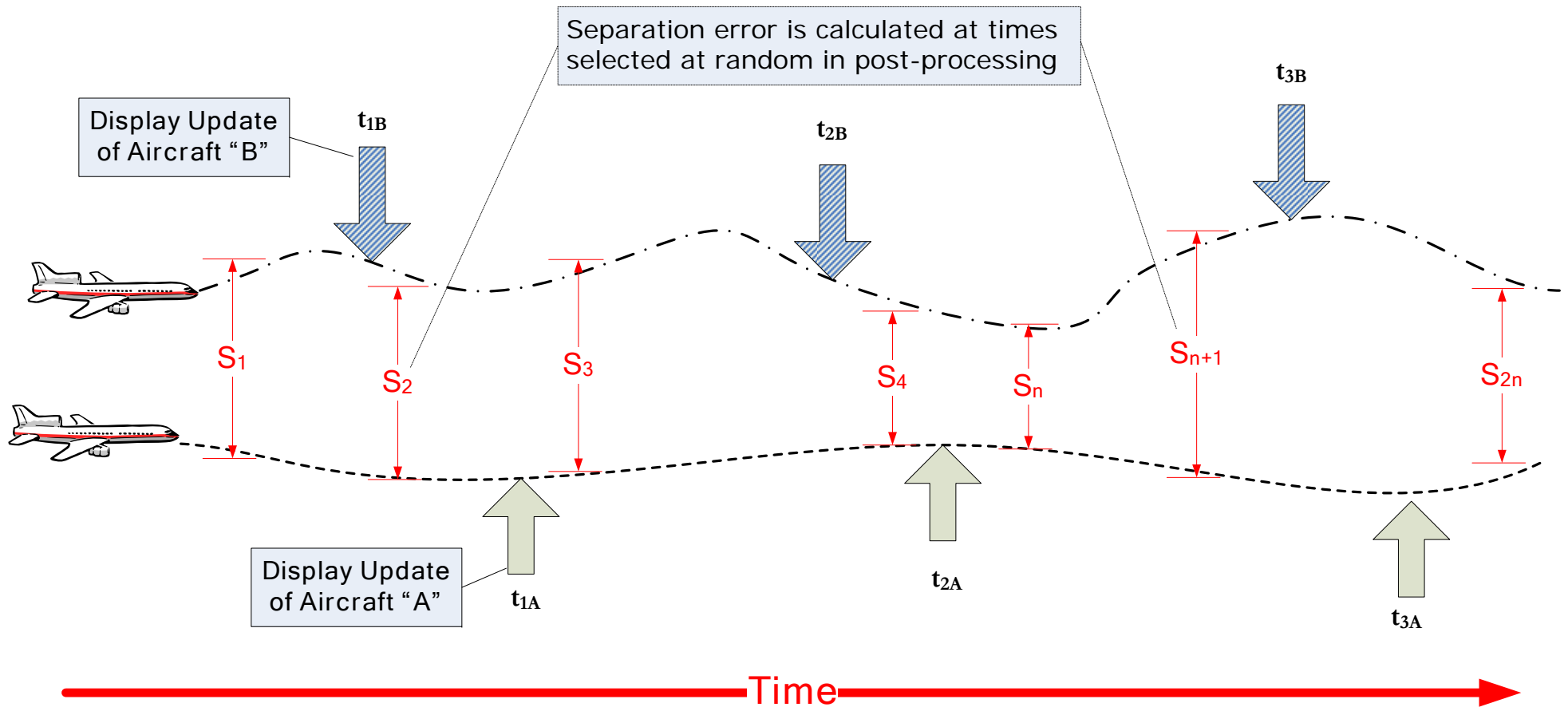
- **Statistics Per Simulation Run “Statistics of Statistics”**

- RMS – average and std of the RMS separation error
- 10th Percentile – average, std, 5% and 95% statistics on the ‘worst’ 10% separation errors

