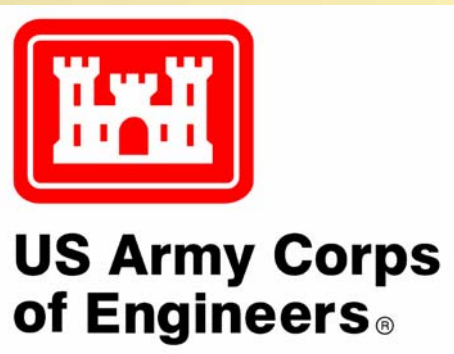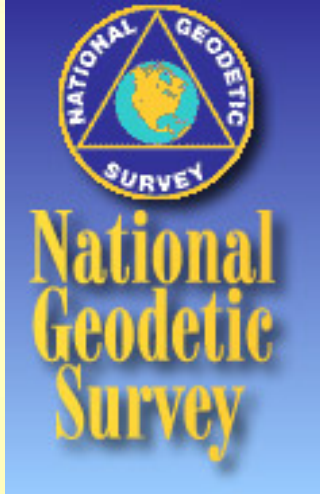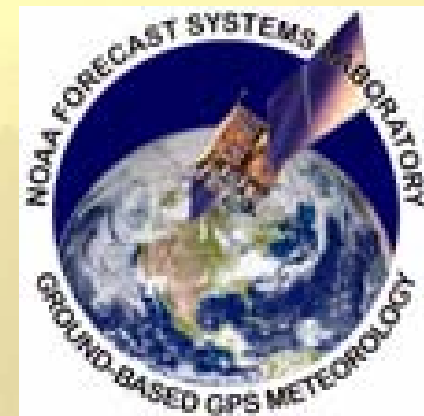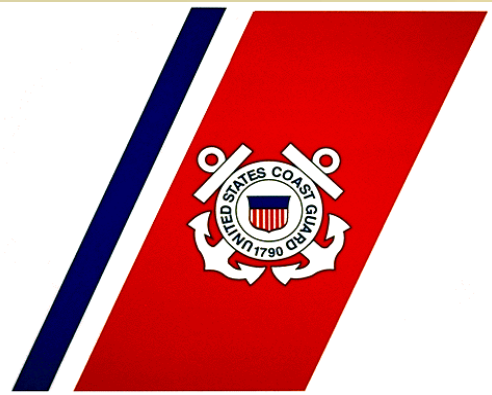# High Accuracy Nationwide Differential Global Positioning System (HA-NDGPS)

UPDATE

Jim Arnold
September, 2009

Problem Statement
& Program Objective

**Problem Statement:** 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.

Perspective on Accuracy Horizontal, Dynamic, 95%

HA-NDGPS(Dynamic)
(.1 Meters)

HA-NDGPS(Static)
(.01 Meters)

NDGPS
(1-2 meters)

