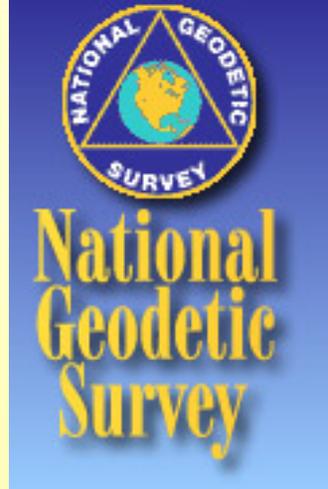
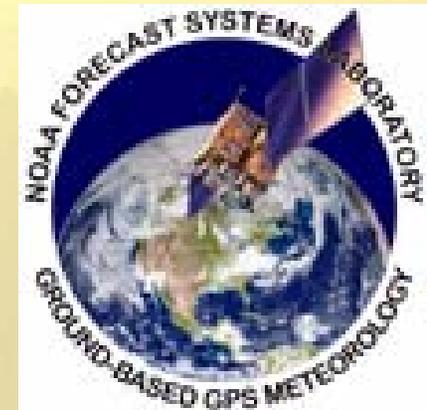




# High Accuracy Nationwide Differential Global Positioning System (HA-NDGPS)



**US Army Corps  
of Engineers®**



Tim Klein  
CGSIC - Hawaii  
June, 2009



U.S. Department of Transportation  
**Federal Highway  
Administration**

# Problem and Program Objectives

## HA-NDGPS

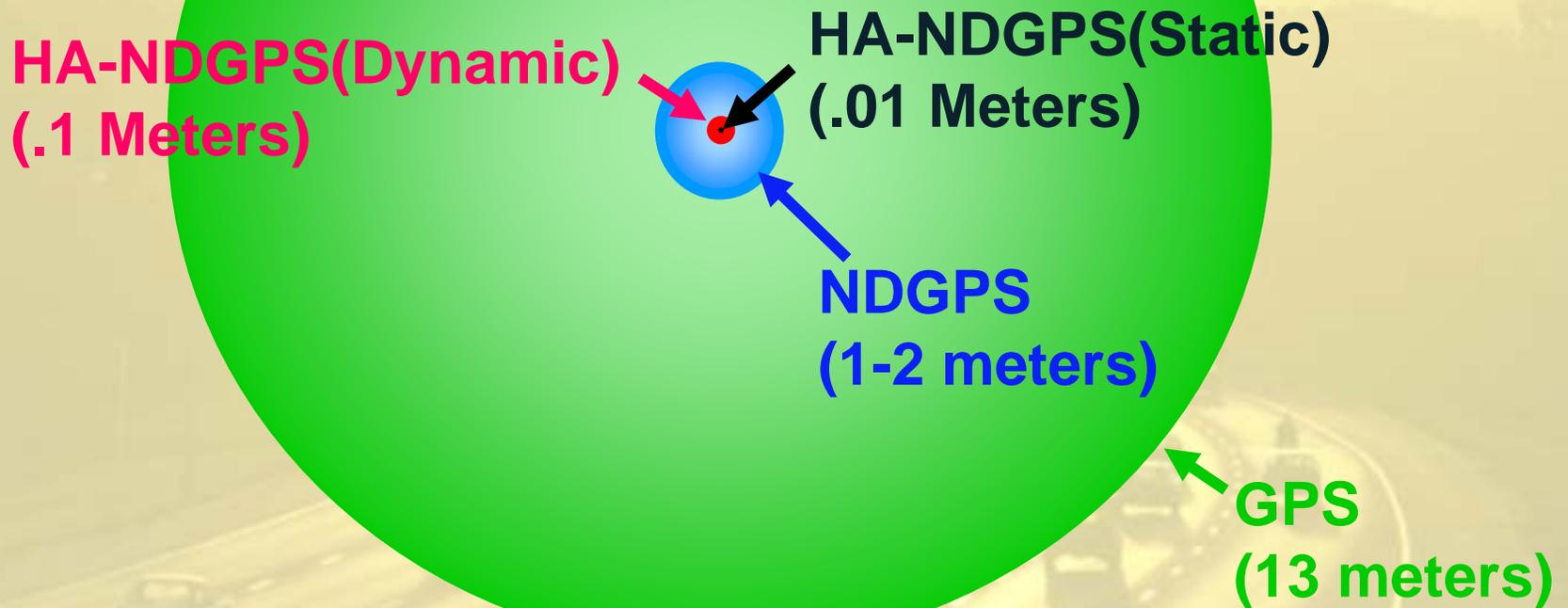
**Problem:** Submeter resolution of vehicle position needed for many advanced vehicle safety concepts.