- **Single Sensor vs. Multi Sensor**

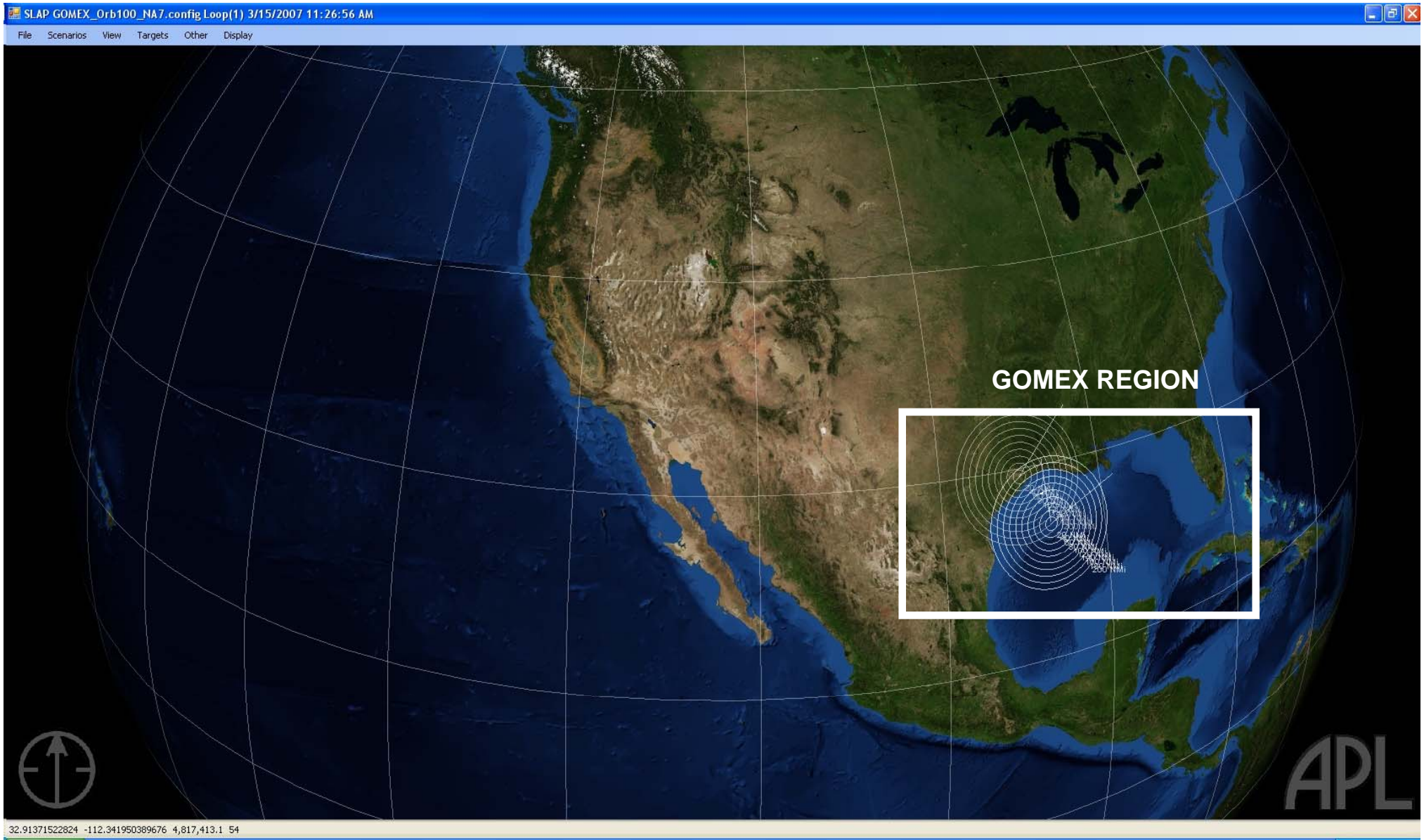
- Results can be filtered to remove missed updates or by other criteria

What is separation error?

