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Airport ASF Mapping Methodology Update

International Loran Association

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Outline

- Proposed Methodology (Spatial)
  - Pre-test and field work
- Field Test to Prove the Methodology
  - Airports in Maine and Ohio
- Results of Field Test
- Conclusions

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Proposed Methodology

Current Strategy

- Aviation
  - Set of static ASFs for each airport
    - One set if possible
    - Two if ASF variations are too large, rcvr to "interpolate" between the two
  - No temporal correction; ASF values chosen in the middle of the seasonal range
- Need a standard, validated procedure for establishing these airport values
  - ASF Correction Estimates (ACE) – published – (median of seasonal variations)

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Proposed Methodology – Part 1

- Identify airport area and runways
- Run BALOR predictions to estimate ASFs along airport approach paths
- Determine whether 1 set of ASFs is sufficient
  - Based on worst case of
    - ASF differences
    - Station geometries
    - Expected signal levels
  - Use simulation – aiming for a maximum error in the position domain of 120m.

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Methodology Part 1 Con't

- Simulation model:

$$TOA_{actual} = TOA_{(predicted)} + BALOR_{(ASF\ prediction)} + Noise$$

  - Noise (1 sigma) – aviation values
    - Rcvr/channel 25-100ns
    - Directional variation 100ns

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Methodology Part 1 Con't

- Locations for field measurements
  - End points of approach paths (Initial Approach Fix) – 10 miles out
  - Airport (each runway end?, tower?)
  - Other potential "hot spots" – identified by BALOR or topography
  - Desired points may not be reachable
    - ½ mi crosstrack from centerline, ½mi along track?

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Methodology Part II

- Conduct Field test
  - Static monitor at airport to remove temporal variations during testing
  - Static measurements at each of the identified points
  - Collect sufficient data:
    - Error in the ASF measurement of less than 25 ns, 1 sigma?
    - Remember that differencing between mobile and ground reference doubles the noise

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Methodology Part II con't

- Adjust measured ASFs to true ASFs using system timing data from TFE at Loran stations
- Assign ASF Correction Estimates (ACE)
  - one set – airport "center"
  - two sets – airport and 10mi out for each approach path
    - User receiver interpolates between the two?

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Field Test

Field Test to Validate Methodology

- Tests conducted by USCGA / Alion / FAATC during July/August/September 2005
- Goals
  - Assess BALOR
  - Evaluate/prove proposed methodology; modify as necessary
- Test Components
  - Ground Measurements
  - Flight Verification of RNP 0.3
  - Long Baseline Measurements – BALOR model validation
  - ASF Profile vs. Altitude – determine a bound on altitude variation in ASF

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Ground Measurements

- Procedure
  - Collect static data at multiple points along each approach path (every 2NM).
  - Ground reference station
    (to remove temporal variation)
  - Do some testing with two ground reference stations
    - Assess the geographic stability of the temporal measurement
  - Analysis
    - Average ASF* value calculated for each point
    - Correct for any system time errors

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Flight Verification

- Flight verifications using FAATC Convair 580
- Procedure
  - Fly all approaches five times
    - 10NM out along extended runway centerline to the threshold
  - Collect TOA/ASF* data during flights
- Analysis
  - Post-process TOA data with ACE data for approach, calculate position error

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Airports for Field Test

- Maine
  - Auburn-Lewiston (LEW)
    - 20 ground points
  - Portland International (PWM)
    - 16 ground points
- Ohio
  - Lorain County (LPR)
    - 10 ground points
  - Toledo Express (TOL)
    - 20 ground points

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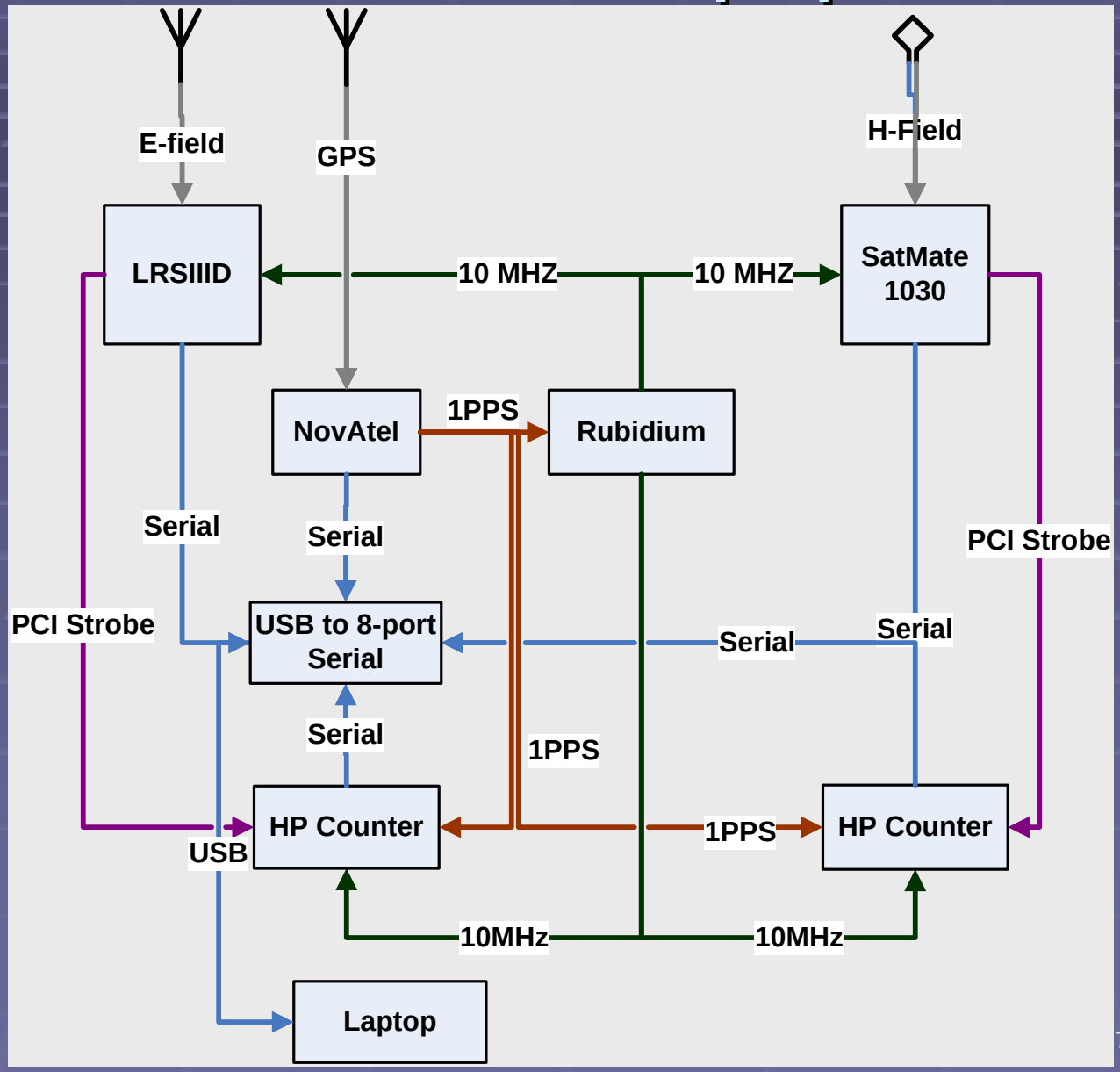
Test Van

