

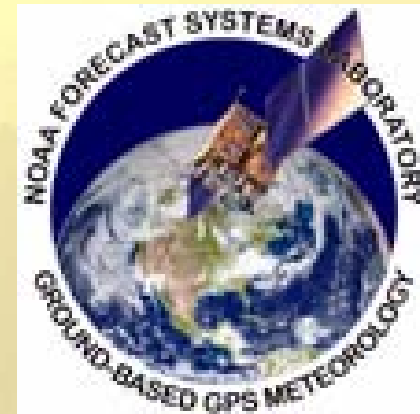


National
Geodetic
Survey

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



**US Army Corps
of Engineers®**

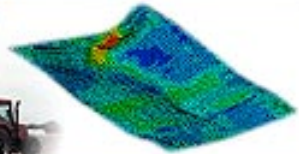
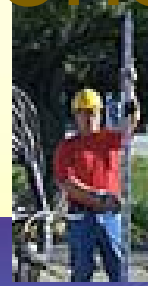


Jim Arnold
June 2007



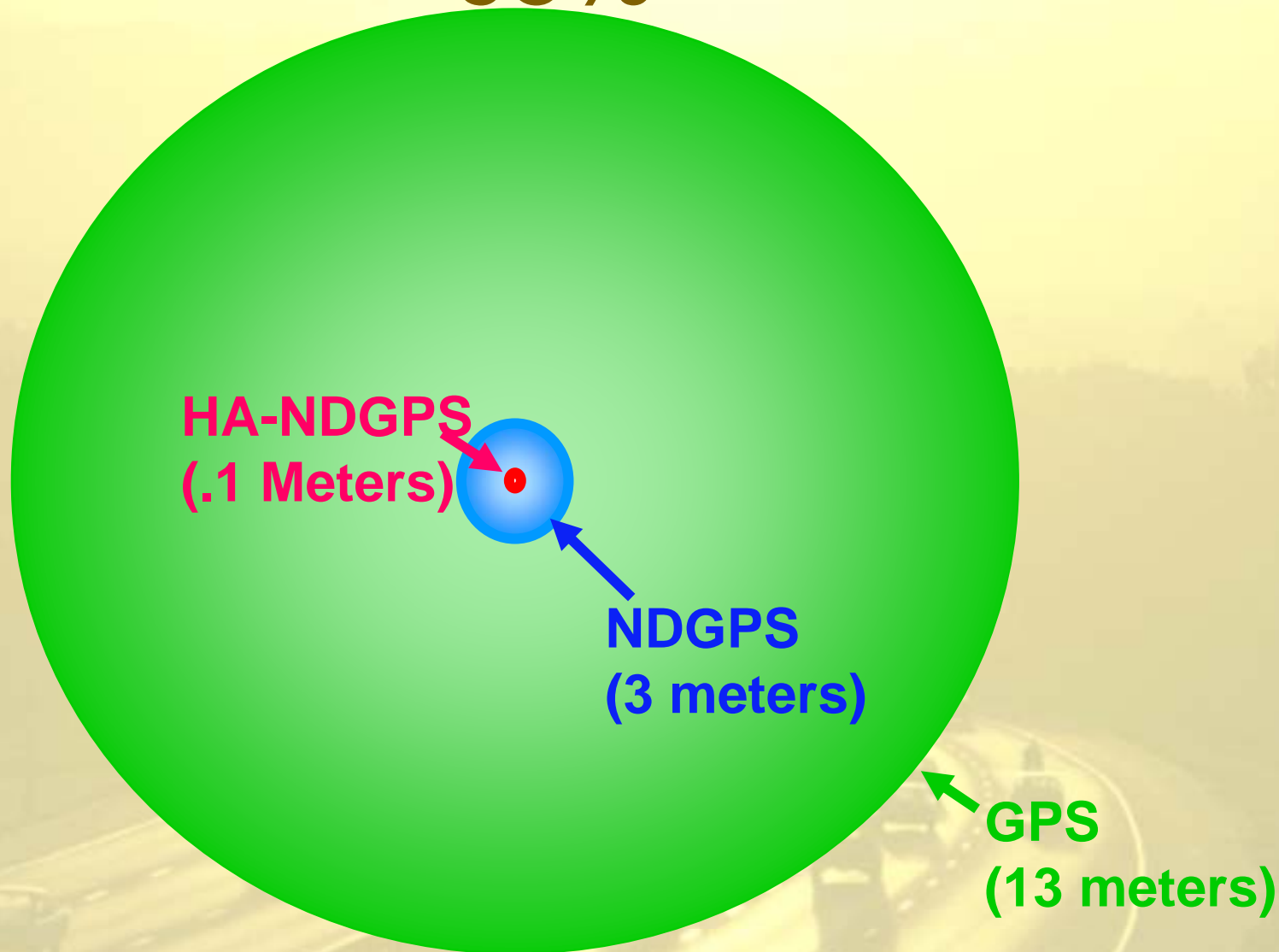
U.S. Department of Transportation
**Federal Highway
Administration**

Applications



Accuracy, Horizontal, Dynamic

- 95% -



Program Objectives

“Assess the implementation feasibility for improving the accuracy of the NDGPS service, using the 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

The Broadcast

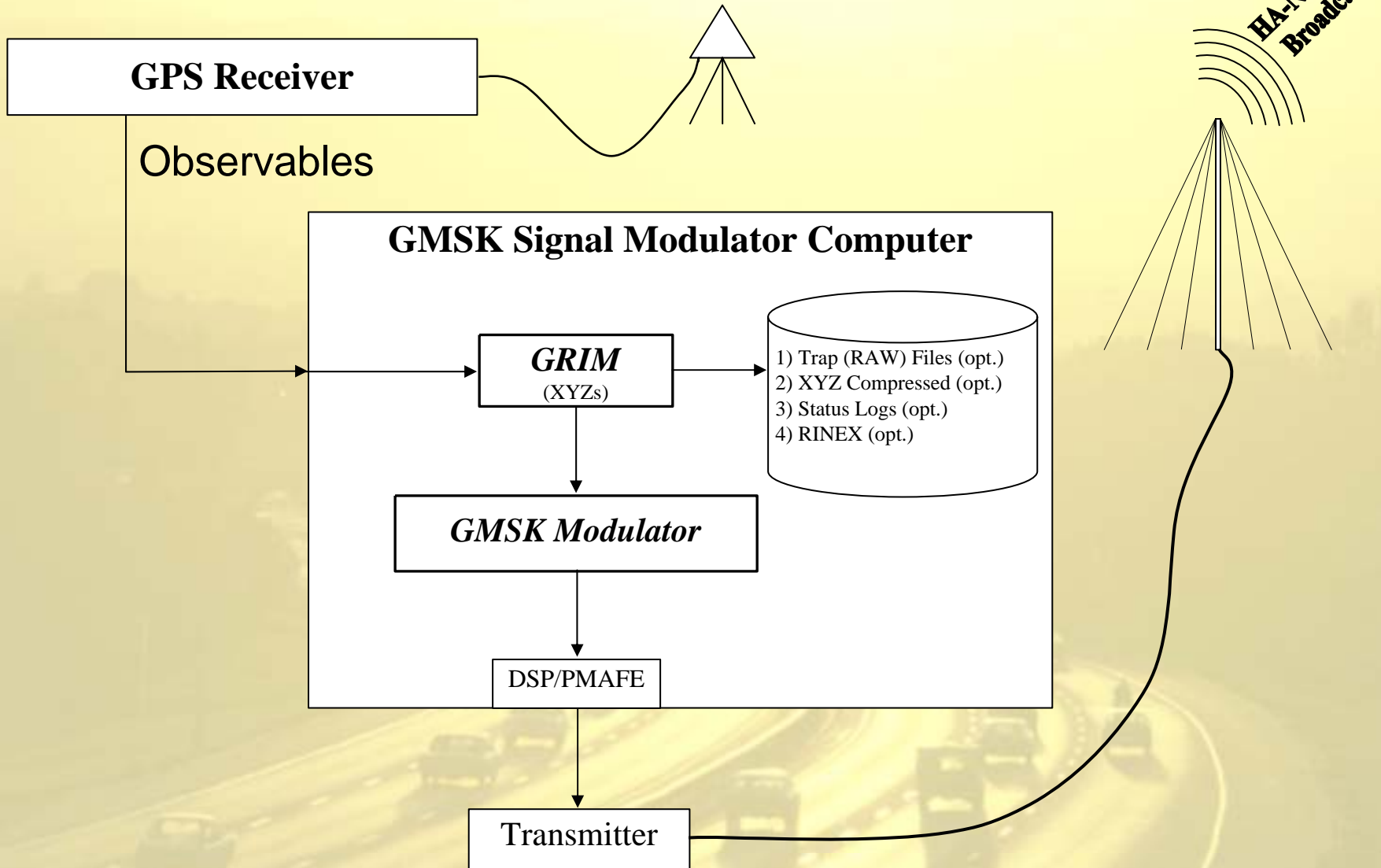
- Broadcast Code and Carrier Phase Data
 - Capability to broadcast all observables (L1,L2C,L5, and others) contained in less than 1000 bits
 - Data rates - 1KBPS
 - Initially L1 and L2-P(Y) observables are broadcast
- Utilize an Advanced Broadcast Link
 - Data synchronized to GPS time
 - Carrier calibrated with GPS to sub-hertz levels
 - Spectrally efficient modulation (raised cosine MSK)
 - “One second data” in compact mode

