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

Tim Klein
CGSIC - Hawaii
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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(Dynamic) (.1 Meters)
- HA-NDGPS(Static) (.01 Meters)
- NDGPS (1-2 meters)
- GPS (13 meters)
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
Static Positioning at 50 km

Actual Real-time Hydra plot of static geodetic survey application performed at Dickerson, MD 47.8 km from reference station.

Reference Data Source – Hagerstown HA-NDGPS Broadcast
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.
Multi-Station
“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 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 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

Jim Arnold
Federal Highway Administration
Turner-Fairbank Highway research Center
McLean, VA 22101
(202)493-3265

Phase I Test Report
http://www.tfhrc.gov/its/ndgps/02110/index.htm

Phase II Test Report