Field Test Equipment



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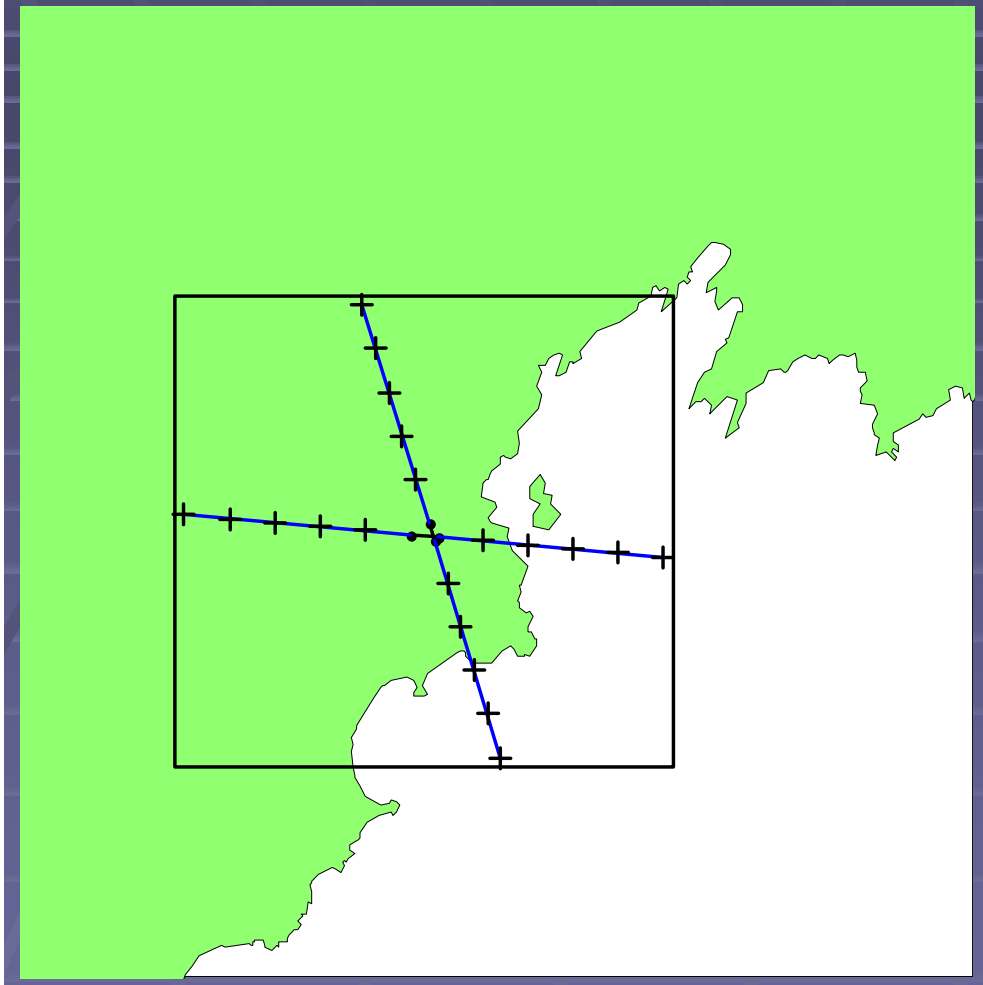
Results

Portland, ME



- Portland International Airport (PWM)
  - Runway ID's: 11, 29, 18, 36
- BALOR boundary box:
  - Top: 43.821 N
  - Bottom: 43.475 N
  - Left: 70.565 W
  - Right: 70.06 W

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Lorsta Fox Harbor
Lorsta Comfort Cove
Lorsta Cape Race
Lorsta Caribou
PWM
Lorsta Seneca
Lorsta Dana
Lorsta Nantucket
Lorsta Carolina Beach
Image © 2005 EarthSat
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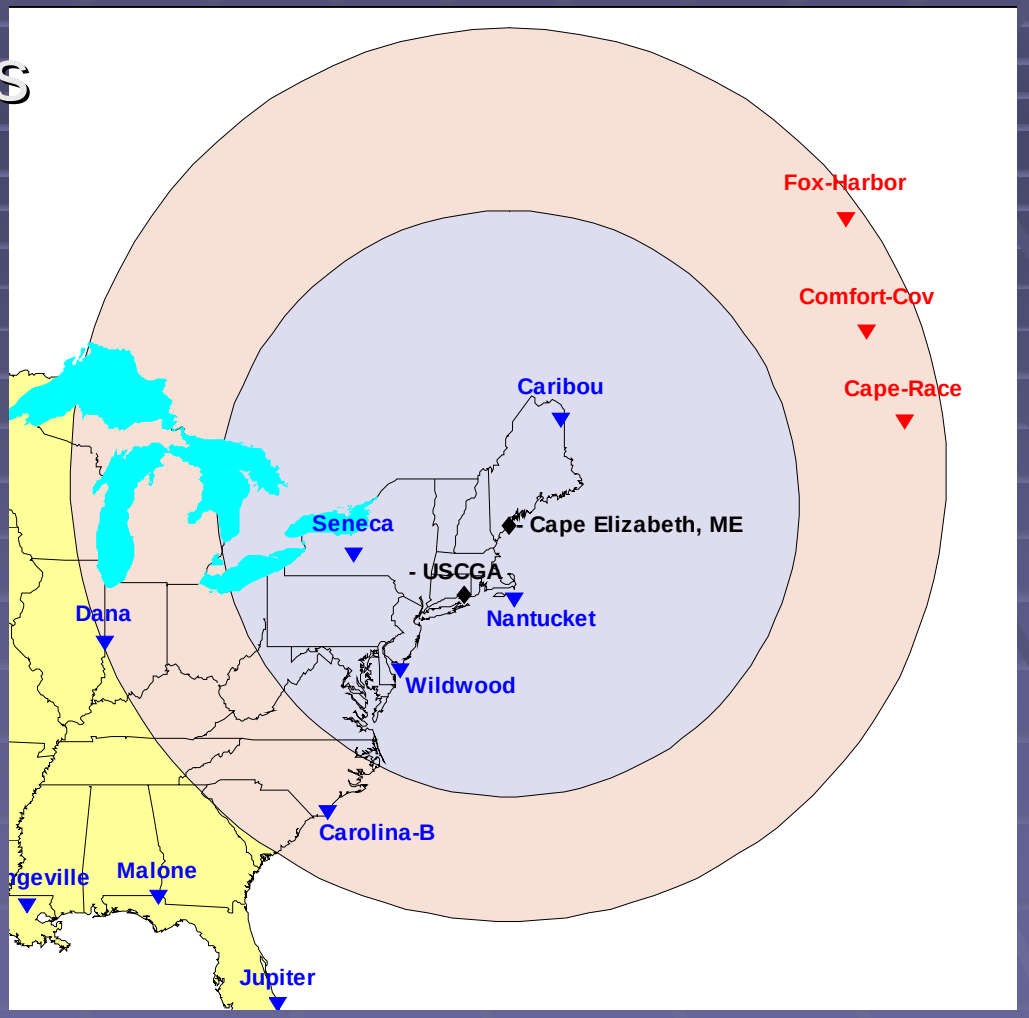
Loran Stations Near Maine

- Possible Loran Towers
  - <1000km
    - Nantucket
    - Caribou
    - Seneca
  - >1000km
    - Carolina Beach
    - Cape Race
    - Comfort Cove
    - Fox Harbor
    - Dana