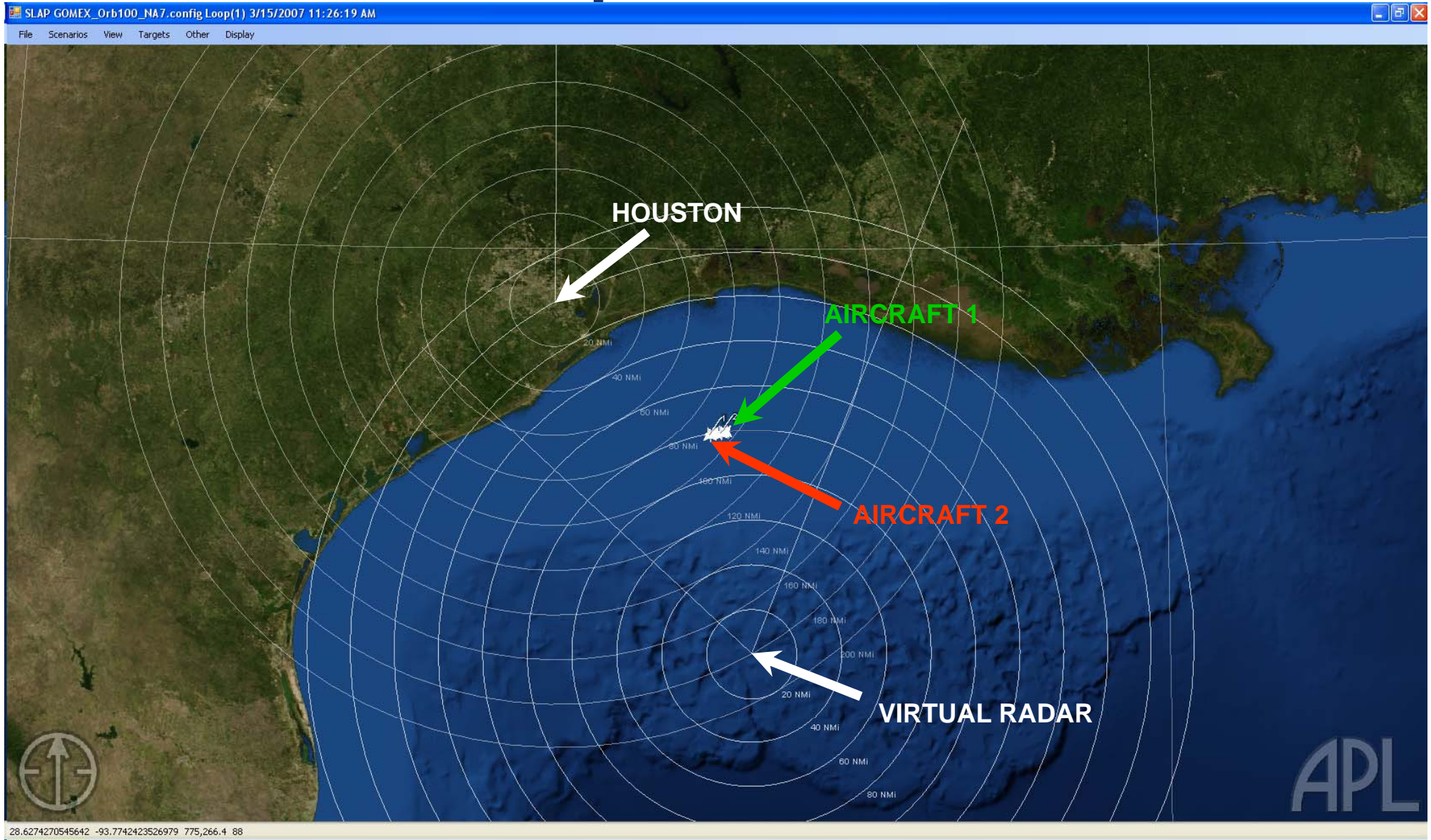


- Separation is calculated randomly to account for update frequency between systems
- Missed updates occur when a given target has had no update for > 12 sec

SLAP Screen Capture World View



SLAP Screen Capture GOMEX Region



Model Assumptions

- **RADAR (MSSR)**

- Modeling monopulse secondary surveillance radar (MSSR)
- 12 second sweep
- Random +/- 1ACP azimuth bias plus azimuth jitter
- 99% Blip scan
- CD2 Quantization

- **ADS-B in GoMex**

- Virtual Radar @ Lat 27° Lon -93.5°
- ADS-B reports conditioned to behave like Mode-S Radar
- 12 Second Virtual Sweep
- Extrapolates position report to Virtual Radar Sweep

- **WAM in Juneau**

- Virtual Radar @ Lat 57.9632° Lon -135.311°
- Simulated CD-2 messages to MEARTS at ZAN
- 12 Second Virtual Sweep
- No position extrapolation