GPS
(13 meters)
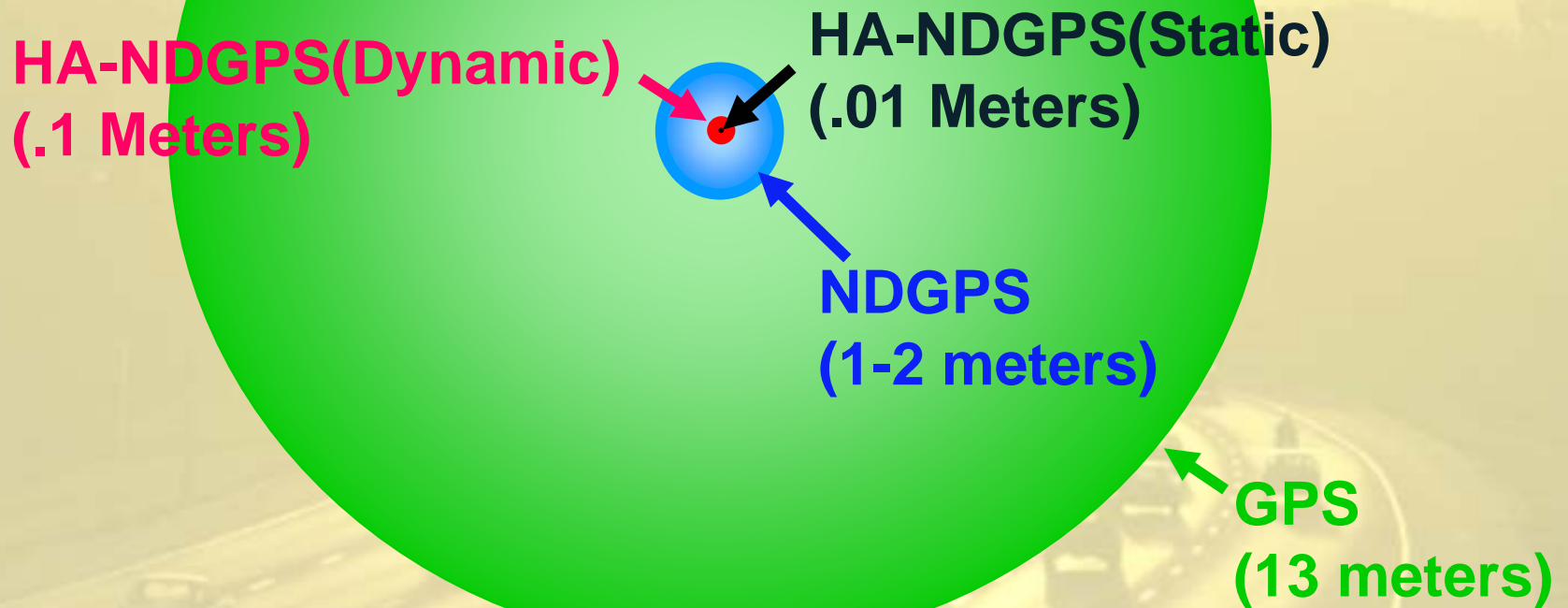
Program Phase

- Phase I – Make the System Work
  - ✓ Develop Modulator and Data Link Receivers
  - ✓ Interface System Modules
  - ✓ Broadcast Characterization and Optimization
  - ✓ Single Site Concept Demonstration (Hagerstown, MD)

- Phase II – Refine the Approach
  - ✓ Pre-Broadcast Integrity Algorithm
  - ✓ Multiple Site/Baseline Concept Demonstration (Hawk Run, PA)
  - ✓ Iono/Tropo Prediction
  - ✓ Application Development