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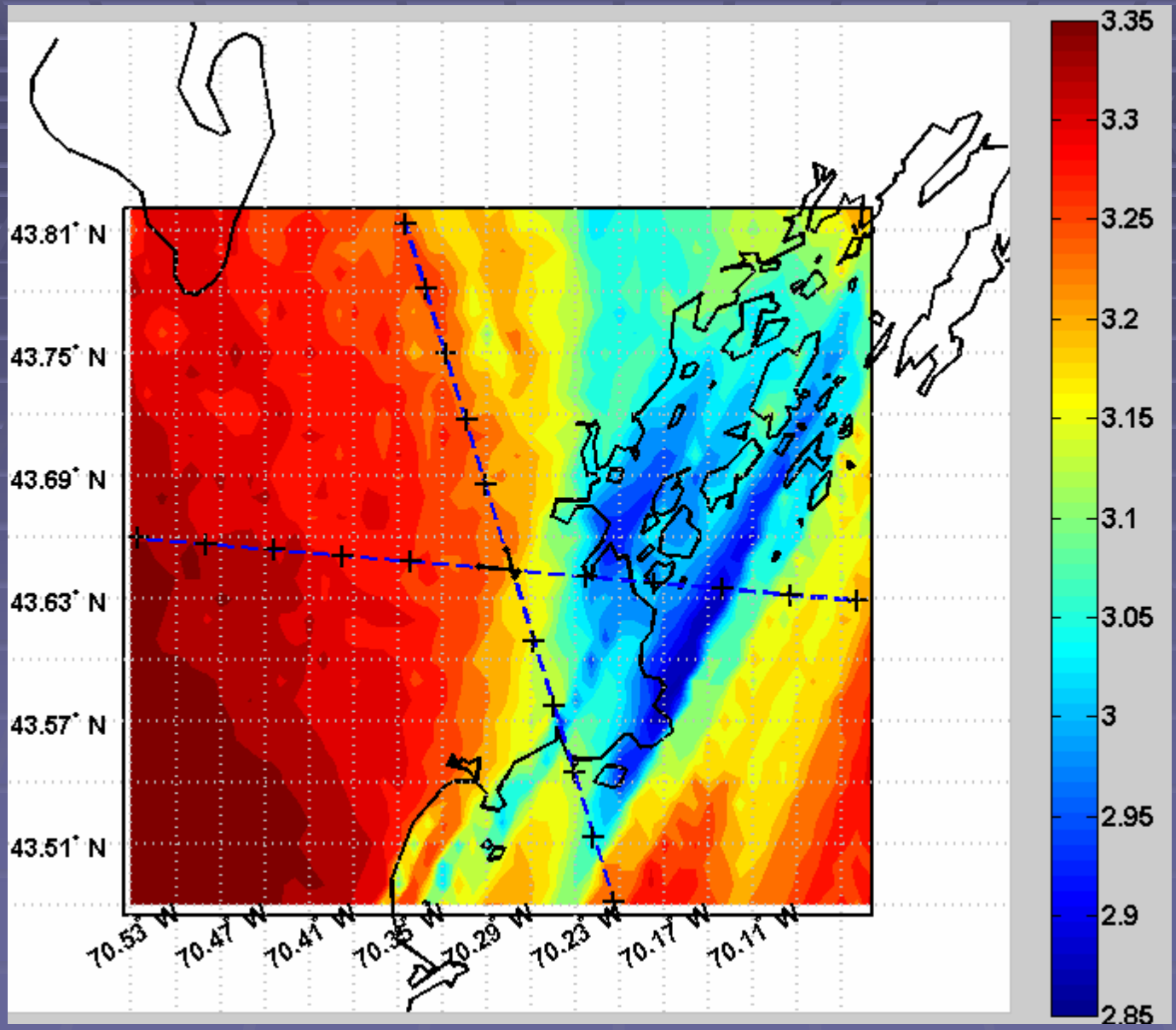
BALOR - Caribou



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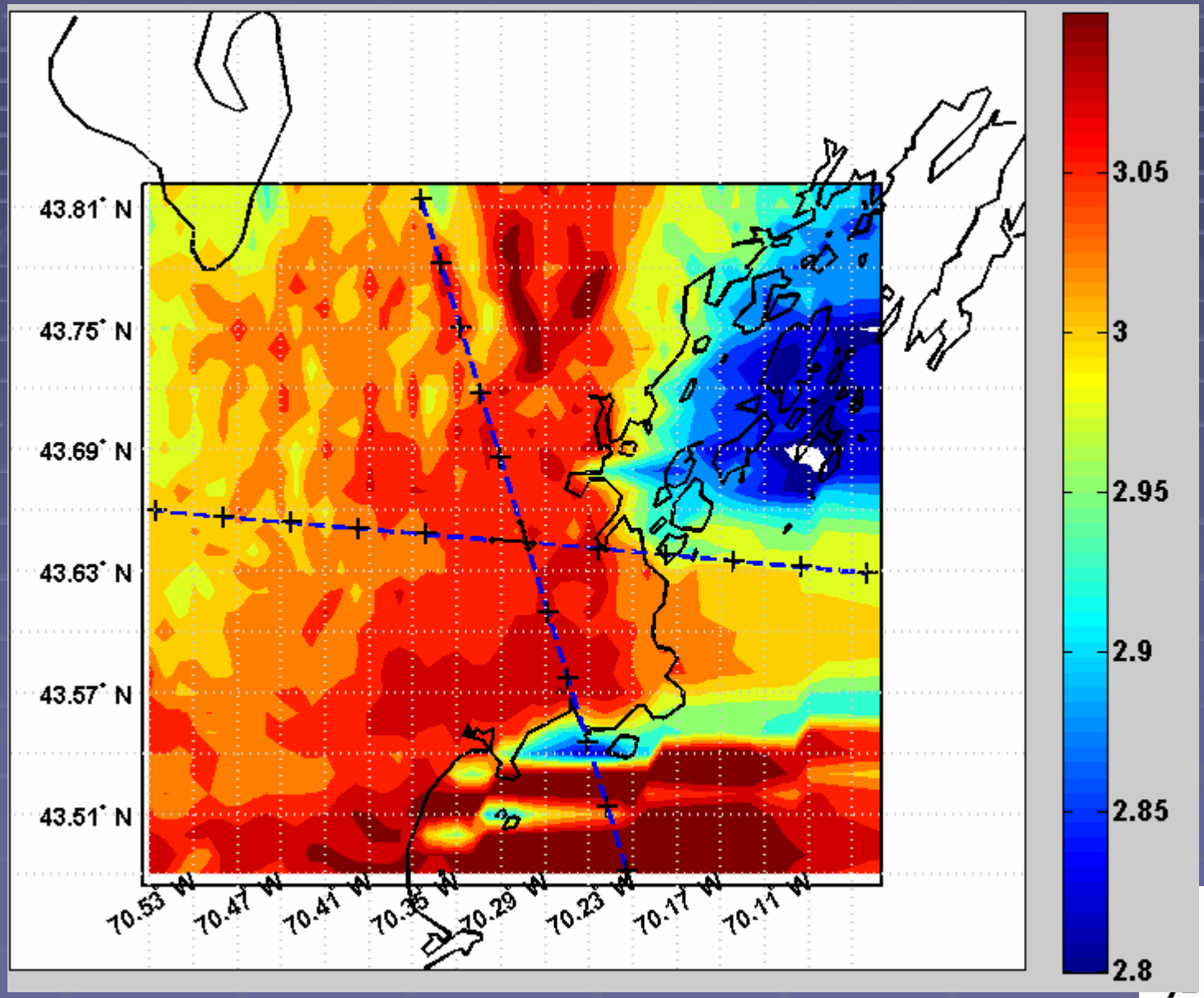
BALOR -Seneca