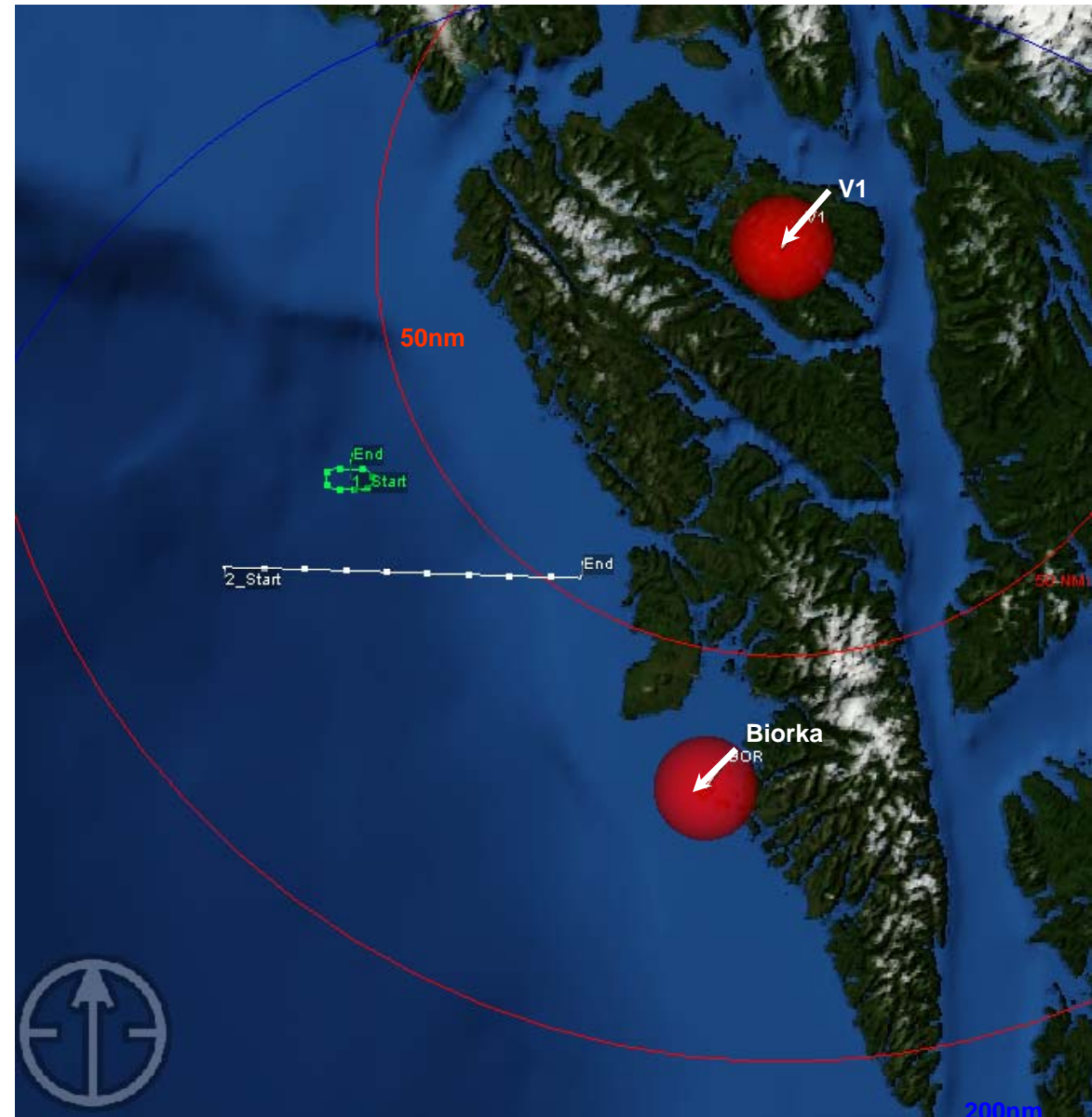
In-Trail Orbit

- Two aircraft flying in-trail, maintaining 5 NM separation
- Radius from radar is 60NM, 100NM and 200NM
- 600 kts
- 1000 sec
- 400 runs
- ~80 Radar reports per run (~32000 total Radar reports)
- Highlights errors due to latency and radar azimuth jitter