HIGH ACCURACY - NDGPS

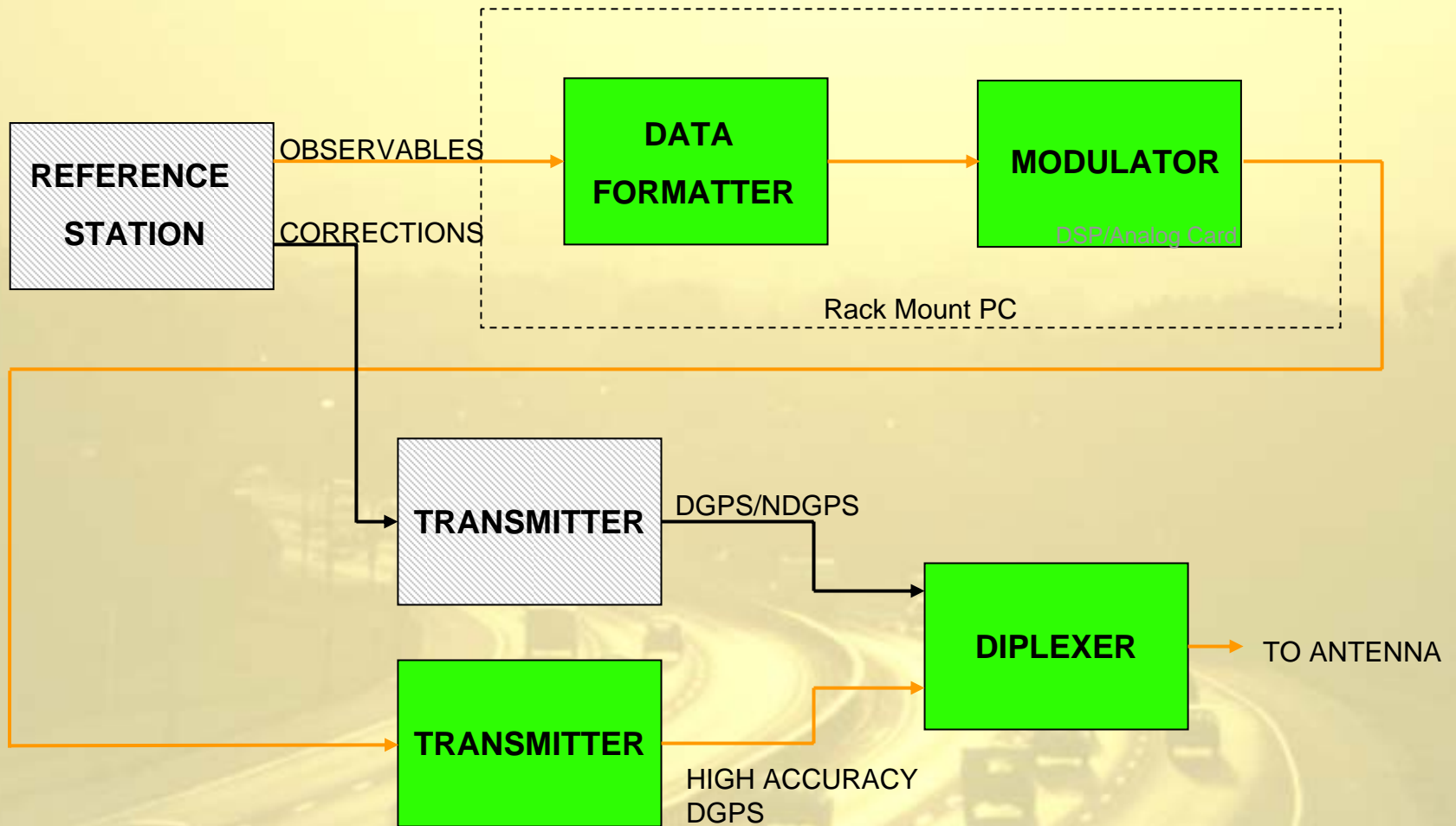


- Caretaker Sites
- ◆ New Site
- Coast Guard Site
- Green - Operating
- Red - Planned
- Dark Blue - HA-NDGPS Installed
- Light Blue - HA-NDGPS Planned