✓ Phase III – Develop the Applications
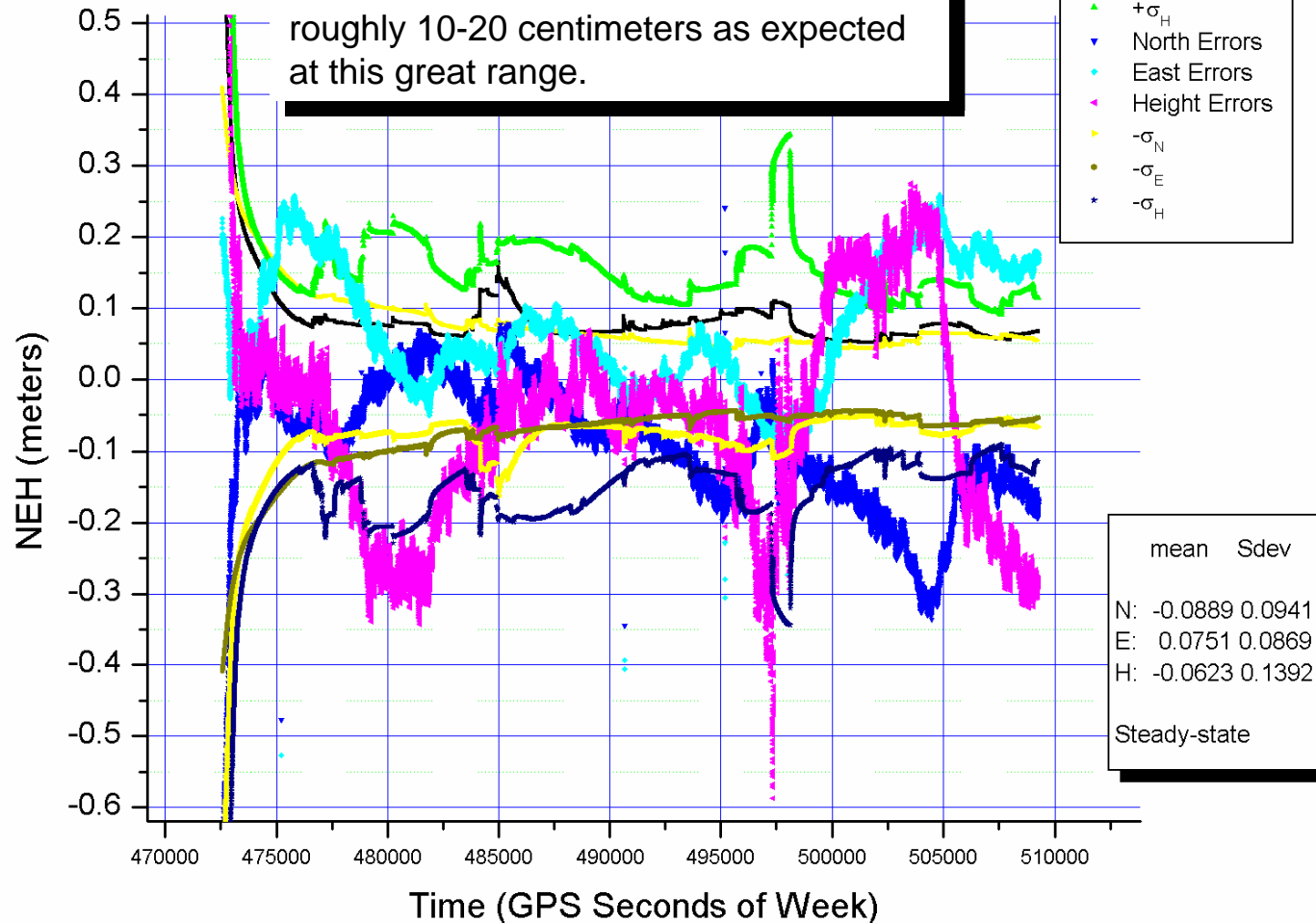 - ✓ Define/Document site changes
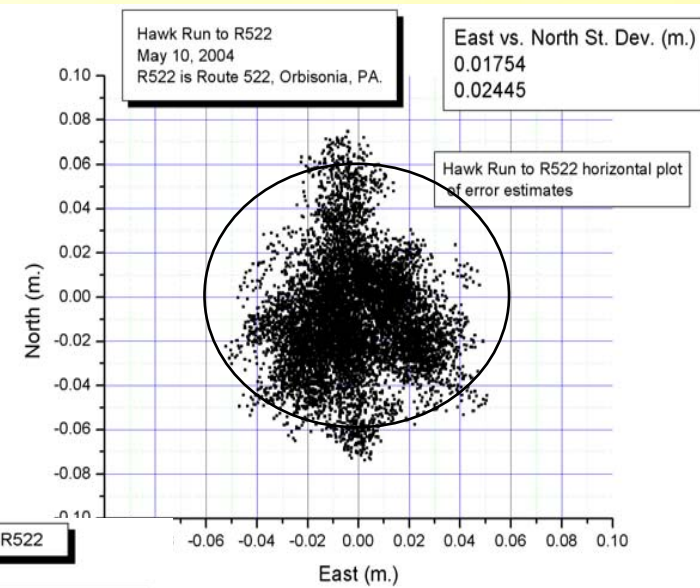 - ✓ Develop Test Plans