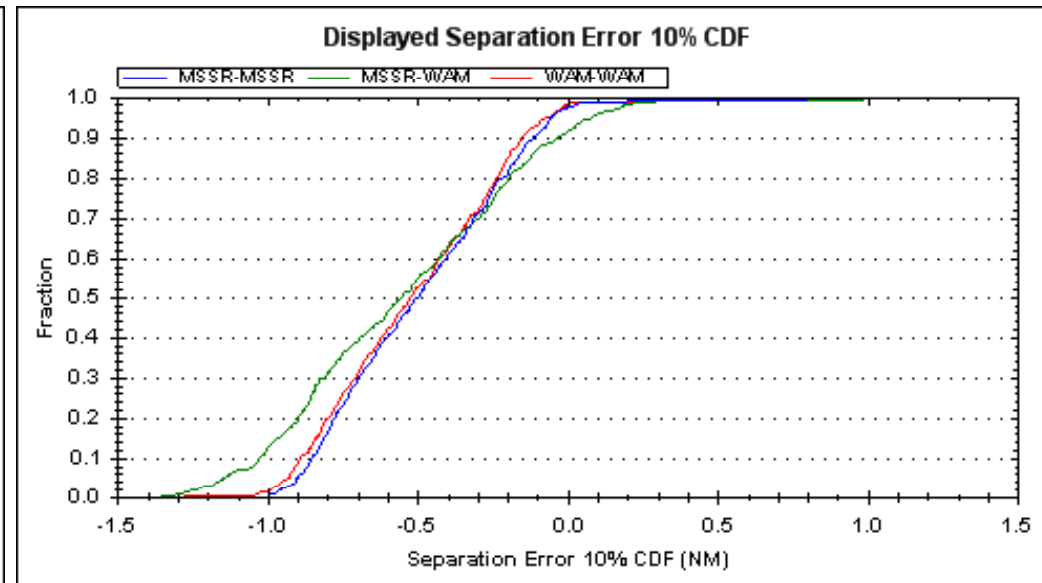
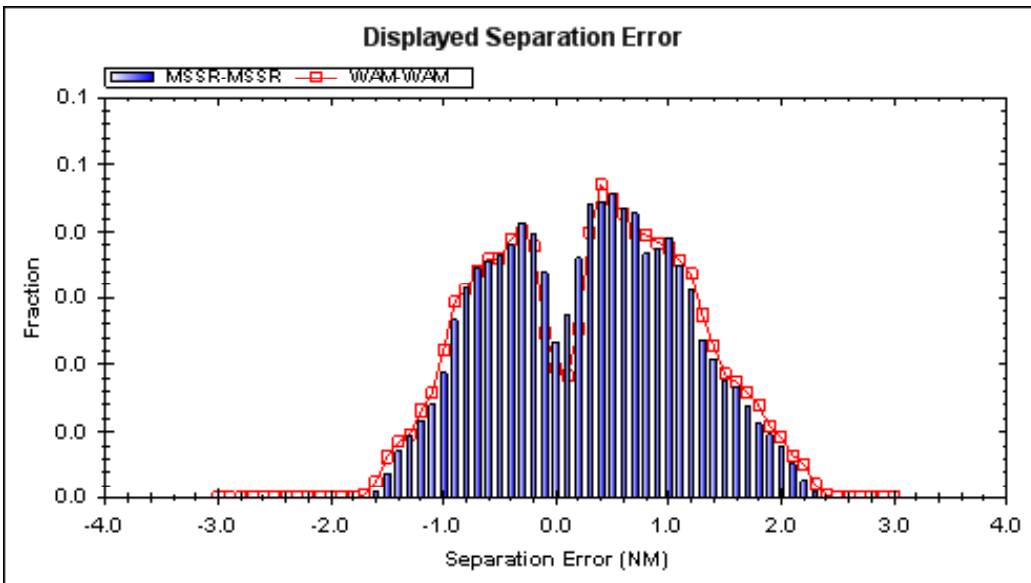


Holding Pattern

- High Altitude
 - AC1 holds with 1 min straight legs and 3°/sec (25° max bank) turns
 - AC2 passes AC1 at 10NM min separation
 - AC1 = 200 kts
 - AC2 = 600 kts
 - Center of holding pattern is 60NM at -45° V1
 - 251 sec
 - 400 runs (~8300 Radar reports)
 - Dynamic scenario