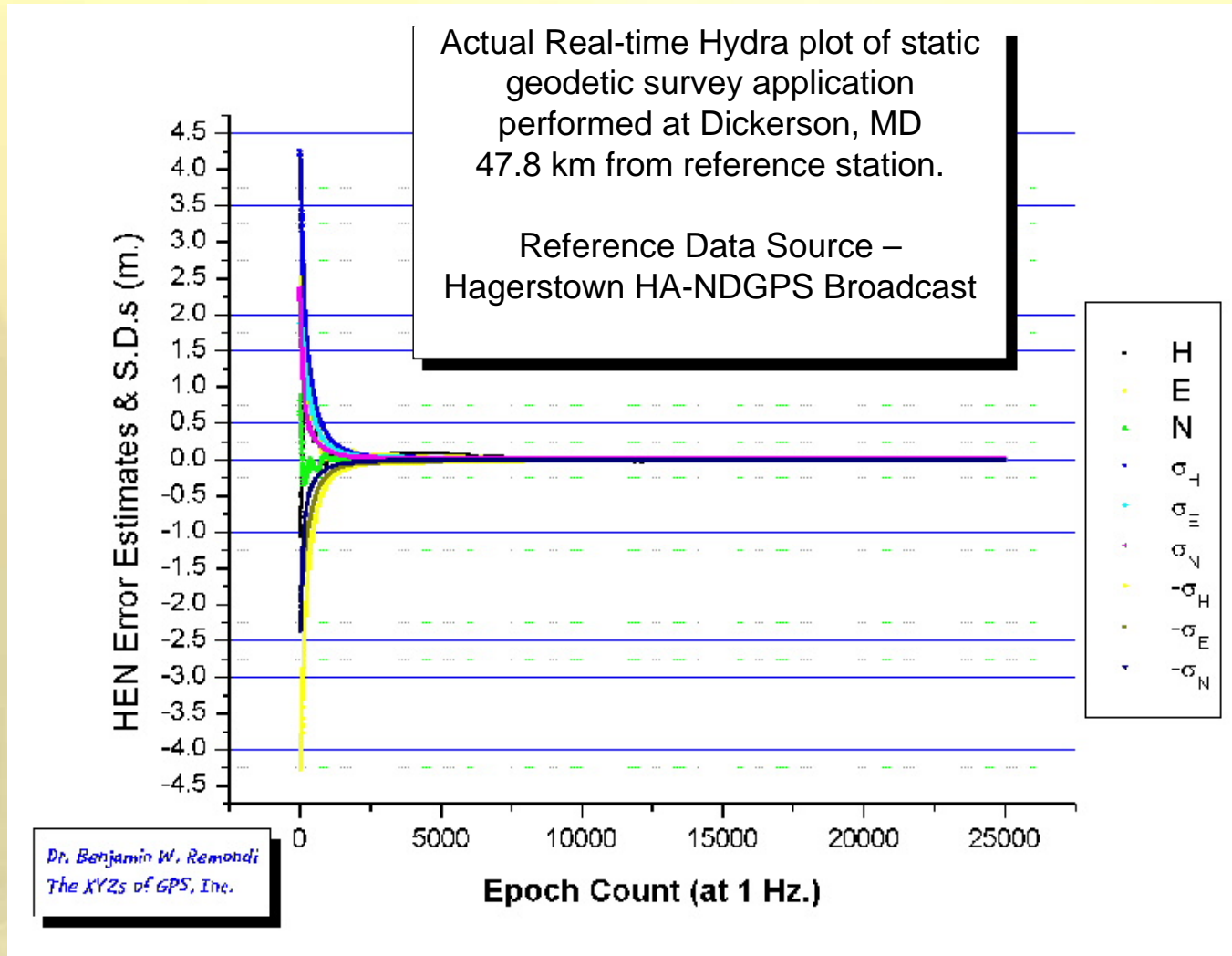
Broadcast



Broadcast Site Configuration

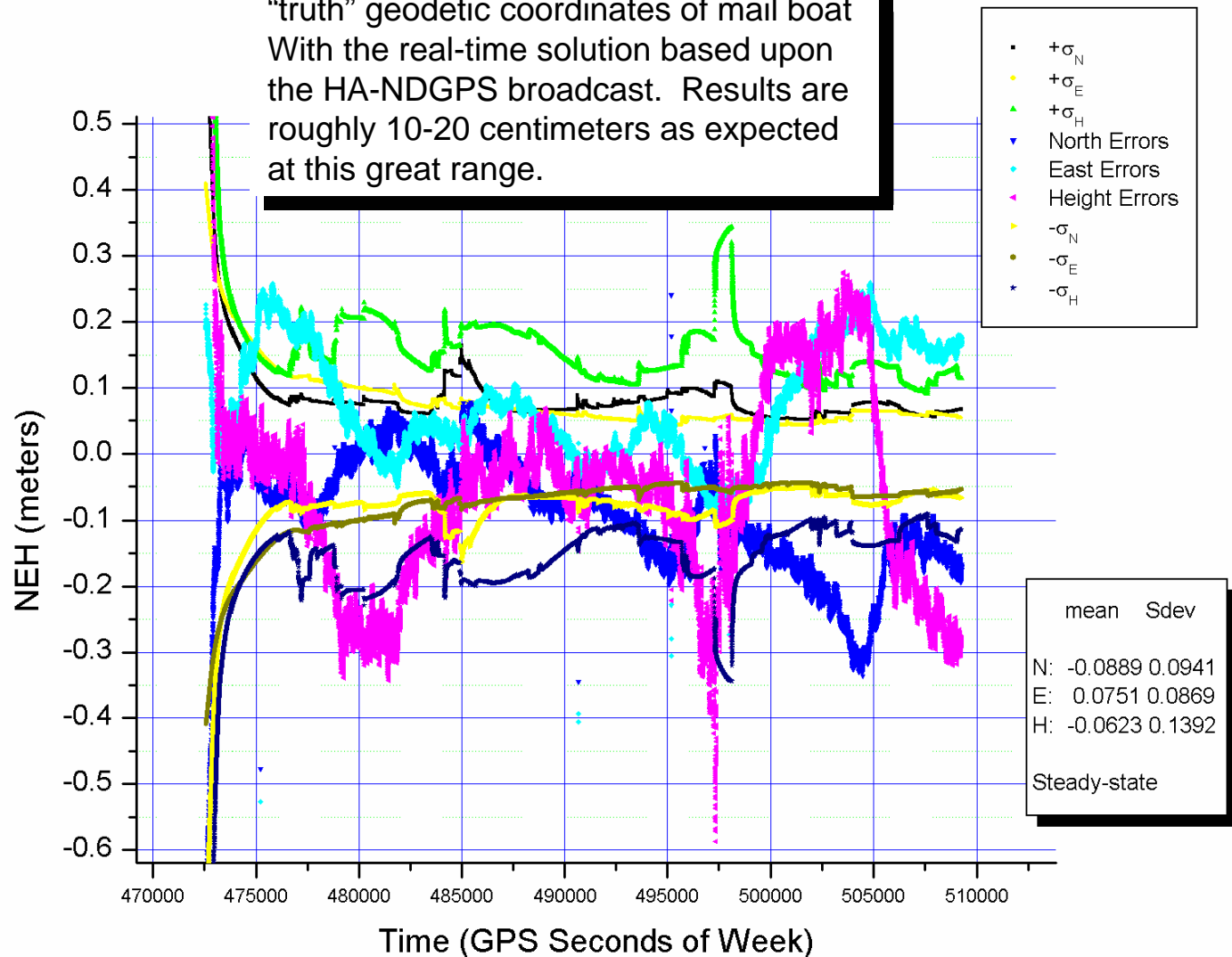


Static Positioning at 50 km

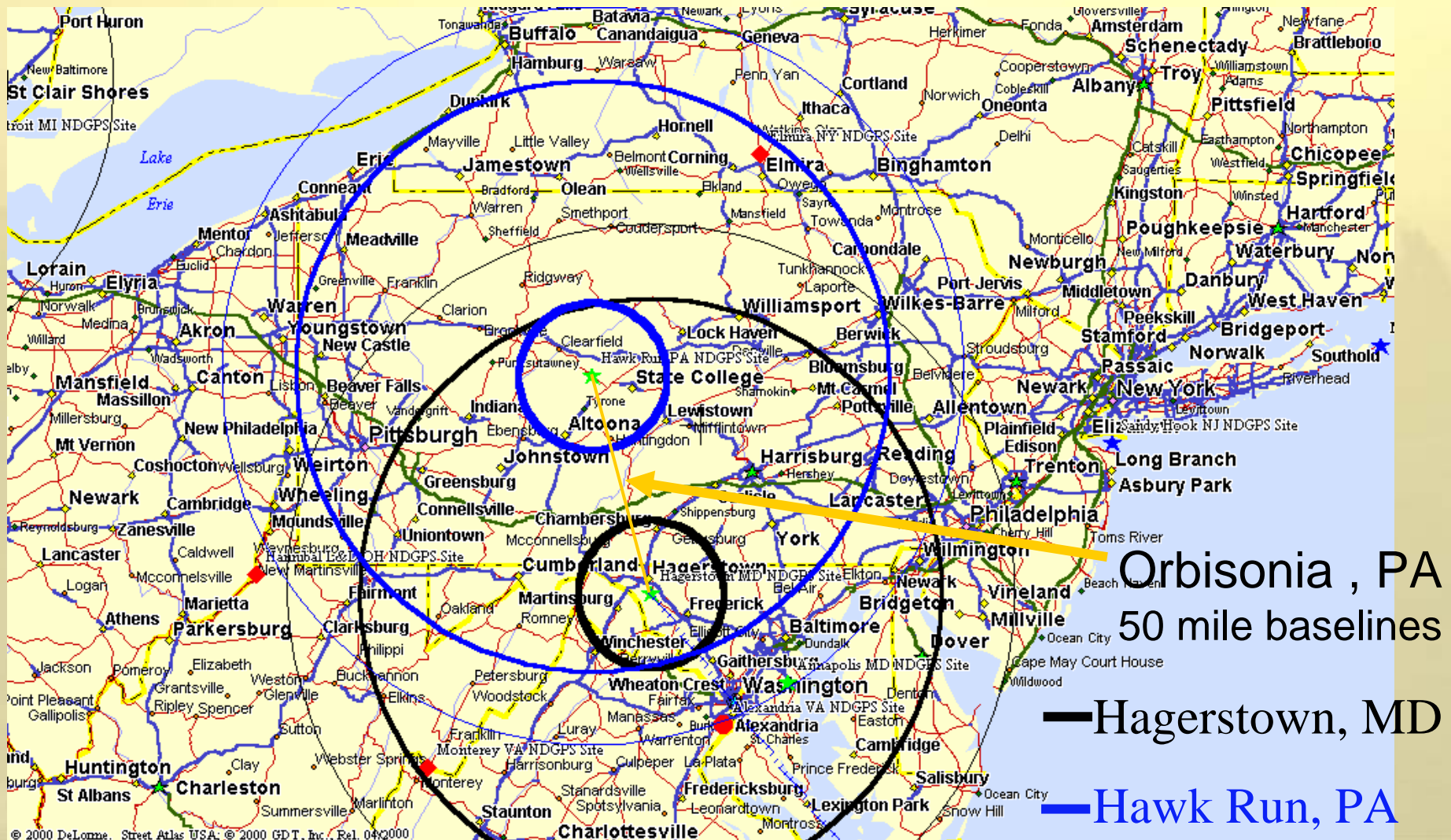


Long Range Single Baseline

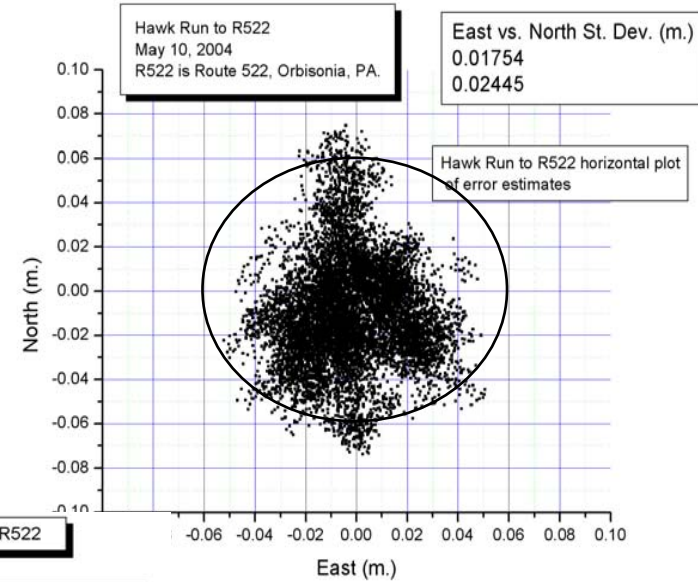