**Program Objective:** Assess the implementation feasibility for improving the accuracy of the NDGPS service, using existing infrastructure, to meet the requirements of additional applications without decreasing availability and integrity and still meeting the needs of existing users.

- Examine ways to enable 3-D dynamic positioning at the centimeter level throughout the US,
- Coexist with existing infrastructure,
- Minimize deployment costs.

# Perspective on Accuracy

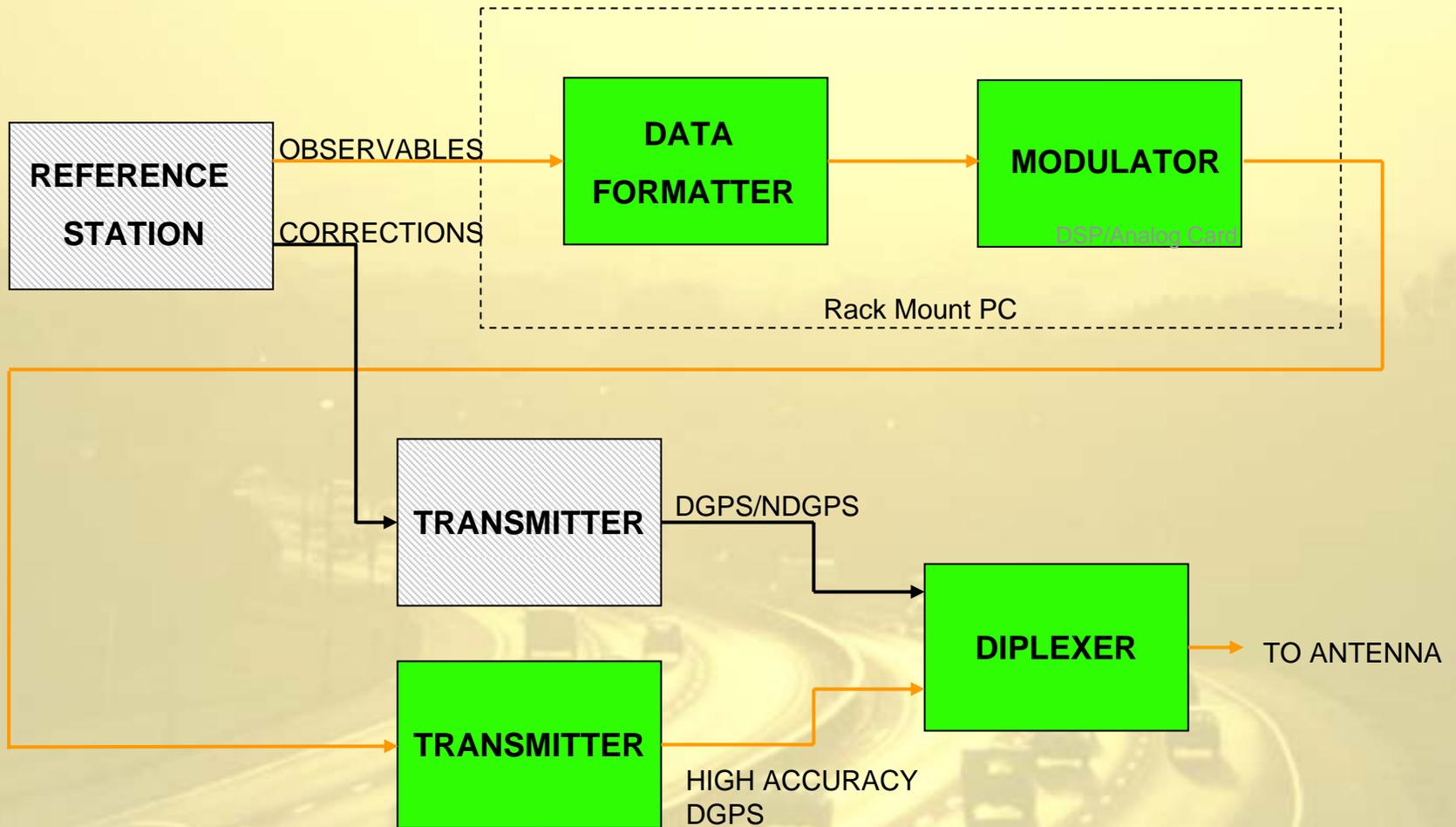