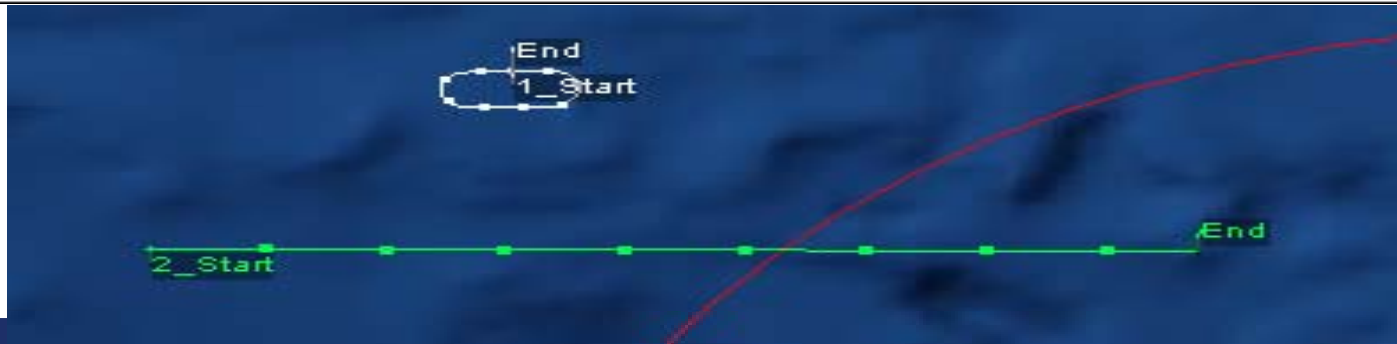
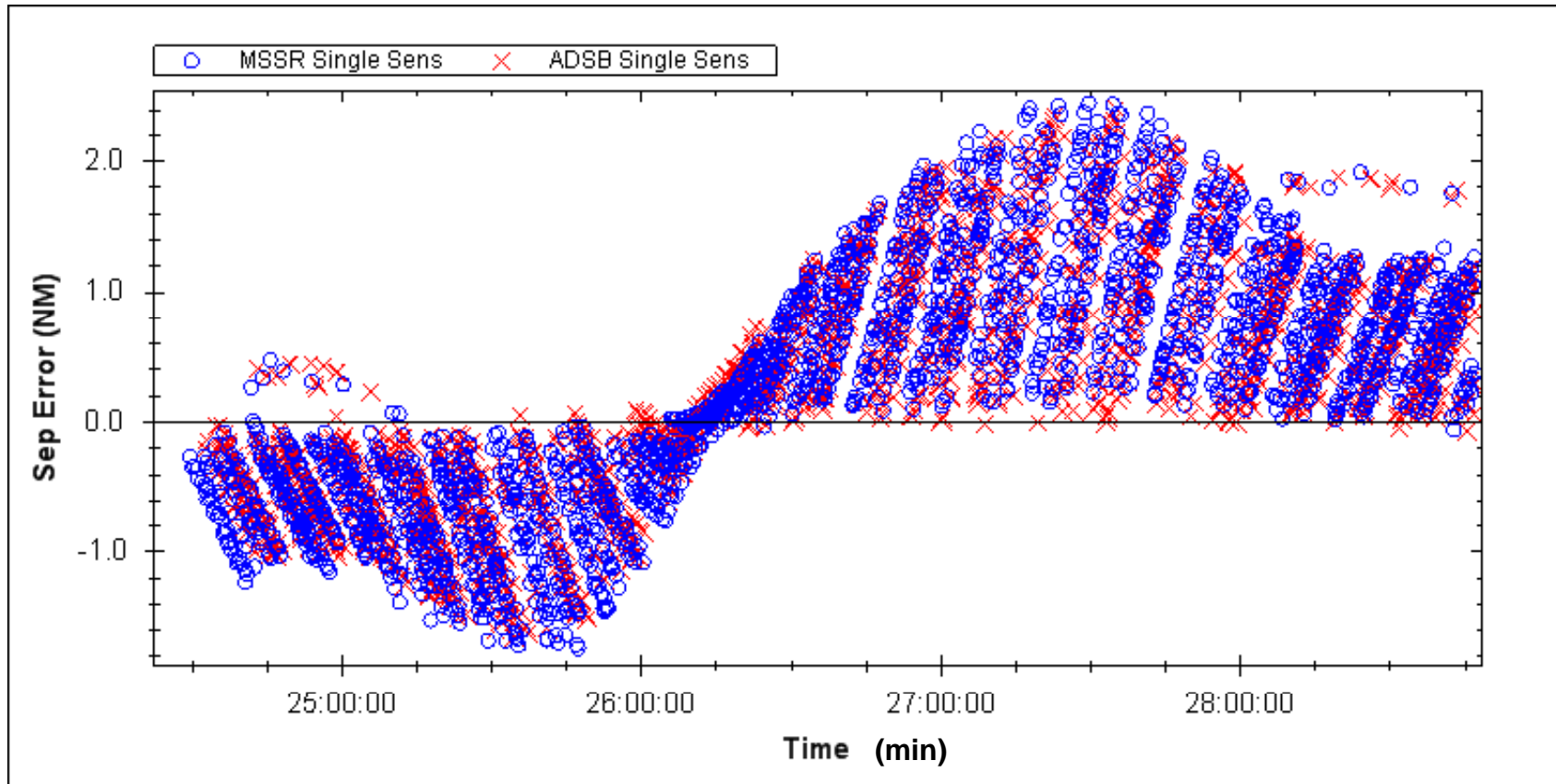
Single-Sensor Performance Separation Error Statistics Holding Pattern JNU-WAM