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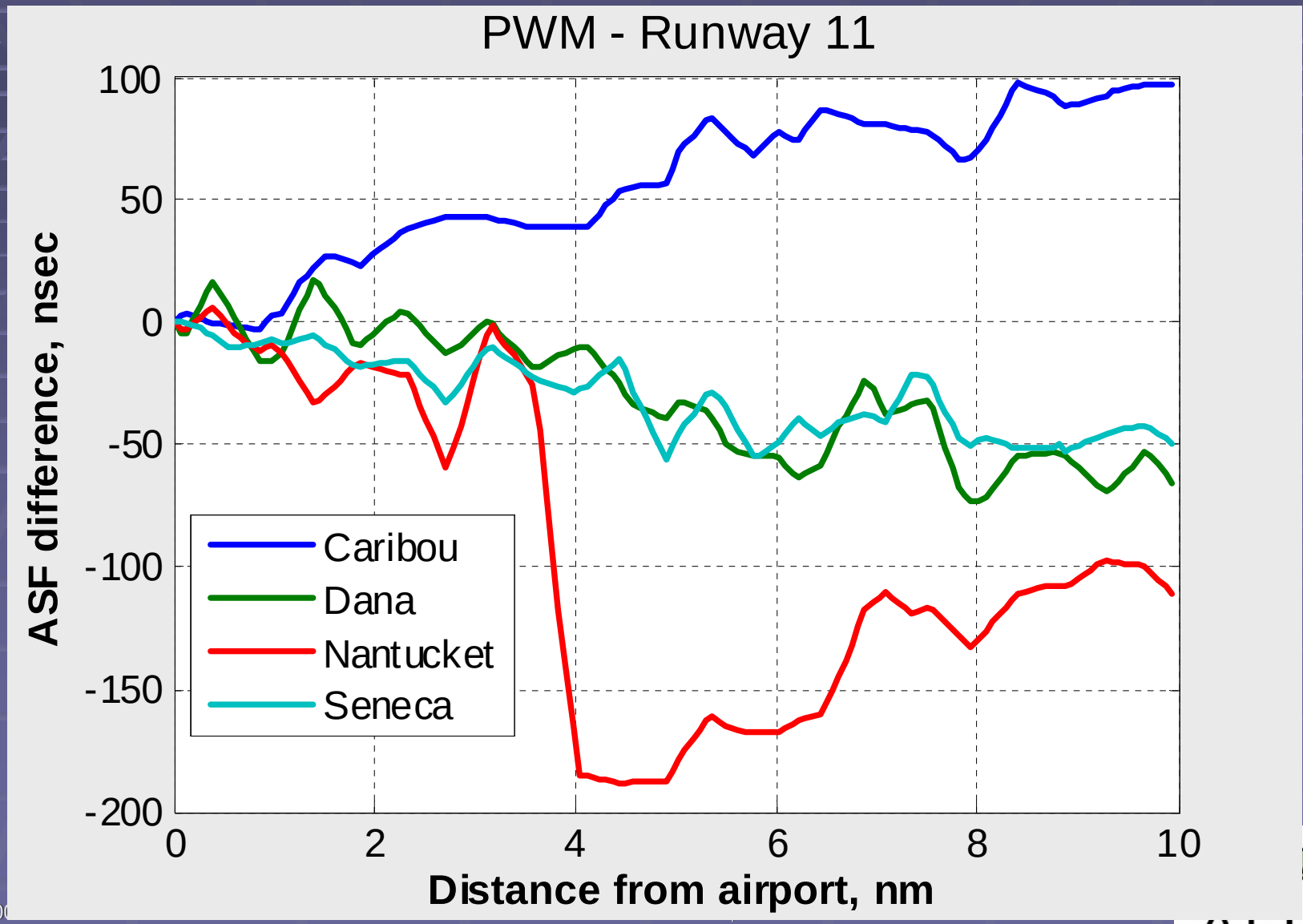
Typical ASF Variation



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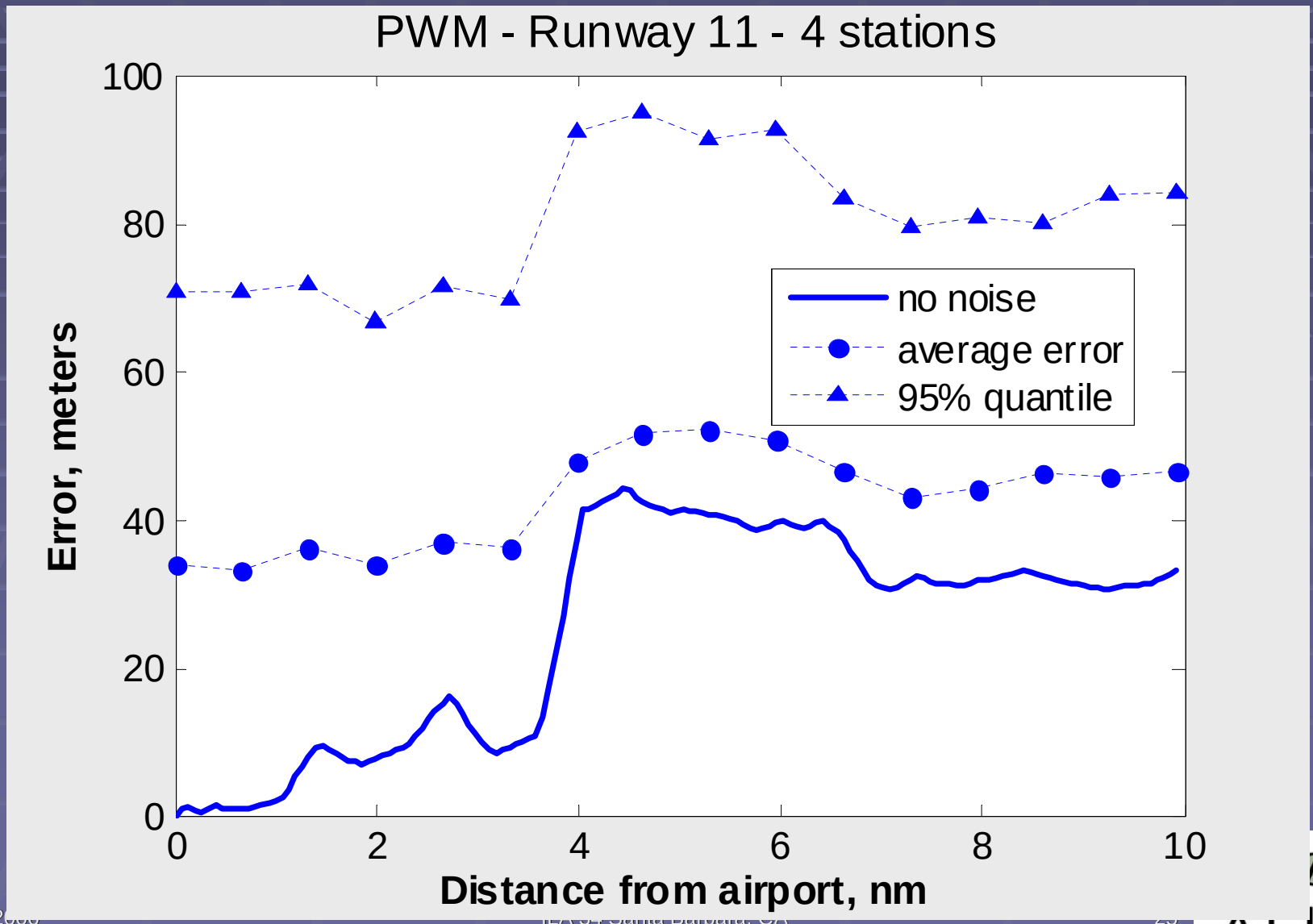
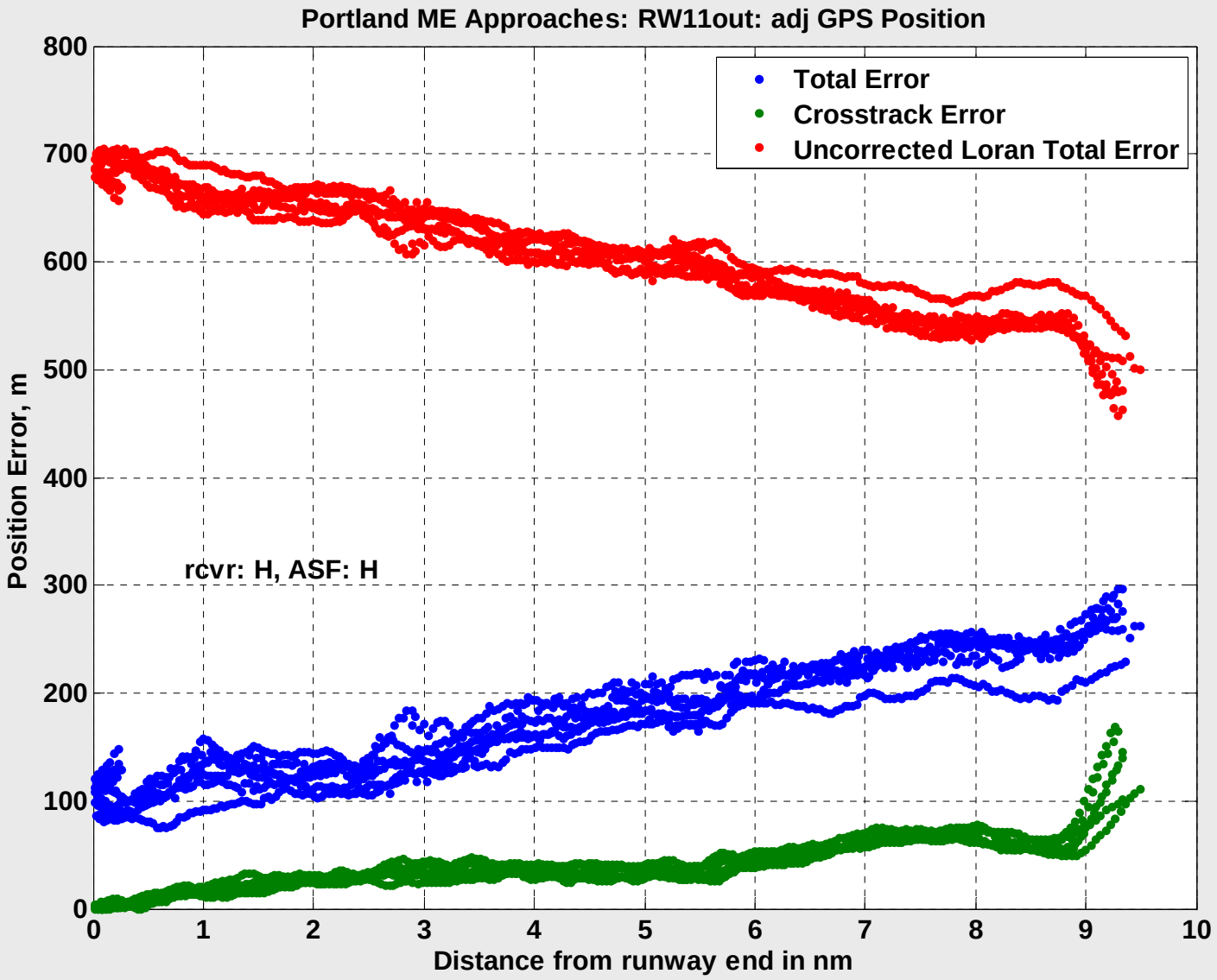
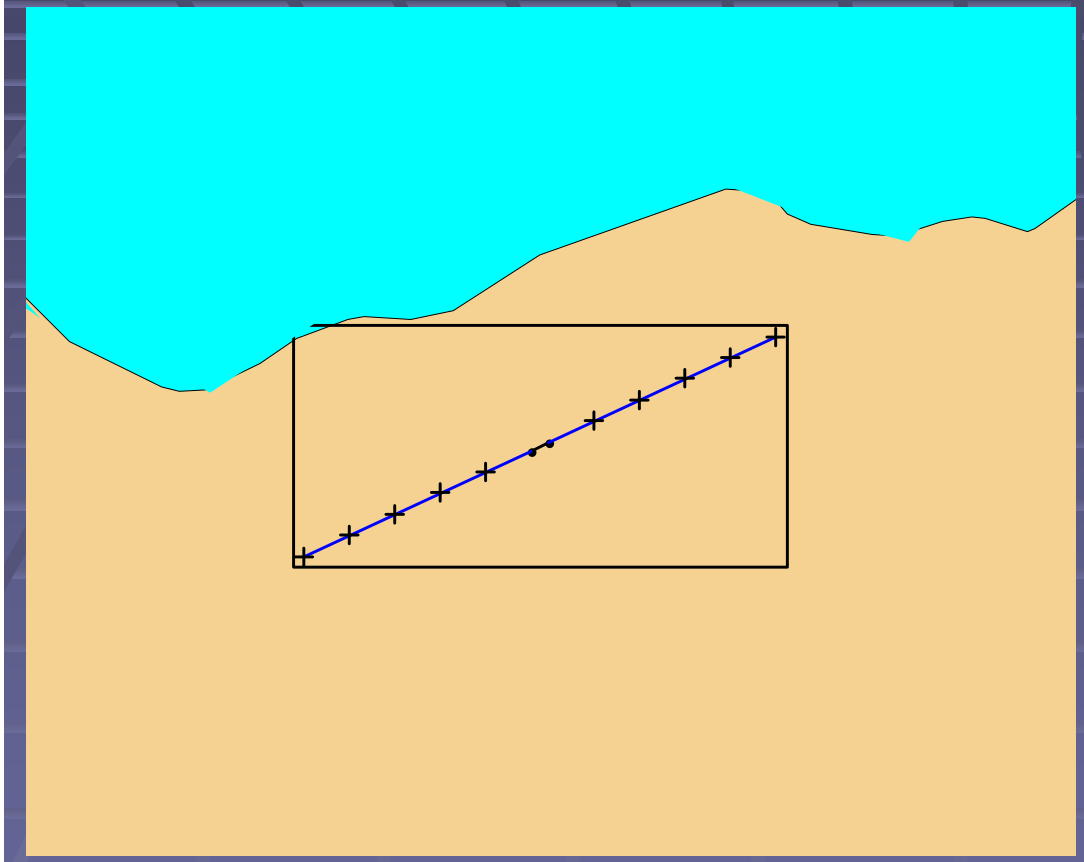
Performance Simulation