## Horizontal, Dynamic, 95%



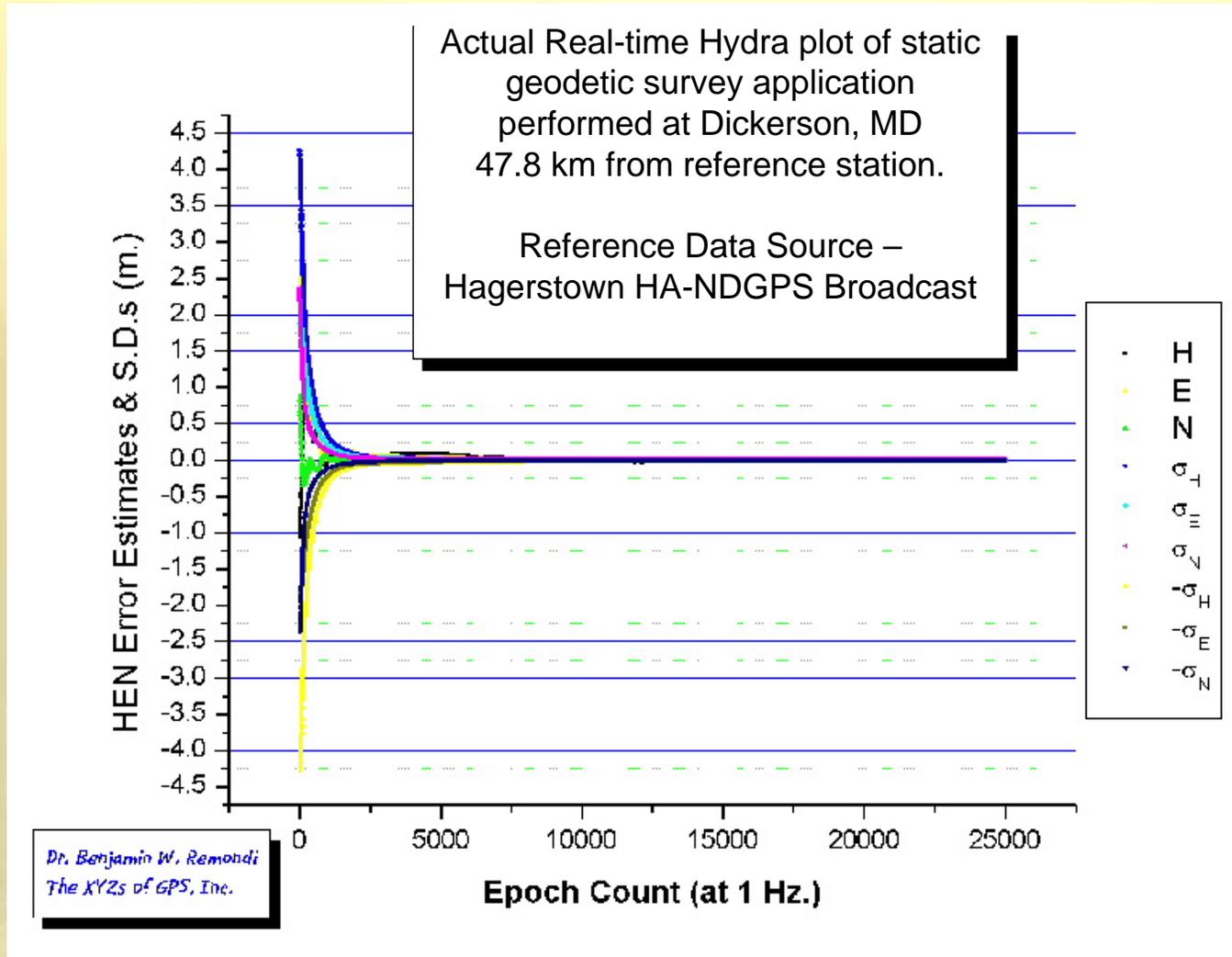
# HA-NDGPS Program Phases

- Phase 1
  - ✓ Develop Modulator and Data Link Receivers
  - ✓ Interface System Modules
  - ✓ Broadcast Characterization and Optimization
  - ✓ Single Site Concept Demonstration (Hagerstown, MD)
- Phase 2
  - ✓ Pre-Broadcast Integrity Algorithm
  - ✓ Multiple Site/Baseline Concept Demonstration (Hawk Run, PA)
  - ✓ Iono/Tropo Prediction
  - ✓ Application Development