Broadcast Site Configuration Phase I
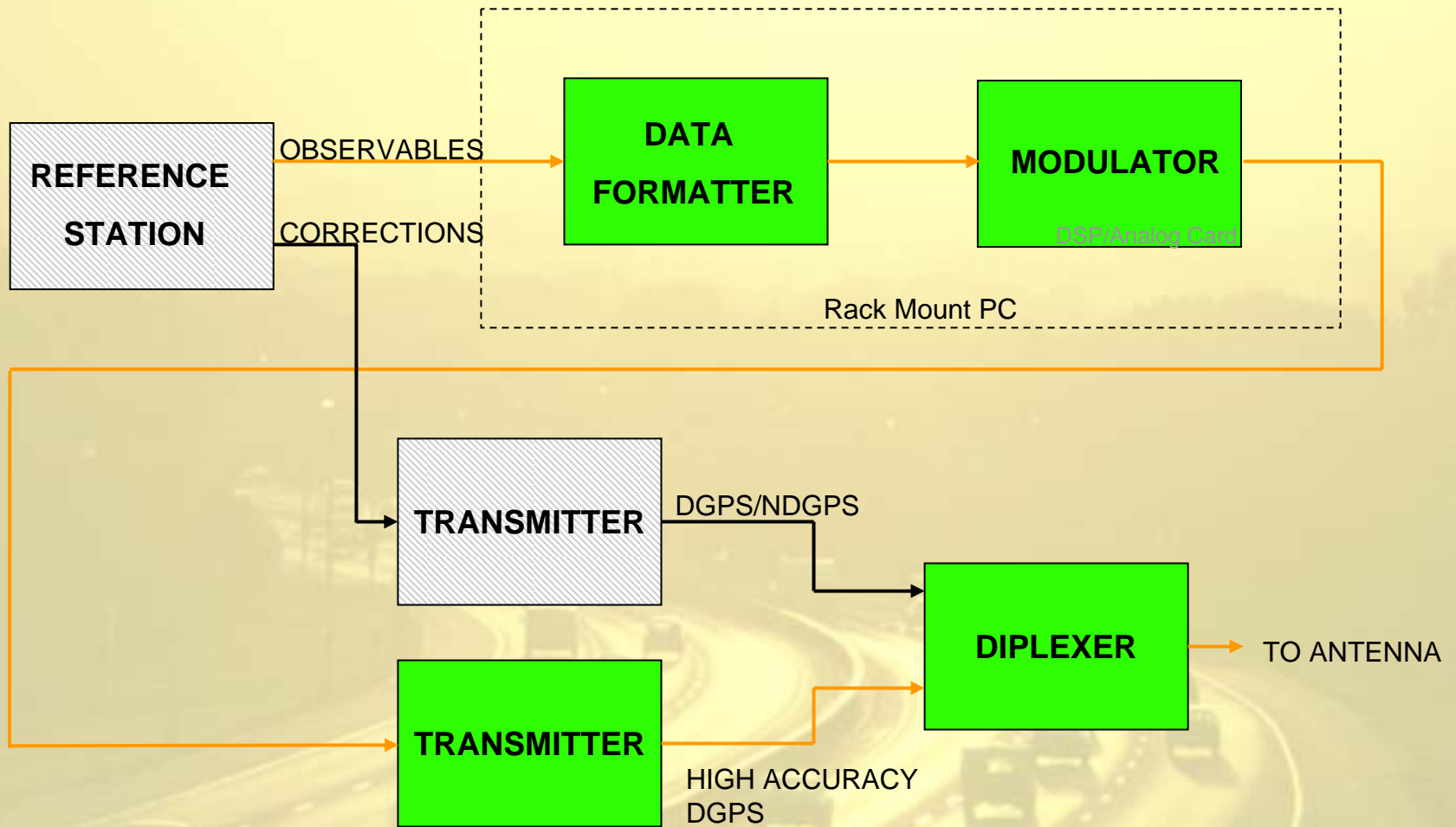
Long Range Single Baseline Test   Phase I

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.

Legend:
- $+\sigma_N$
- $+\sigma_E$
- $+\sigma_H$
- North Errors
- East Errors
- Height Errors
- $-\sigma_N$
- $-\sigma_E$
- $-\sigma_H$

	mean	Sdev
N:	-0.0889	0.0941
E:	0.0751	0.0869
H:	-0.0623	0.1392

Steady-state

Axis labels: NEH (meters) vs Time (GPS Seconds of Week)

Multi-Station - Phase II

Hagerstown to R522
May 10, 2004
R522 is Route 522, Orbisonia, PA.

Hagerstown to R522 horizontal plot
of error estimates

East vs. North St. Dev. (m.)
0.02148
0.02097

Hawk Run to R522
May 10, 2004
R522 is Route 522, Orbisonia, PA.