Actual Flight Test – rw 11



Lorain, OH



- Lorain County Airport (LPR)
  - Runway ID's: 7, 25
- BALOR boundary box
  - Top: 41.425 N
  - Bottom: 41.264 N
  - Left: 82.396 W
  - Right: 81.958 W

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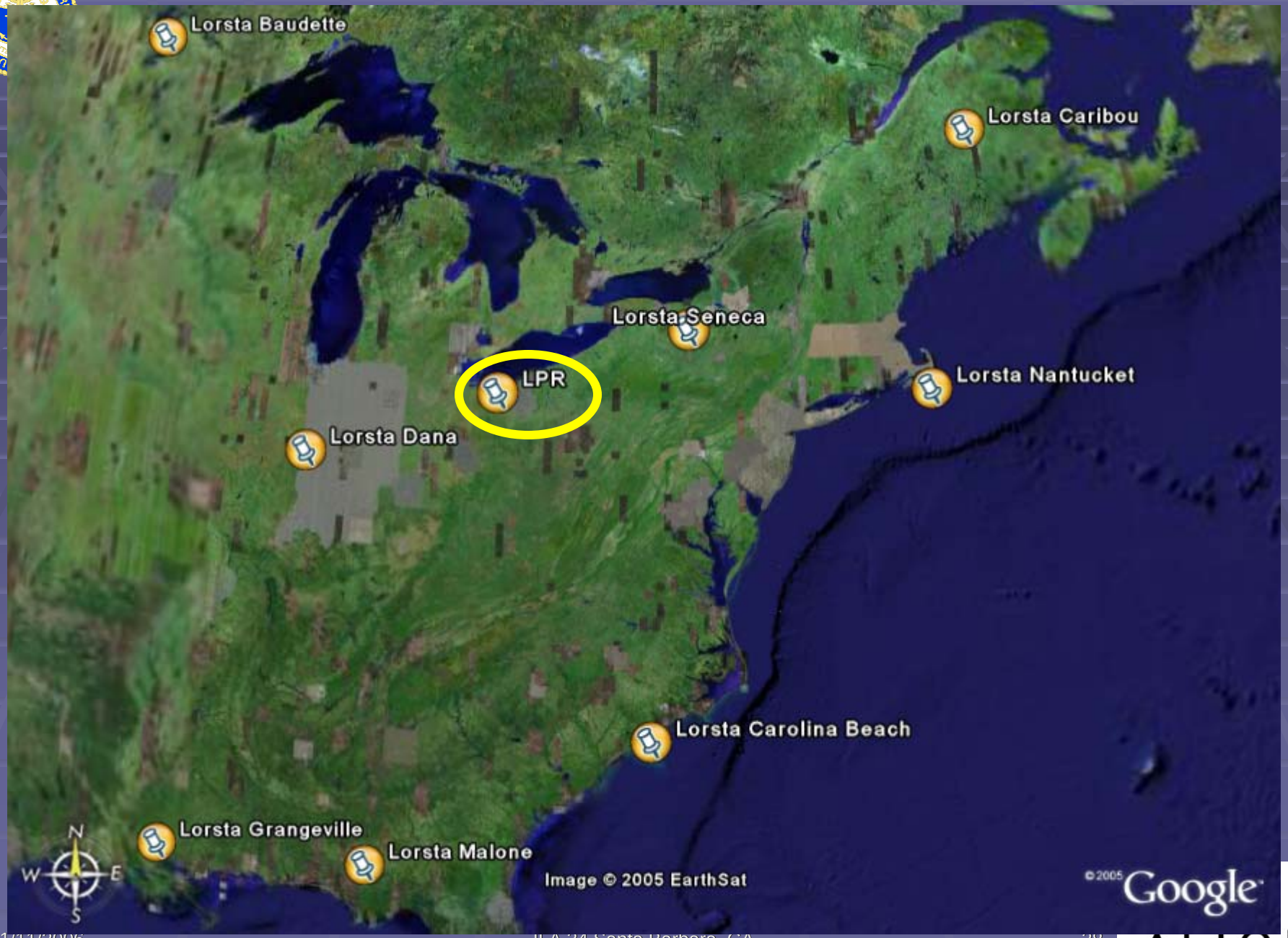