# Broadcast Site Configuration

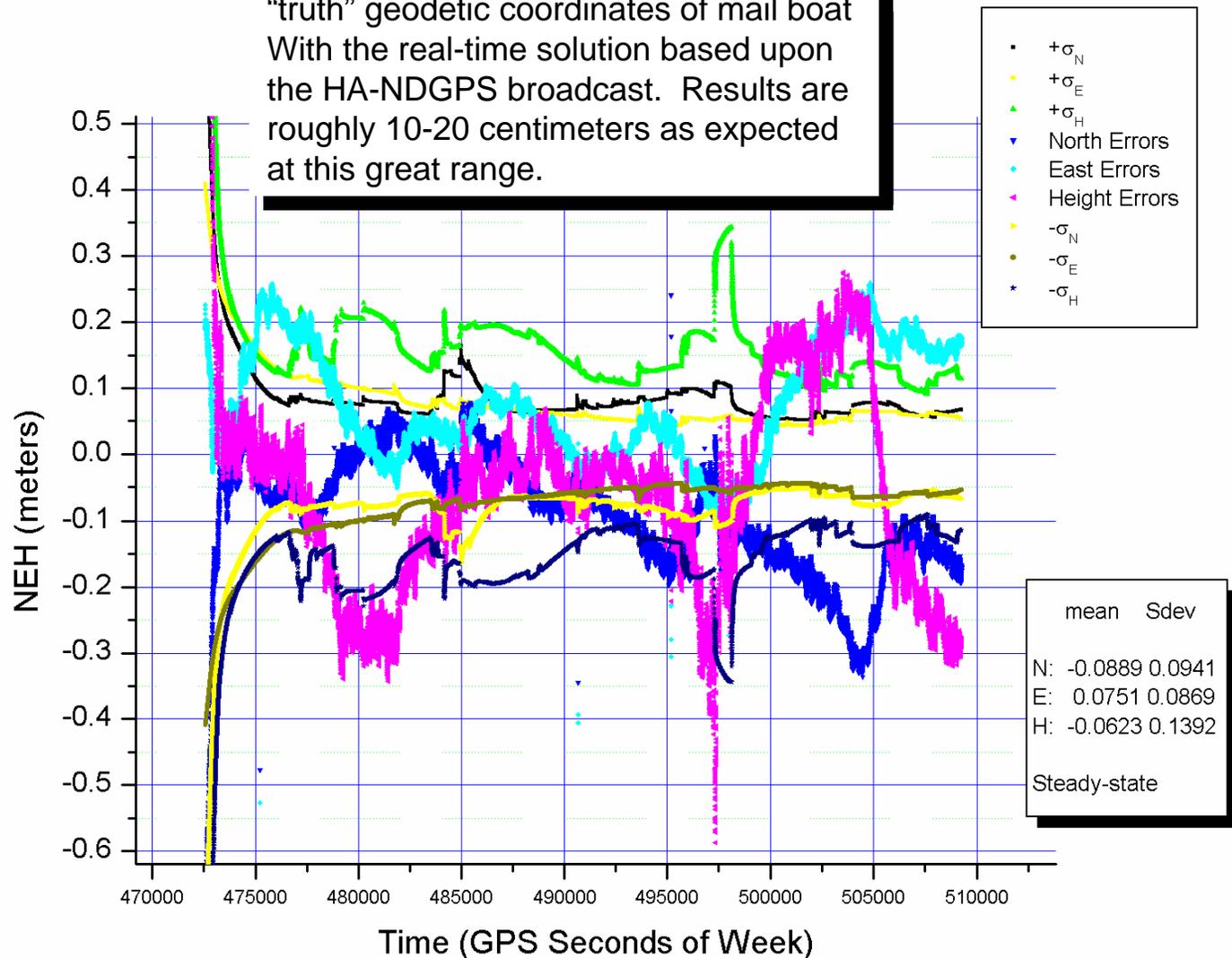


# Static Positioning at 50 km

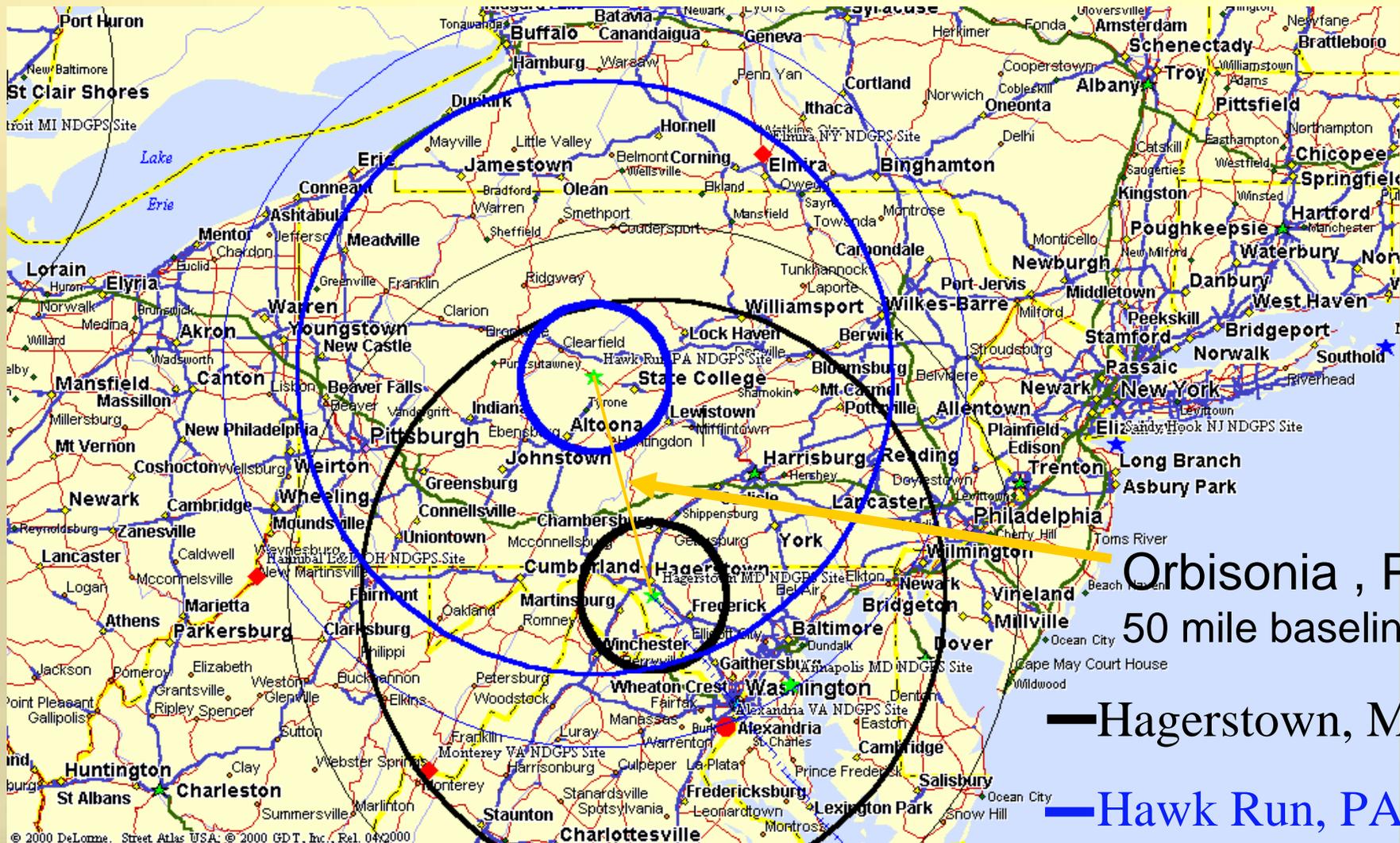