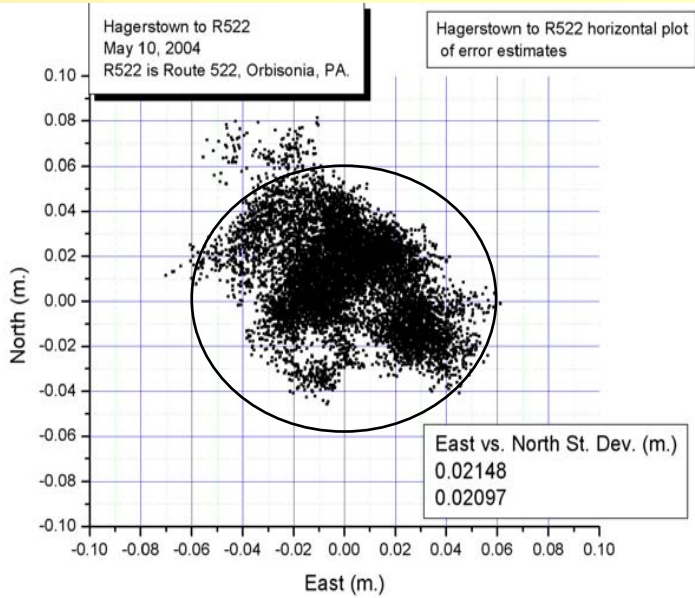
Tangier Island HA-NDGPS Experiment (250 km). Comparison of approximate "truth" geodetic coordinates of mail boat With the real-time solution based upon the HA-NDGPS broadcast. Results are roughly 10-20 centimeters as expected at this great range.