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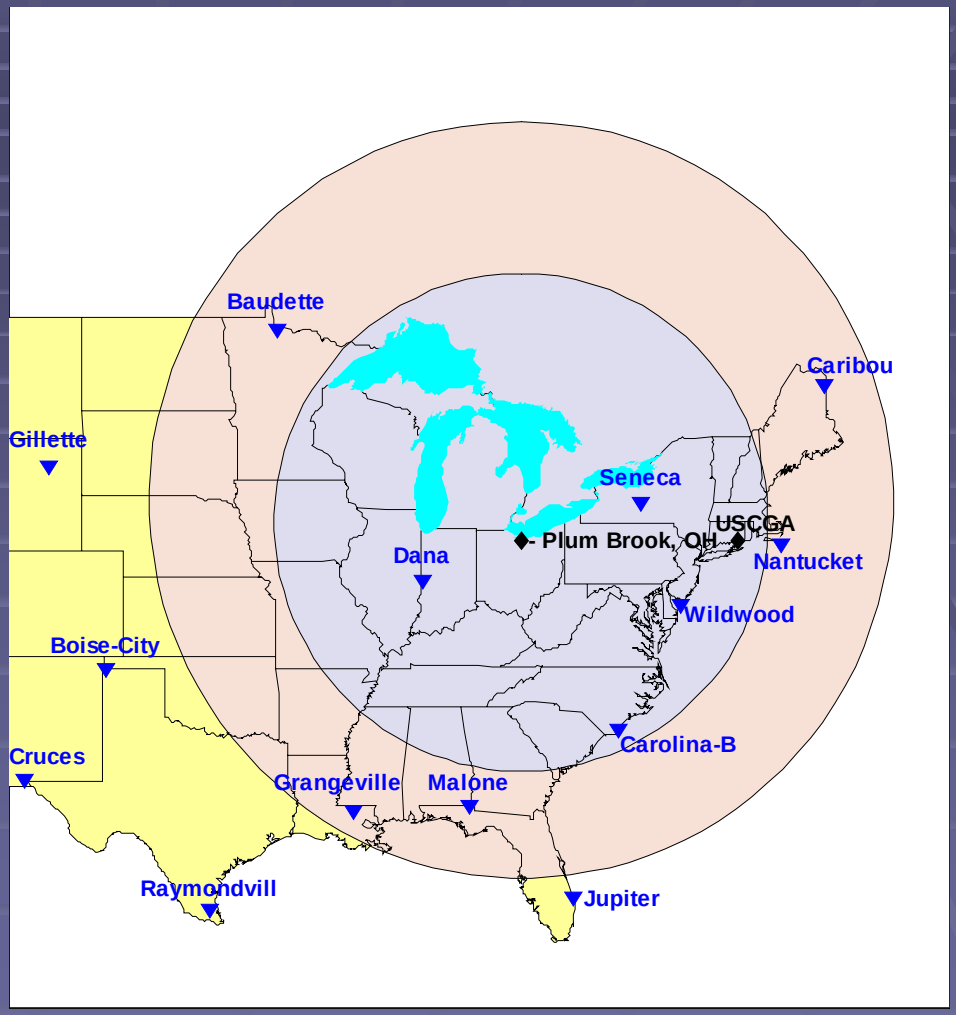
Loran Stations Near Ohio

- Possible Loran Towers
  - <1000km
    - Dana
    - Seneca
    - Carolina Beach
  - >1000km
    - Nantucket
    - Malone
    - Baudette
    - Grangeville
    - Caribou



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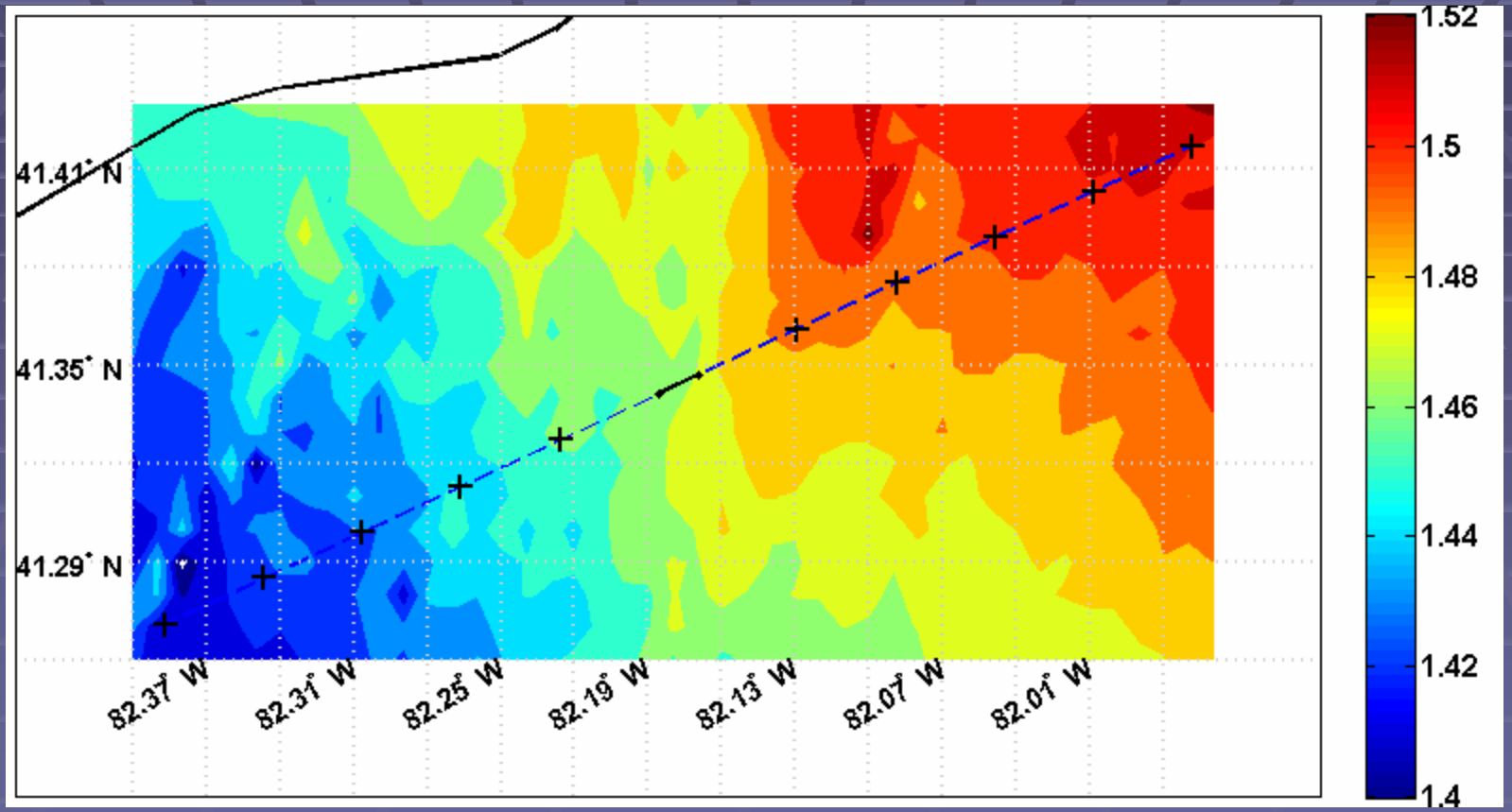
BALOR - Dana