# Long Range Single Baseline

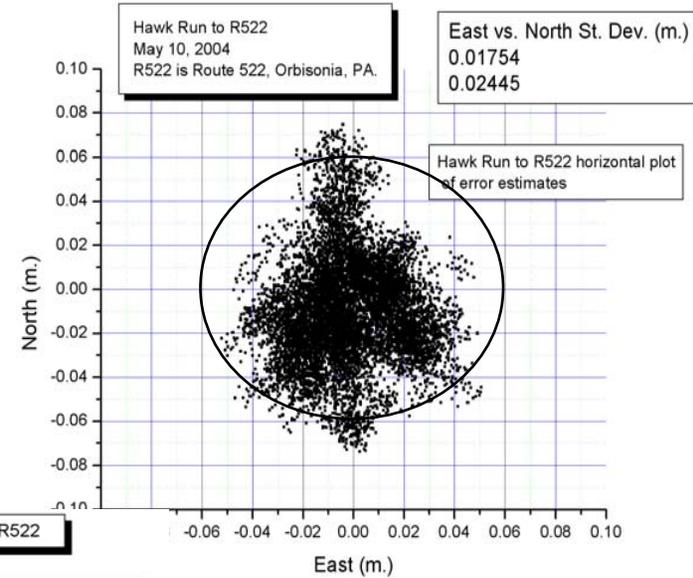
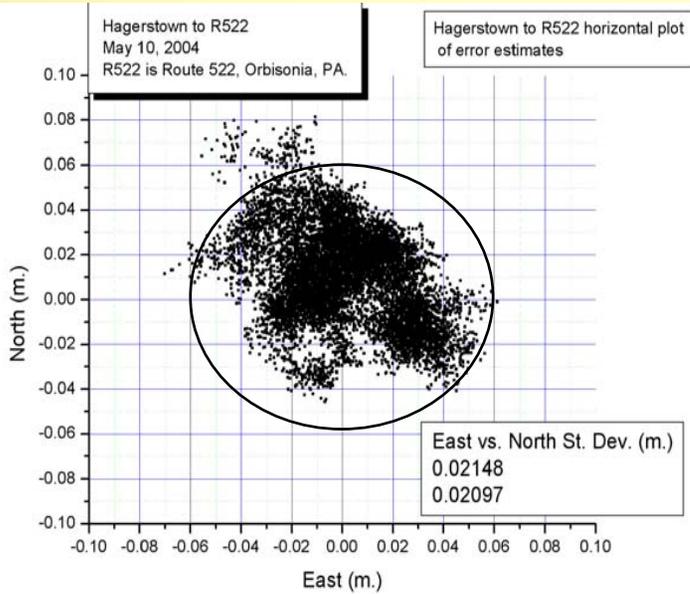
Tangier Island HA-NDGPS Experiment (250 km). Comparison of approximate "truth" geodetic coordinates of mail boat With the real-time solution based upon the HA-NDGPS broadcast. Results are roughly 10-20 centimeters as expected at this great range.