East vs. North St. Dev. (m.)
0.01754
0.02445

Hawk Run to R522 horizontal plot
of error estimates

Weighted Average of Hagerstown & Hawk Run to R522

May 10, 2004
Weighted Average, Orbisonia, PA.
Horizontal plot of error estimates

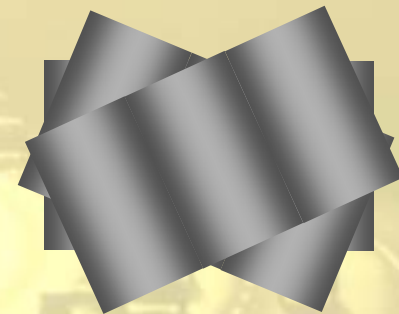East vs. North St. Dev. (m.)
0.01783
0.02080
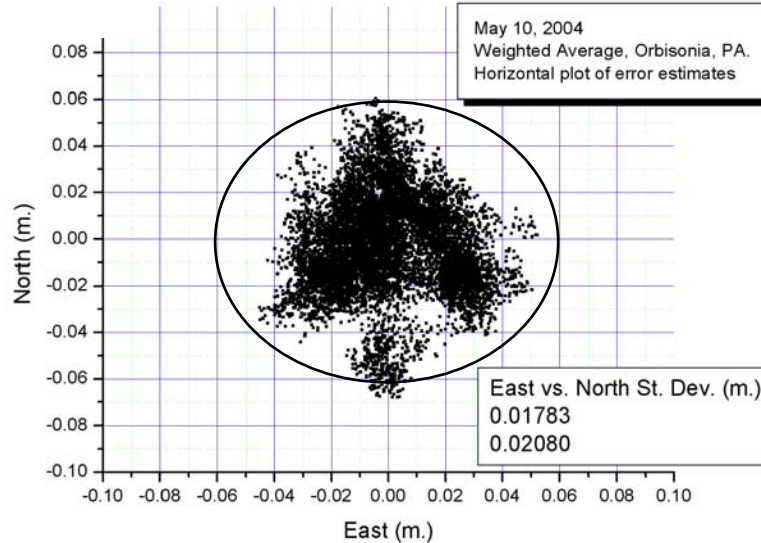
Documentation Package Phase III

- HA ECR Form;
- HA Prototype R&D Plan;
- HA Program Management Plan (PMP);
- HA User Objectives Definition Document;
- HA Equipment Integrated Logistics Support Plan (EILSP);
- System Operational Verification Test (SOVT) Plan;
- Test Procedure for Functional Tests;
- Test Procedure for Site Coverage Tests;
- Documentation Package for Hagerstown; Hawk Run; Topeka; St. Marys; Lincoln; and Pueblo.
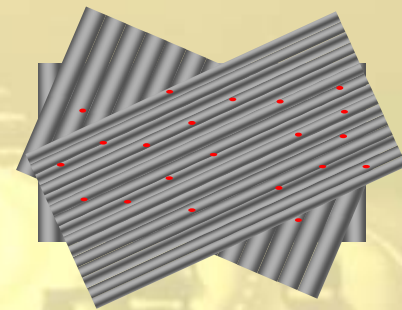
"Accurate" Solution Nationwide RTK?

- **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

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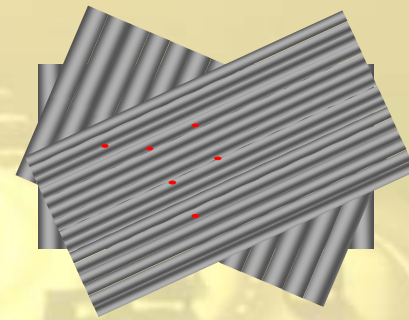 - Very fast integer resolution at long ranges

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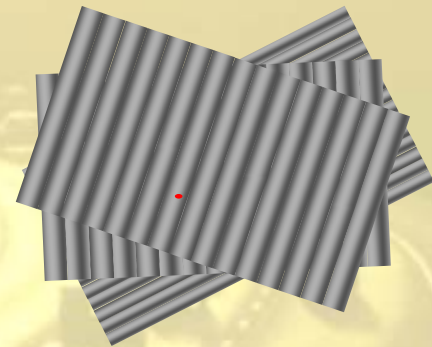 - Very fast integer resolution at long ranges

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Continuing Research

- Independent Ranging System
  - Small Business Innovative Research
  - Phase 1 complete
    - Paper Analysis - How It Could Work
      - Beyond 100 Mile Range
        - » Multipath/Phase Shifts Degrades Solution
      - Other Signals of Opportunity
        - » Improves Performance
  - Phase II starting shortly
    - Product Development

Summary

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

Contact Information

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(202)493-3265

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