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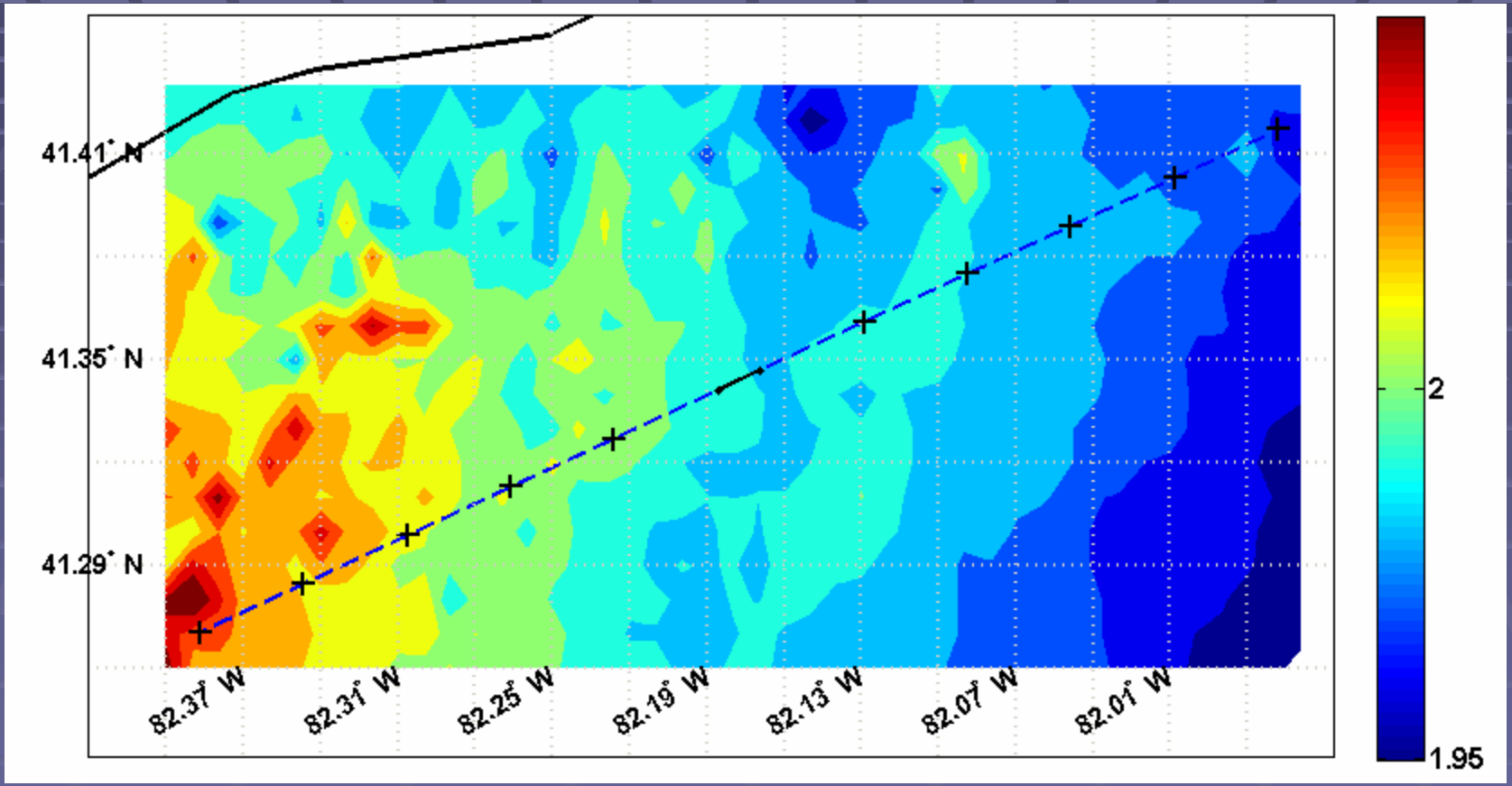
BALOR - Seneca



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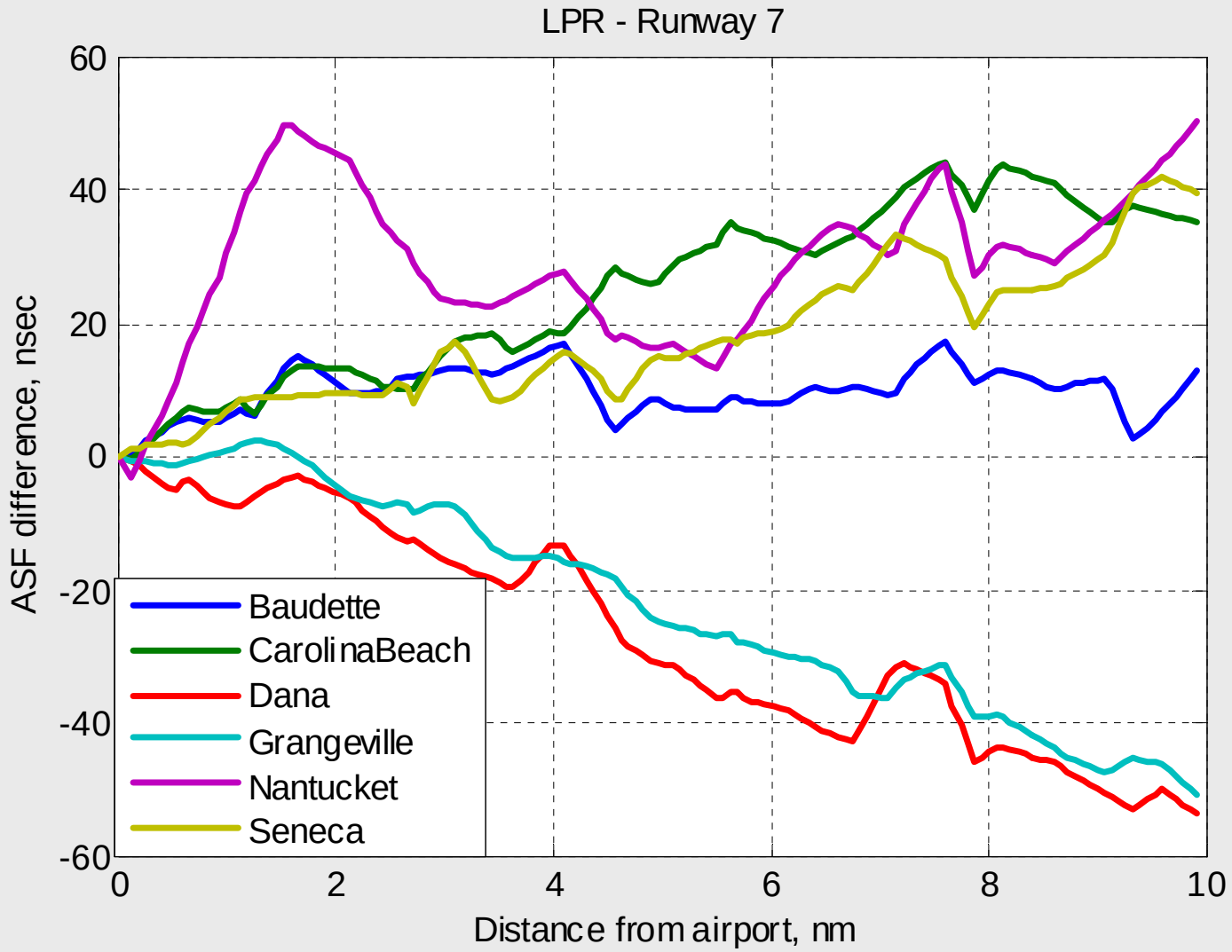