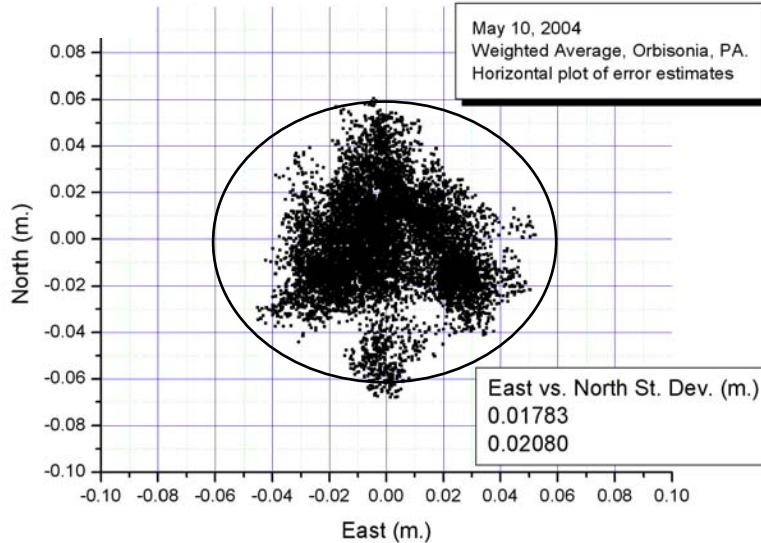
HA-NDGPS Coverage



Multi-Station



Weighted Average of Hagerstown & Hawk Run to R522

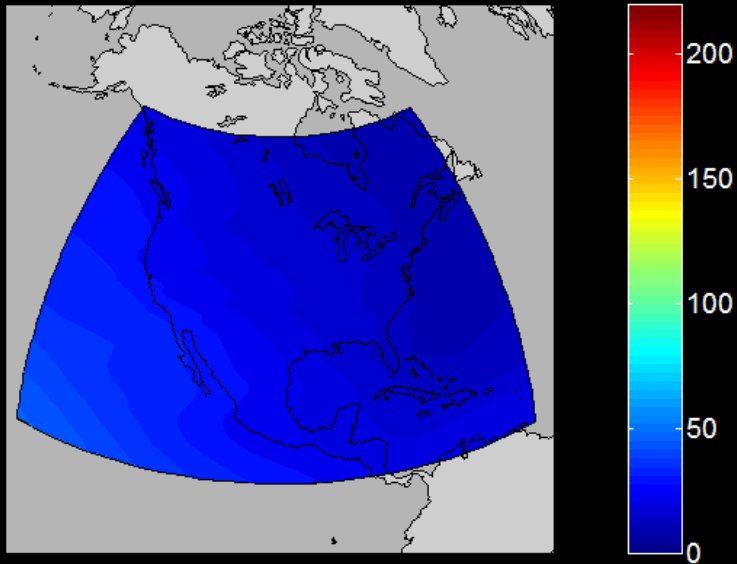


Integrity

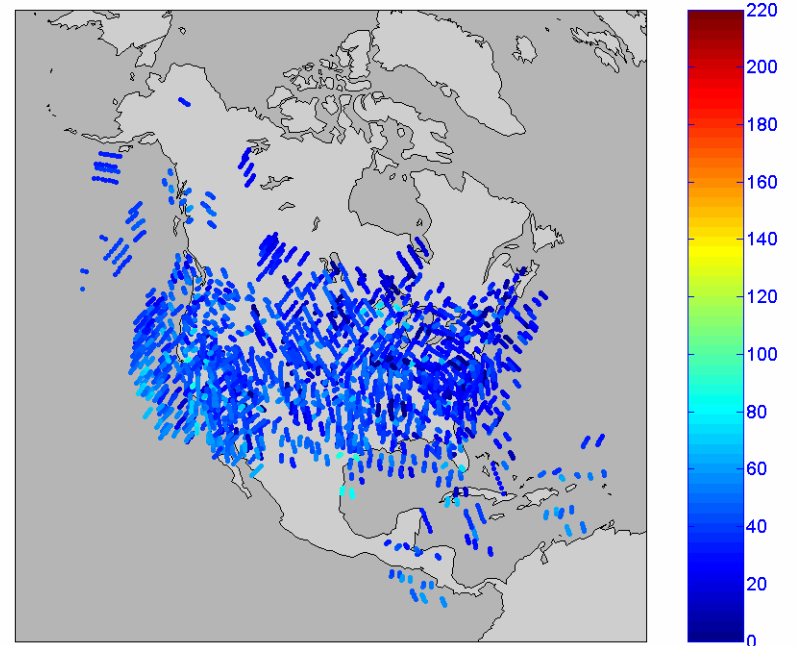
- PreBroadcast
 - Examines Residuals for out of bound results
 - Removes incorrect data before broadcast
- Problem description sent in next epoch
- Time to alarm < 2 seconds

Total Electron Count

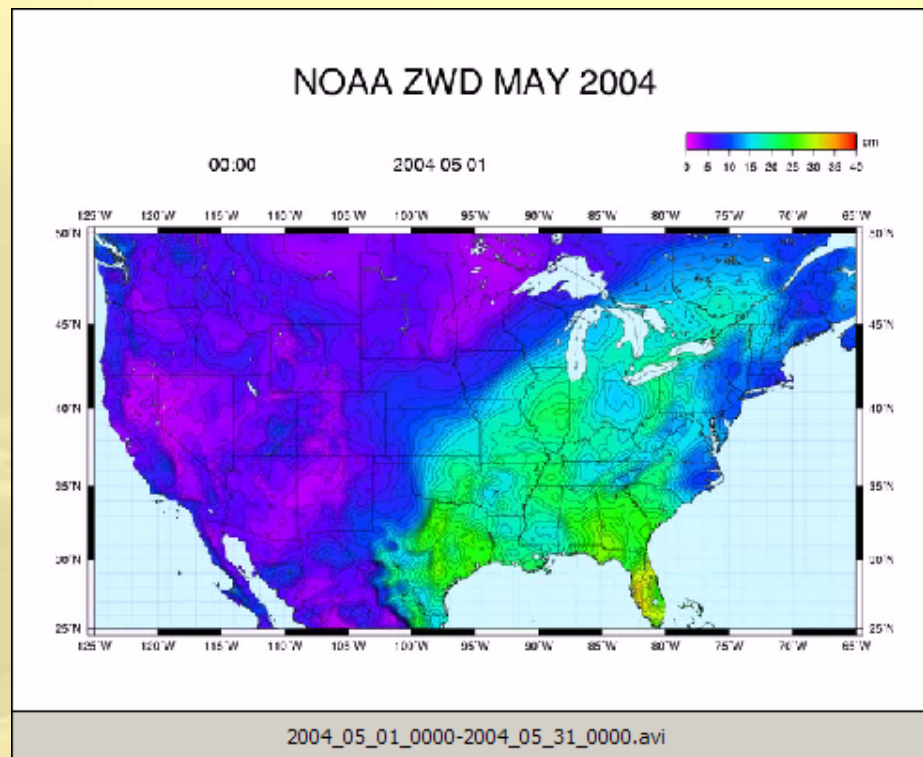
Inversion TEC(TECU) 28-Oct-2003 00:00:00UT



Estimated TEC at 375km shell, 29-Oct-2003 00:00:00UT



Wx Model-Derived Wet Signal Delay Over CONUS



esy, Dr. Sunil Bisnath
formally with USM, now at
Harvard Smithsonian
Astrophysical Observatory

Improved Position Solution

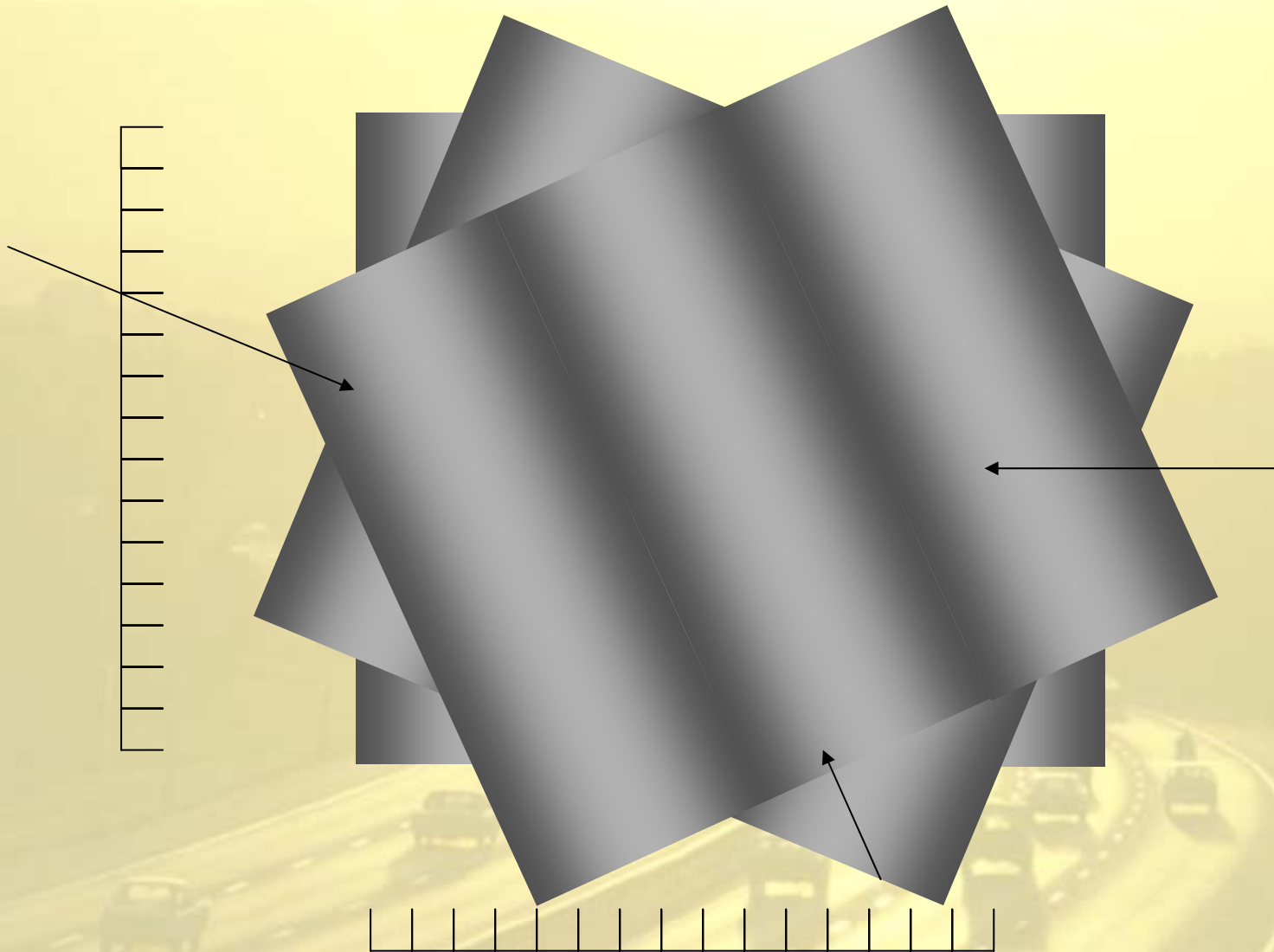
- What You Need:

- Satellite Lock
- Ground based system broadcasting observables
- Accurate Ephemeris
- Accurate Clock data
- Good ionosphere model
- Good Troposphere model
- Integrity Check

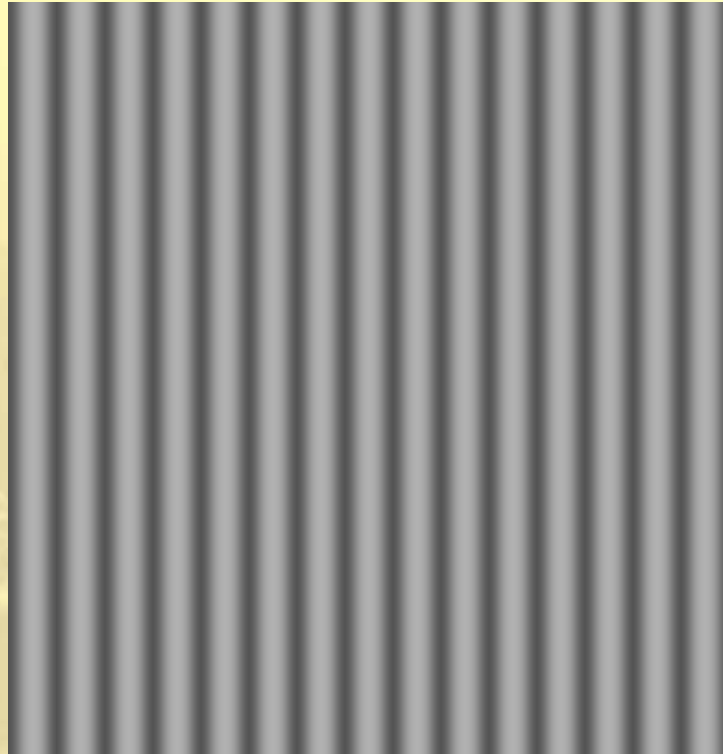
- What You Get:

- Initial 1 to 2 meter code accuracy
- Integer resolution within 2-4 epochs
- Instant Integrity alarm