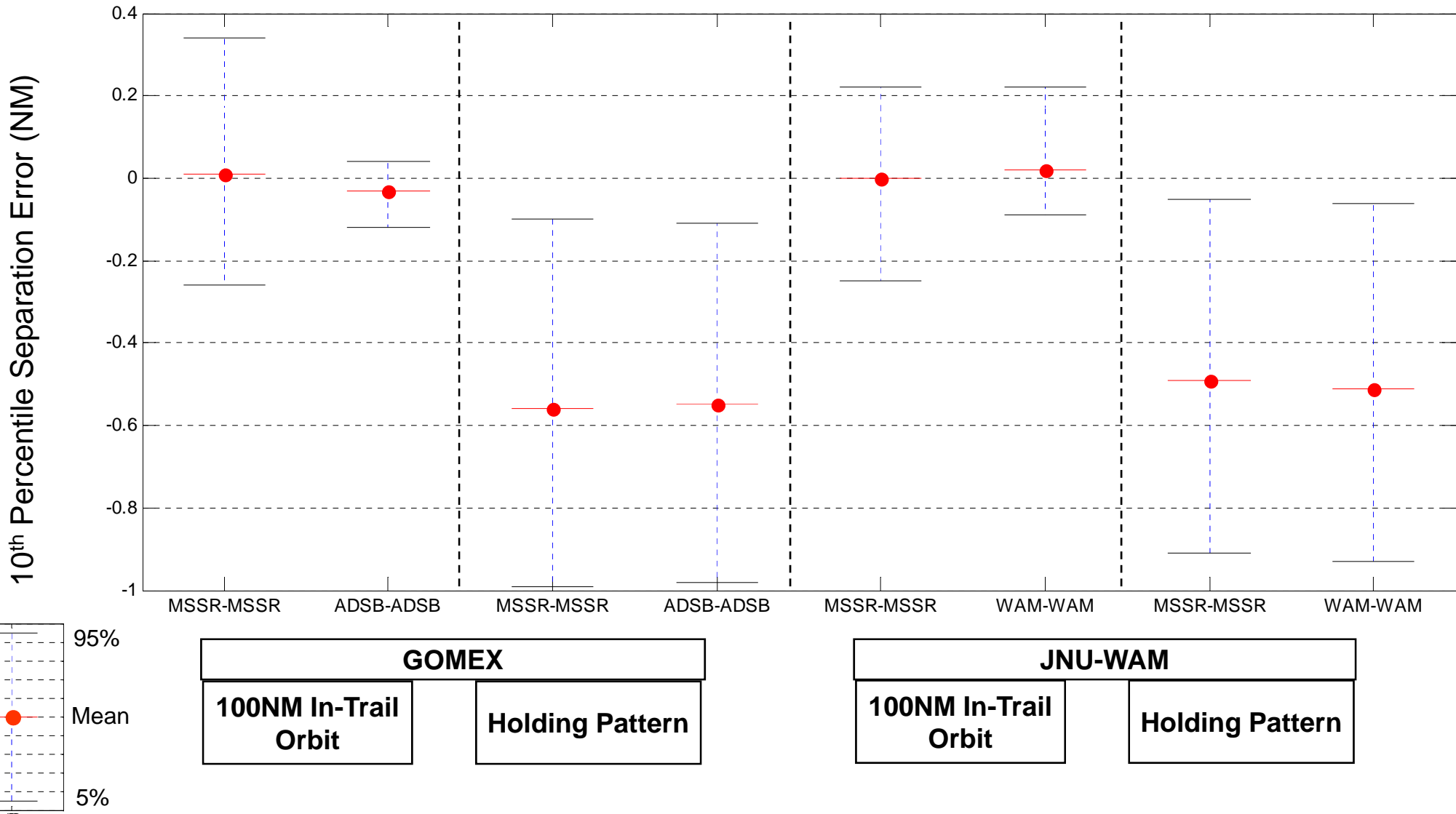
* Units in NM

Single-Sensor Performance

Separation Error Plot vs Aircraft Route



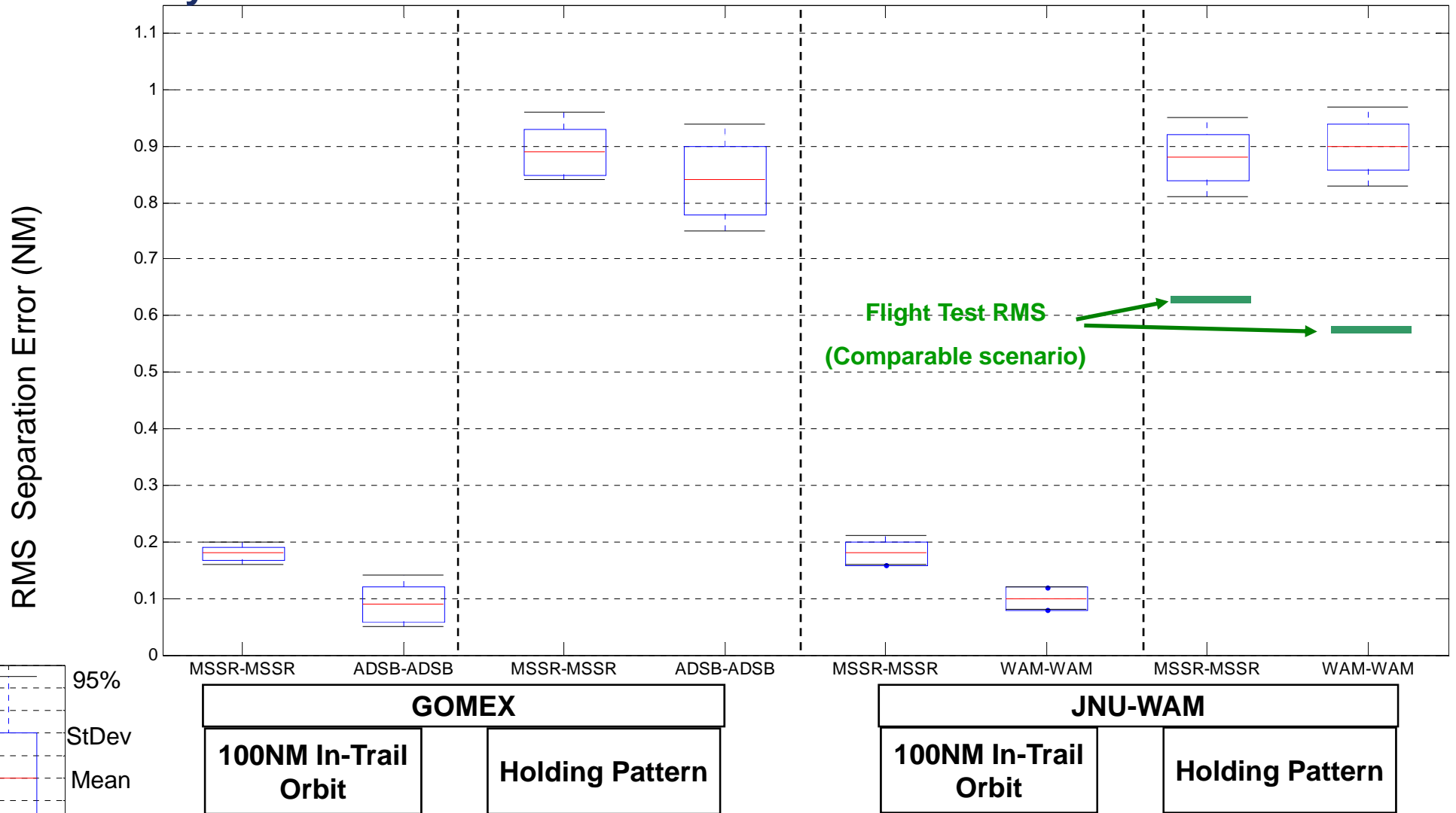
Single-Sensor Performance 10th Percentile Separation Error Summary



* Units in NM



Single-Sensor Performance RMS Separation Error Summary



* Units in NM

Conclusions from Modeling

- **JHU/APL has several surveillance simulations being used in SBS Separation Standards Working Group**
 - WAM-WAM separation errors in JNU and ADS-B-ADS-B separation errors in GoMex are less than or equal to MSSR-MSSR errors
 - These surveillance systems support 5 NM separation based on comparative analysis
- **Flight test results from Colorado WAM indicates modeling assumptions are more conservative than the fielded system**
- **Independently conducted MIT-Lincoln Lab simulations support & cross-validate conclusions**