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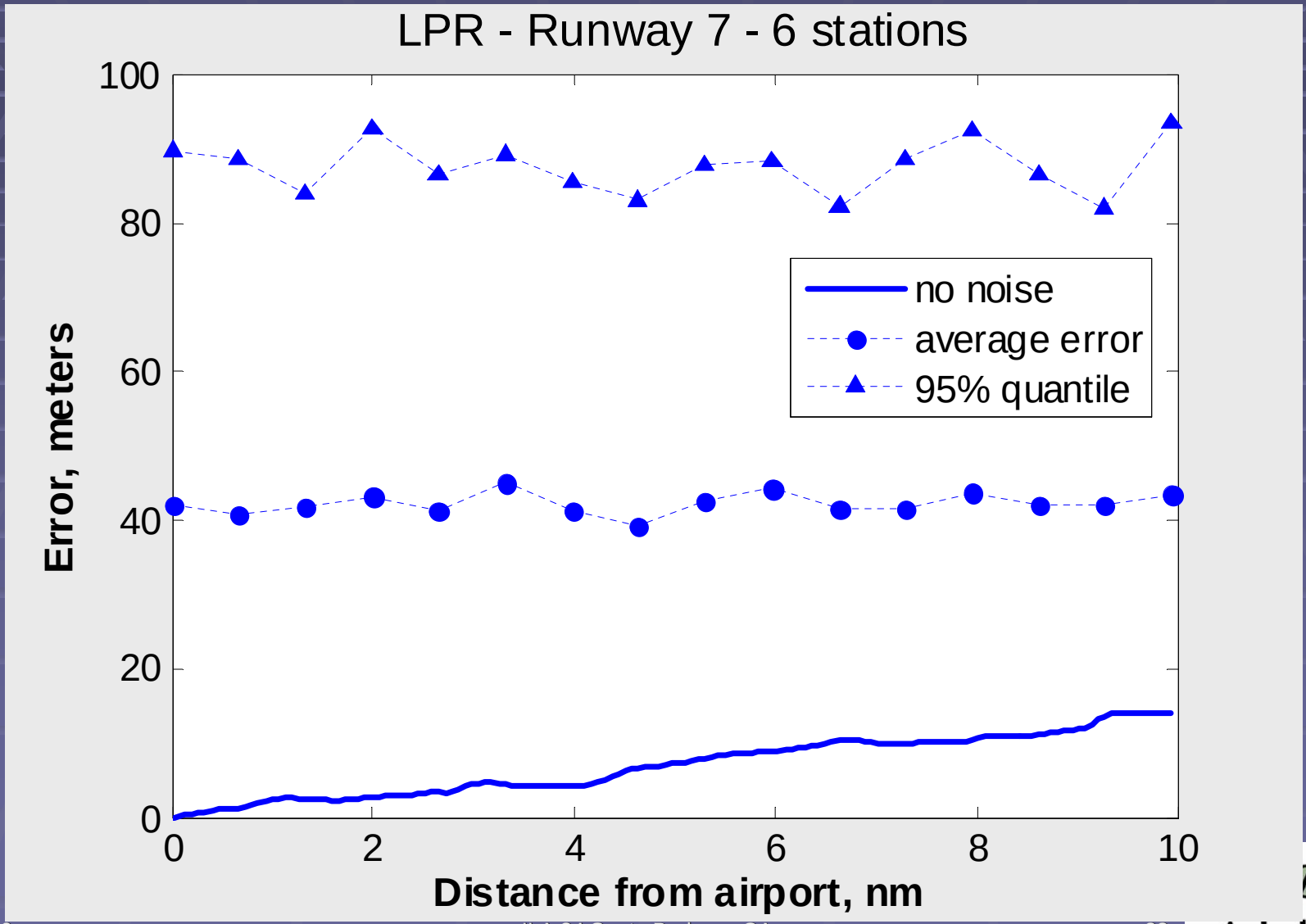

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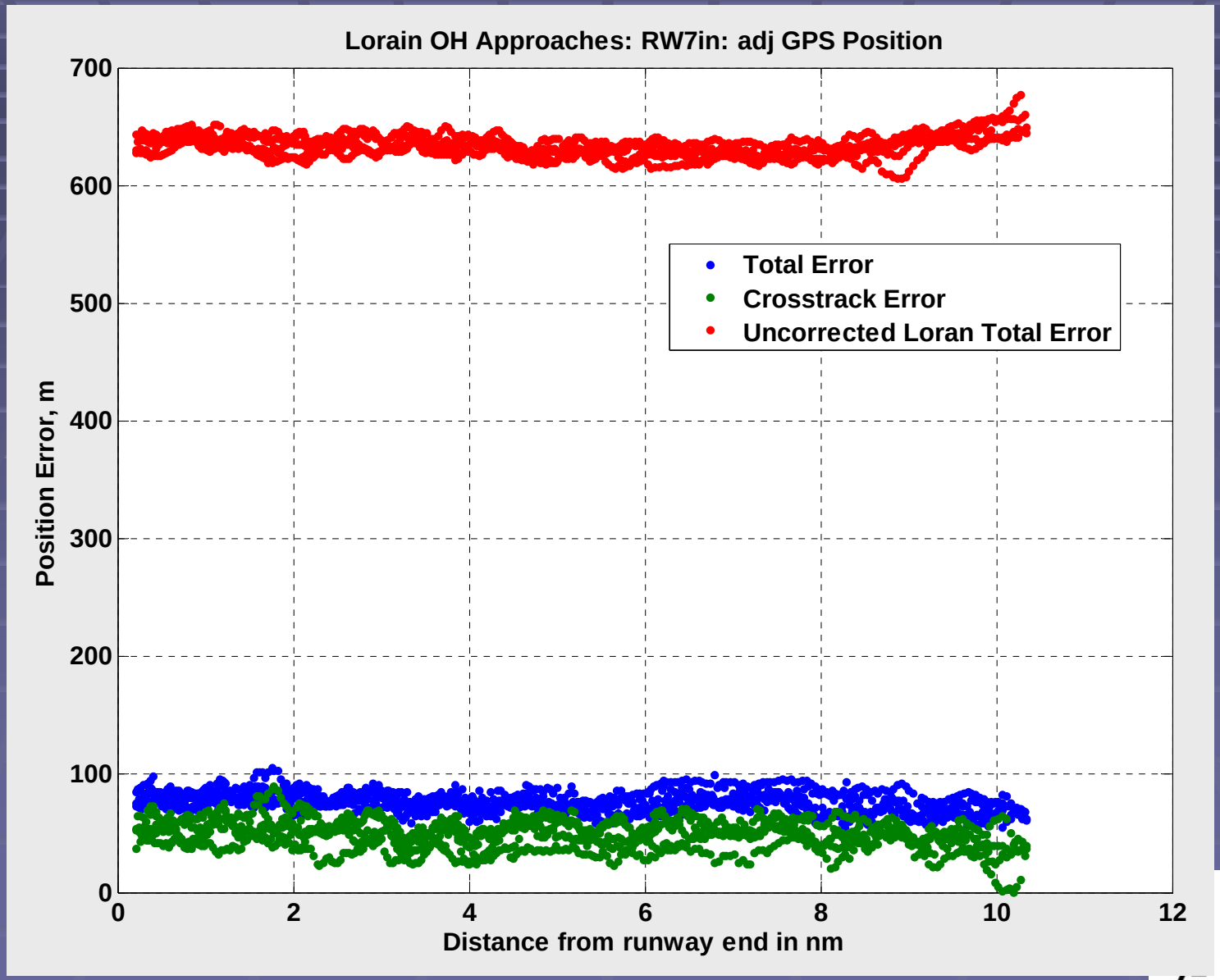
Actual Flight Test – rw 7



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Conclusion / Future

- With 1 ASF <120m error CROSSTRACK is met, but not TOTAL ERROR
- Still working on BALOR validation
  - Mobile results not well-matched to BALOR…
- Future: focus on BALOR validation
  - Continued analysis of Maine and Ohio data
  - Long Baseline Flights – November
  - BALOR bug fixes and enhancements, further analysis
  - TFE data to get Absolute ASF…
- Airship – See next paper

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Questions?

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Long Baseline Measurements

- Purpose
  - Validate BALOR model for distances >1,000 km from the Loran towers
  - A variety of propagation paths are needed:
    - all seawater
    - all land
    - mixed seawater and land
- Procedure
  - Fly radials to/from Loran towers
  - E and H-field antennas
  - Flights to be conducted at constant 5000ft AGL
- Analysis (post-process)
  - Calculate ASF* values along the flight paths (radials only)
  - Correct ASF* values using TFE data to generate true ASFs
  - Compare resulting ASF and Signal Strength profiles to BALOR

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