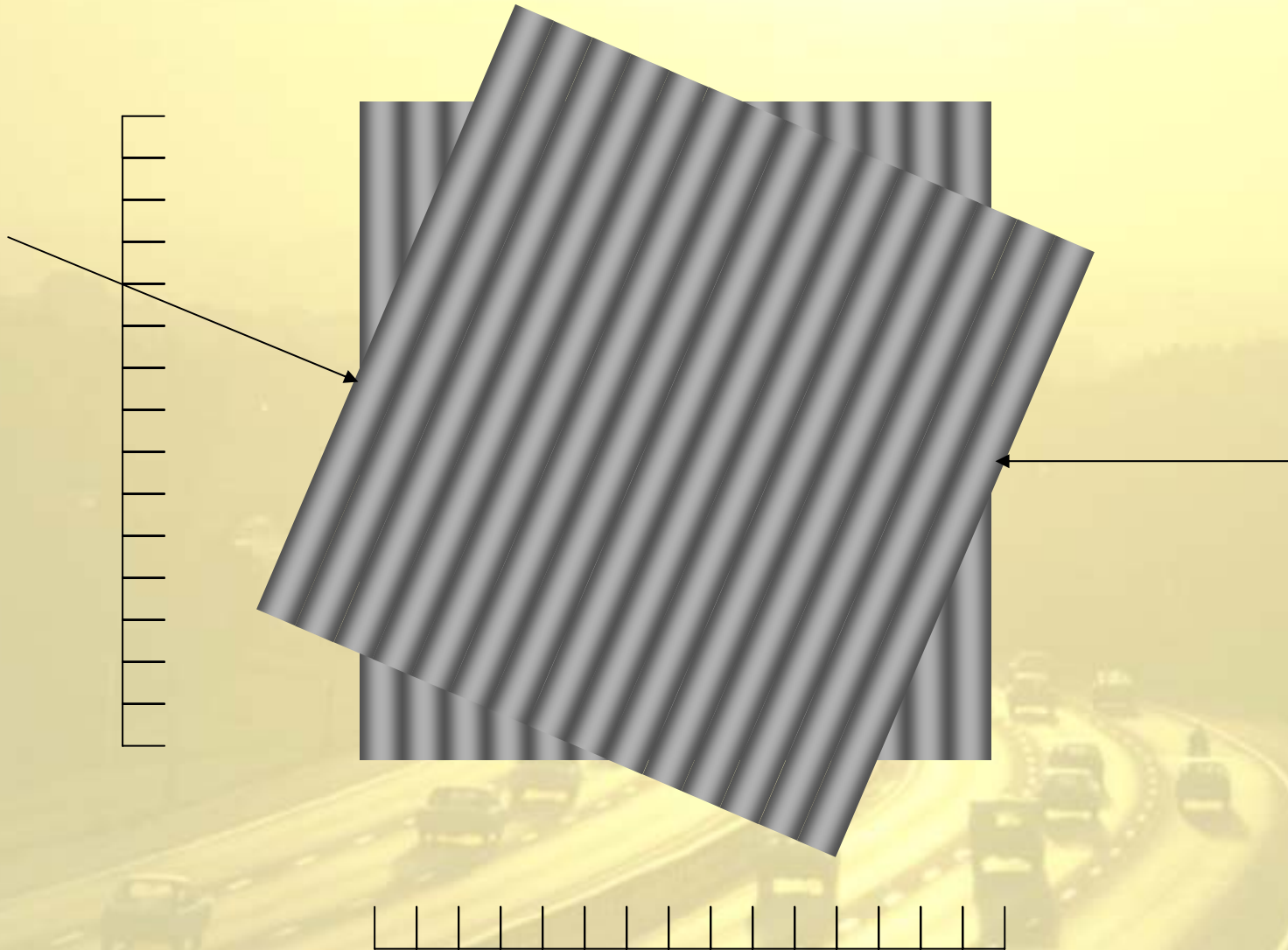
Code Differential Solution



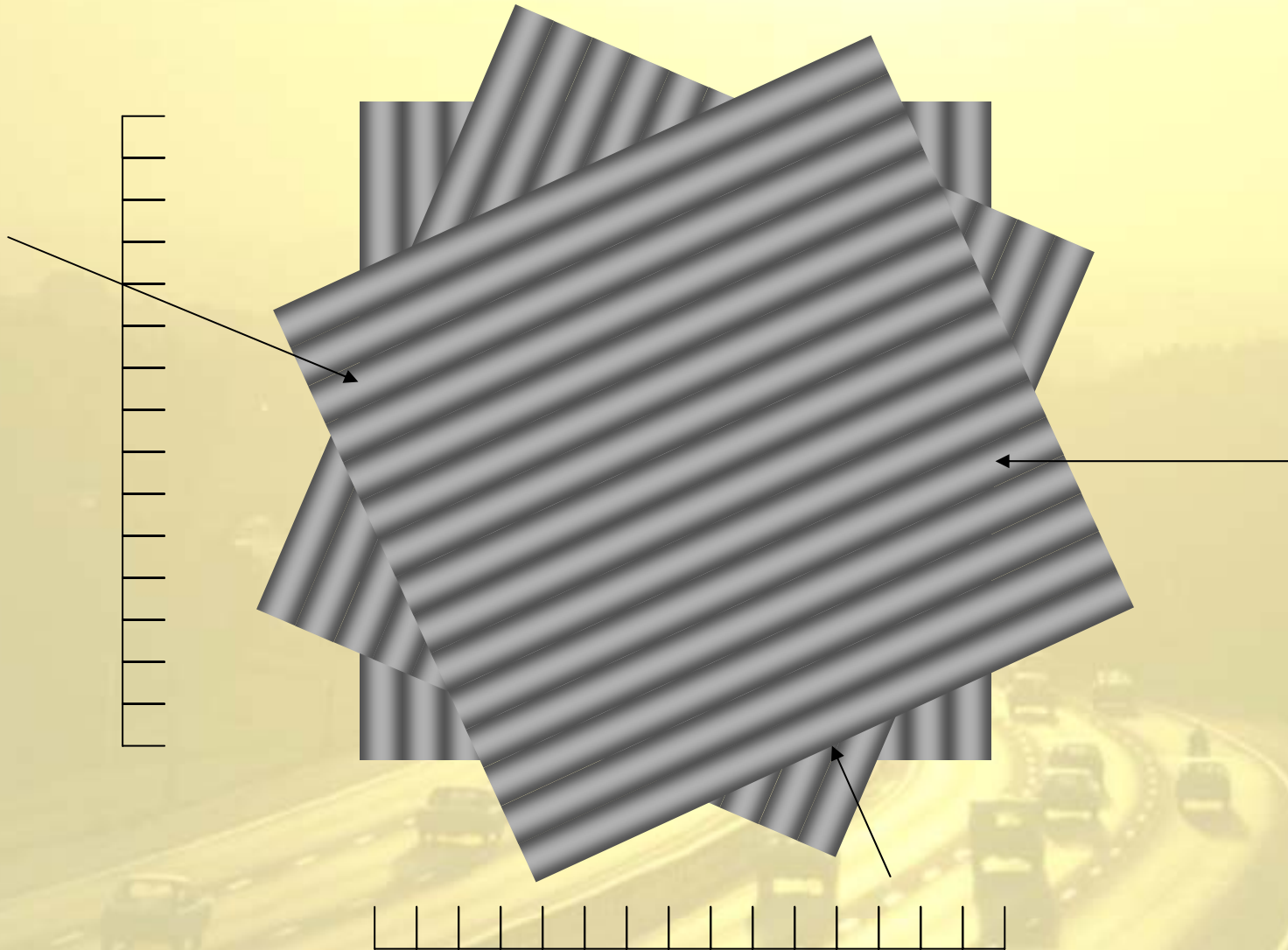
Integer Resolution



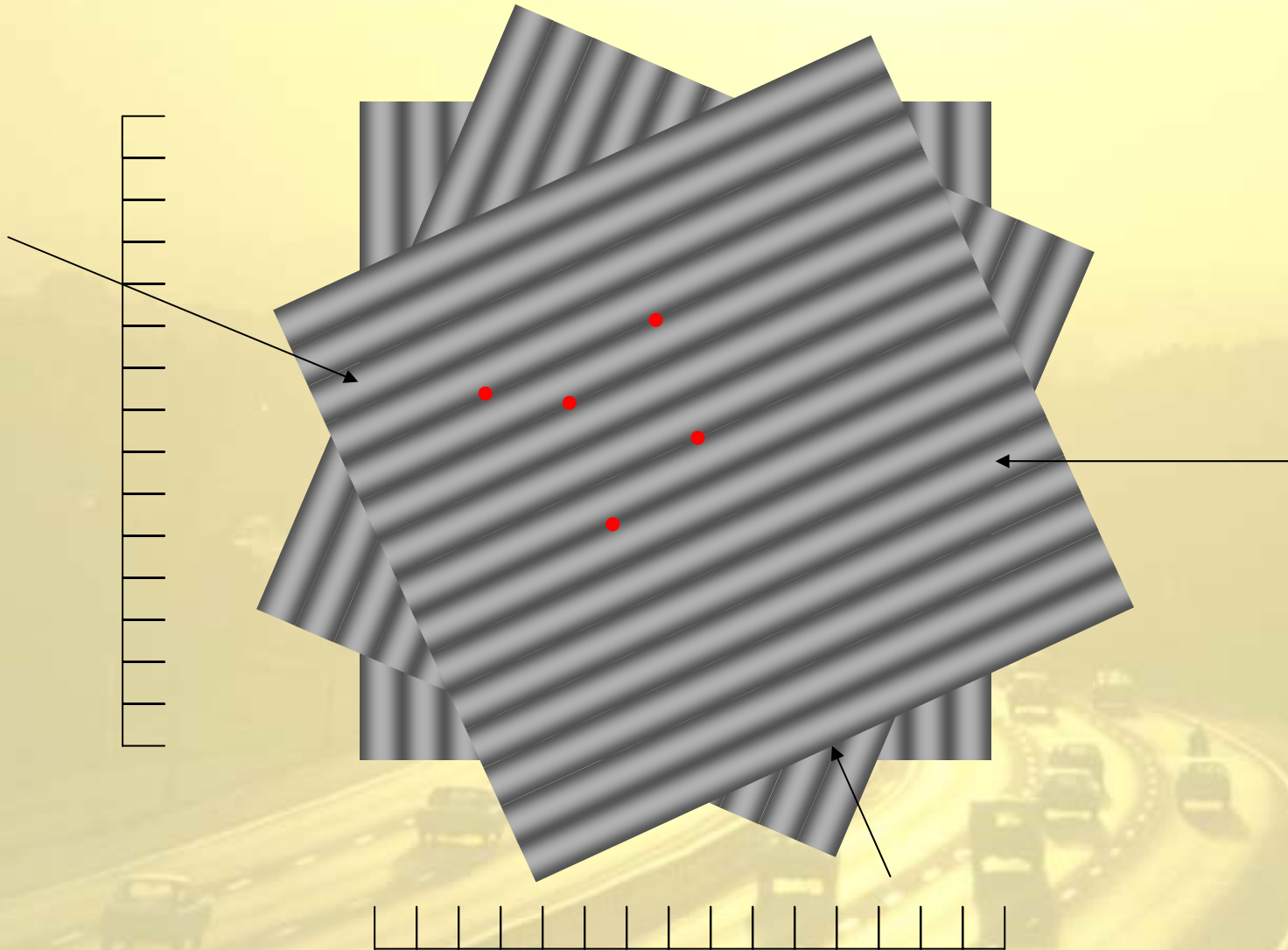
Integer Resolution



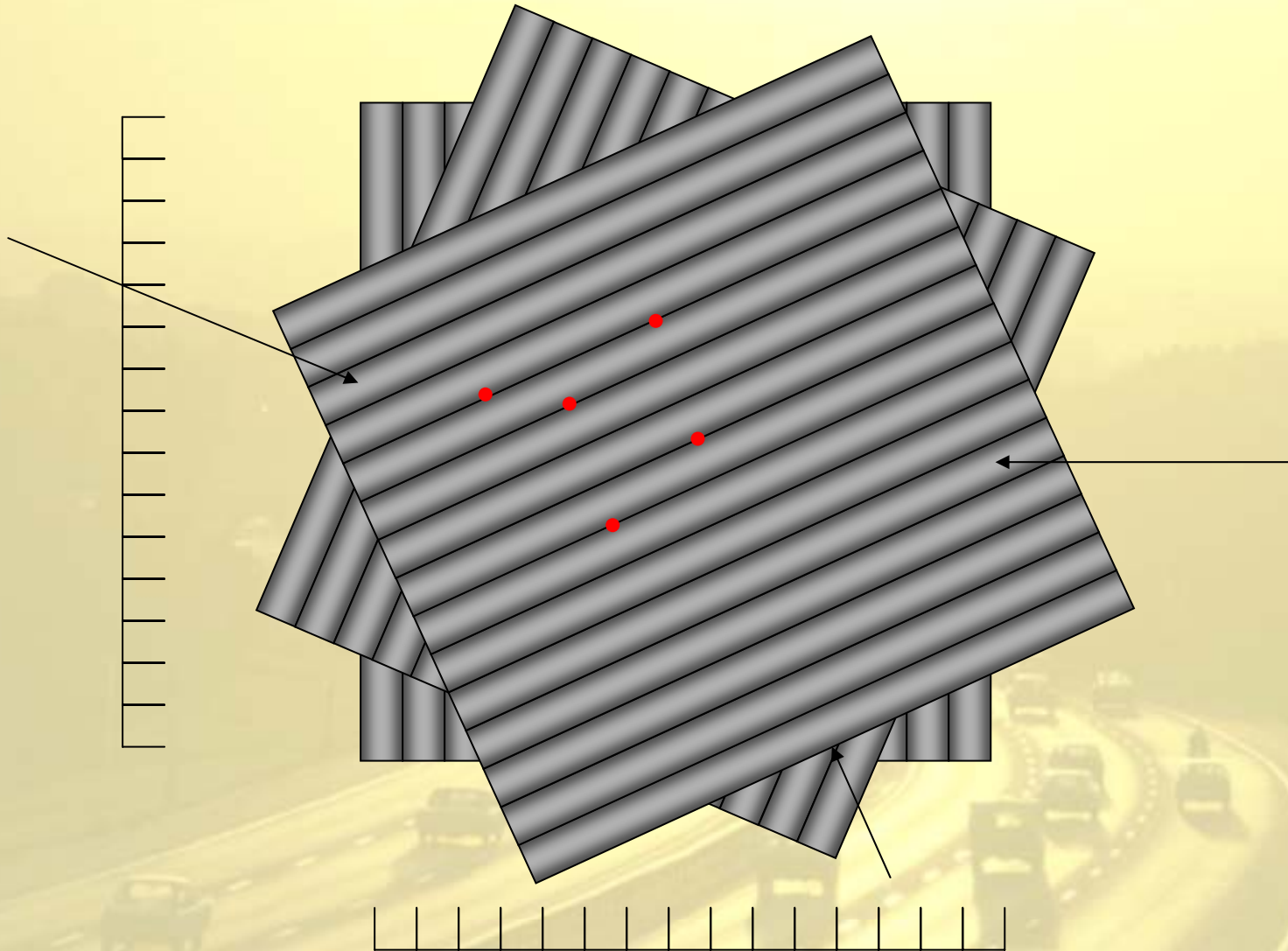