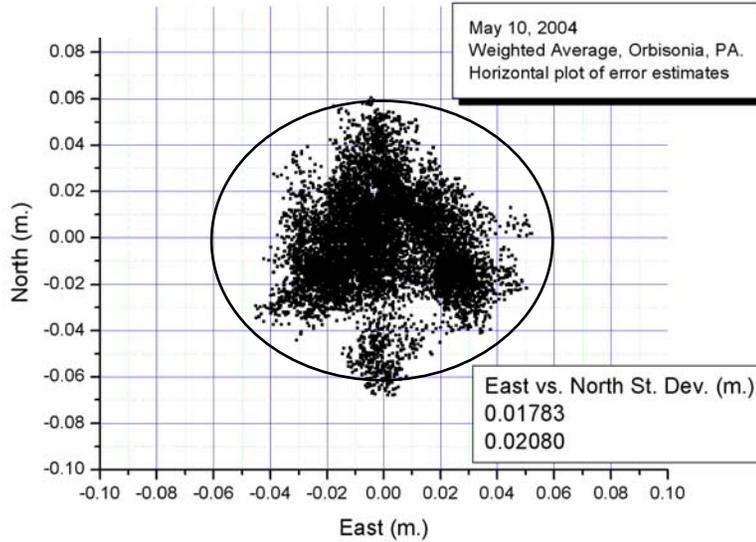
# HA-NDGPS Coverage



# Multi-Station



Weighted Average of Hagerstown & Hawk Run to R522



# “Accurate” Solution Nationwide RTK?

- What You Need:
  - Satellite Lock
  - Ground based system broadcasting observables
  - Multiple reference stations at less than 200 mile baselines
  - Accurate Ephemeris
  - Accurate Clock data
  - Good ionosphere model
  - Good Troposphere model
  - Integrity Check
- What You Get:
  - Initial .5 to 2 meter code accuracy
  - Reduced search space for integers
  - Very fast integer resolution at long ranges

# Continuing Research

- Consider what we have:
  - Two broadcasts from a multiple sites
  - Both broadcasts can have both their carrier and their data time synchronized to GPS or some other common timing source
  - Broadcast is low frequency – ground obstructions generally don't block the signal
- This implies
  - Potential stand alone two dimensional navigation service

# SBIR Project

- Examining NDGPS/HA-NDGPS as a stand alone navigation solution
- Data indicates multipath (skywave) an issue beyond 100 miles
- Supplement with other services (LORAN?)
- Analysis supports sub 10 meter resolution.
- Potential to augment DGPS
  - Starting from known high accuracy position, many factors eliminated in short term.
  - Potential for high resolution during short (less than 5 second) GPS outages (urban canyon effects)
  - Need further research

# Summary

- HA-NDGPS signal successfully broadcast from multiple locations
  - State-of-the-Art modulation
  - Reliable duplexing technology
- Developed new atmospheric modeling approaches
- Accuracy better than 10 cm horizontally, 95%
- Availability above 99.9%
- Implementation cost <\$100,000 per site
- Potential as stand alone navigation service

# Applications

- Transportation

- Highway

- Automated Road Construction
    - Intersection Collision Avoidance
    - Dynamic Mapping
    - Digital Highway Measurement Vehicle

- Railroad

- Track Defect Monitoring

- Maritime

- Under keel clearance

- USDA

- Agriculture

- Precision Farming
    - Autonomous Farm Vehicles

- USFS

- Logging boundaries
    - Infestation monitoring

- Interior

- National Park Service

- Monitoring subsidence of critical monuments
    - Real-time boundary marking

- Fish and Wildlife Service

- Monitoring critical habitat
    - Biological Assessments

- EPA

- Hazardous Material Spill containment

- Etc.

# Contact Information

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**Phase I Test Report**

<http://www.tfhrc.gov/its/ndgps/02110/index.htm>

**Phase II Test Report**

<http://www.tfhrc.gov/its/pubs/05034/index.htm>