Integer Resolution



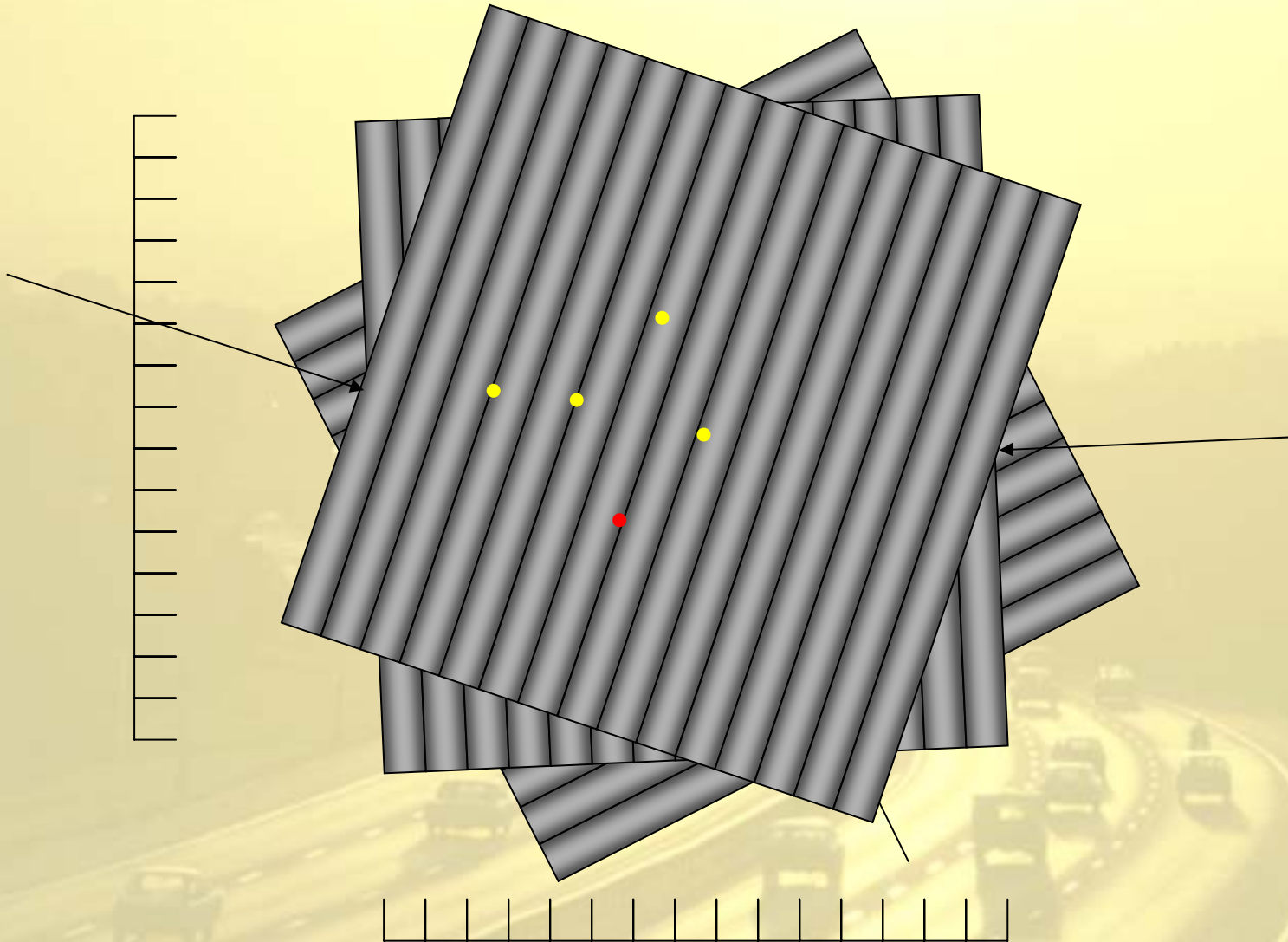
Integer Resolution



Integer Resolution



Integer Resolution



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

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>