GNSS Receiver Use-Case Development

GPS-ABC Workshop VI

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Volpe The National Transportation Systems Center

Advancing transportation innovation for the public good

U.S. Department of Transportation
Office of the Secretary of Transportation
John A. Volpe National Transportation Systems Center

Use Case Outreach

- Worked closely with our federal partners to understand their use case applications
- Conducted outreach with manufacturers who provided use case applications
- Results from these efforts can be located at:
  - Workshop I
  - Workshop II
  - Workshop III
  - Workshop V

Incorporation of Use Cases

- Use cases will be used in conjunction with Interference Tolerance Masks (ITM) and propagation models to provide the power levels that can be tolerated adjacent to GPS/GNSS signals
- Use cases are assembled from DOT's federal partners & industry responses and aggregated by six (6) GPS/GNSS categories:
  - General Aviation [non certified] (GAV)
  - General Location/Navigation (GLN)
  - High Precision & Networks (HPR)
  - Timing (TIM)
  - Cellular (CEL)
  - Space Based (SPB)

Use-Case Summary

Category	Height (feet AGL)		Speed (mph)	Urbanization	Terrain	Antenna Integration	Antenna Orientation
	Min	Max					
GAV	0	40k	920	Urban/Suburban/Rural	Flat/Sloped/Canyon – Open/Impeded - Land/Water	Yes/No	Variable
GLN	0	1,000	600	Urban/Suburban/Rural	Flat/Sloped/Canyon – Open/Impeded - Land/Water	Yes/No	Variable
HPR	0	20,000	180	Urban/Suburban/Rural	Flat/Sloped/Canyon – Open/Impeded - Land/Water	Yes/No	Variable
TIM	0	1000s	100	Urban/Suburban/rural	Flat – Open - Land	No	Fixed
CEL	0	100s	100s	Urban/Suburban/rural	Flat/Sloped/Canyon – Open/Impeded - Land/Water	Yes	Variable
SPB	1,700k	4,300k	16k	n/a	n/a	No	Variable

Selection of Use Case Priorities

EXCOM Letter

". . . without affecting existing and evolving uses of space-based PNT services vital to economic, public safety, scientific, and national security needs."

SPACE-BASED POSITIONING
NAVIGATION & TIMING
NATIONAL EXECUTIVE COMMITTEE

JAN 13 2012

UNITED STATES OF AMERICA

The Honorable Lawrence E. Strickling
Assistant Secretary for Communications and Information
U.S. Department of Commerce
Washington, DC 20230

Dear Assistant Secretary Strickling:

At the request of the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA), the nine federal departments and

The EXCOM Agencies continue to strongly support the President's June 28, 2010 Memorandum to make available a total of 500 MHz of spectrum over the next 10 years, suitable for broadband use. We propose to draft new GPS Spectrum interference standards that will help inform future proposals for non-space, commercial uses in the bands adjacent to the GPS signals and ensure that any such proposals are implemented without affecting existing and evolving uses of space-based PNT services vital to economic, public safety, scientific, and national security needs.

ASHTON B. CARTER
EXCOM Co-Chair
Deputy Secretary of Defense

JOHN D. PORCARI
EXCOM Co-Chair
Deputy Secretary of Transportation

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PNTAB's View: Minimum Criteria for Testing/Evaluation of Interference Potential of High Power Terrestrial Transmitters in Repurposed Radio Bands

1. **Accept and strictly apply the 1 dB degradation** Interference Protection Criterion (IPC) for worst case conditions (This is the accepted, world-wide standard for PNT and many other radiocommunication applications)
2. Verify interference for **all classes of GPS receivers** is below criteria, especially precision (Real Time Kinematic - requires both user and reference station to be interference-free) and timing receivers (economically these two classes are the highest payoff applications – many $B/year)
3. Test and **verify interference for receivers** in **all operating modes** is less than criteria, particularly **acquisition** and **reacquisition** of GNSS signals under difficult conditions (see attachment of representative interference cases)
4. **Focus analysis on worst cases**: use ***maximum*** **authorized transmitted interference** powers and ***smallest-attenuation*** **propagation models** (antennas and space losses) that do not underrepresent the maximum power of the interfering signal (including multiple transmitters)
5. Ensure **interference to emerging Global Navigation Satellite System (GNSS) signals** (particularly wider bandwidth GPS L1C – Galileo, GLONASS), is less than criteria
6. All **testing must include GNSS expertise** and be **open to public comment** and scrutiny.

Why HPR as an Important Use Case?

- EXCOM Priorities
  - Focus on existing uses ✓
  - Vital Needs:
    - Economic ✓
    - Public Safety ✓
    - Scientific ✓
    - National Security ✓
- PNT Advisory Board Priorities
  - Focus on HPR and TIM ✓
  - Focus analysis on most sensitive case ✓
  - Apply the 1 dB degradation ✓
  - Include GNSS ✓

Category	Existing Uses	Vital Needs				Most Sensitive ITM
		Economic	Public Safety	Scientific	National Security	
GAV	✓	✓	✓	✓	✓	
GLN	✓	✓	✓	✓	✓	
HPR	✓	✓	✓	✓	✓	✓
TIM	✓	✓	✓	✓	✓	
CEL	✓	✓	✓	✓		
SPB	✓	✓	✓	✓	✓	✓

Use Case Scenario Focus

Agriculture/Farming

Construction/Infrastructure

Emergency Response

Agriculture/Farming

- Benefits of GPS:
  - Precise operation/auto-steering for tractors, combines and sprayers
  - Non-restrictive operations (e.g. fog and night)
  - Coordinate movements of multiple tractors or other equipment
  - Optimize seed, fertilizer and pesticides placement based on soil conditions and temperature.
  - Precise planting and watering
  - Yield and crop monitoring
- Makes use of augmentation systems:
  - OmniSTAR , StarFire, Terrestar
  - Real Time Kinematic (RTK)

Agriculture/Farming Scenario – Basic Components

Photo courtesy AbeSnap23/ThinkStock

LTE Cellular Tower

Photo courtesy Valio84sl/ThinkStock

Drone/Crop Monitoring

Photo courtesy of John Deere

GPS Guidance System

Photo courtesy of John Deere

High Precision Farming

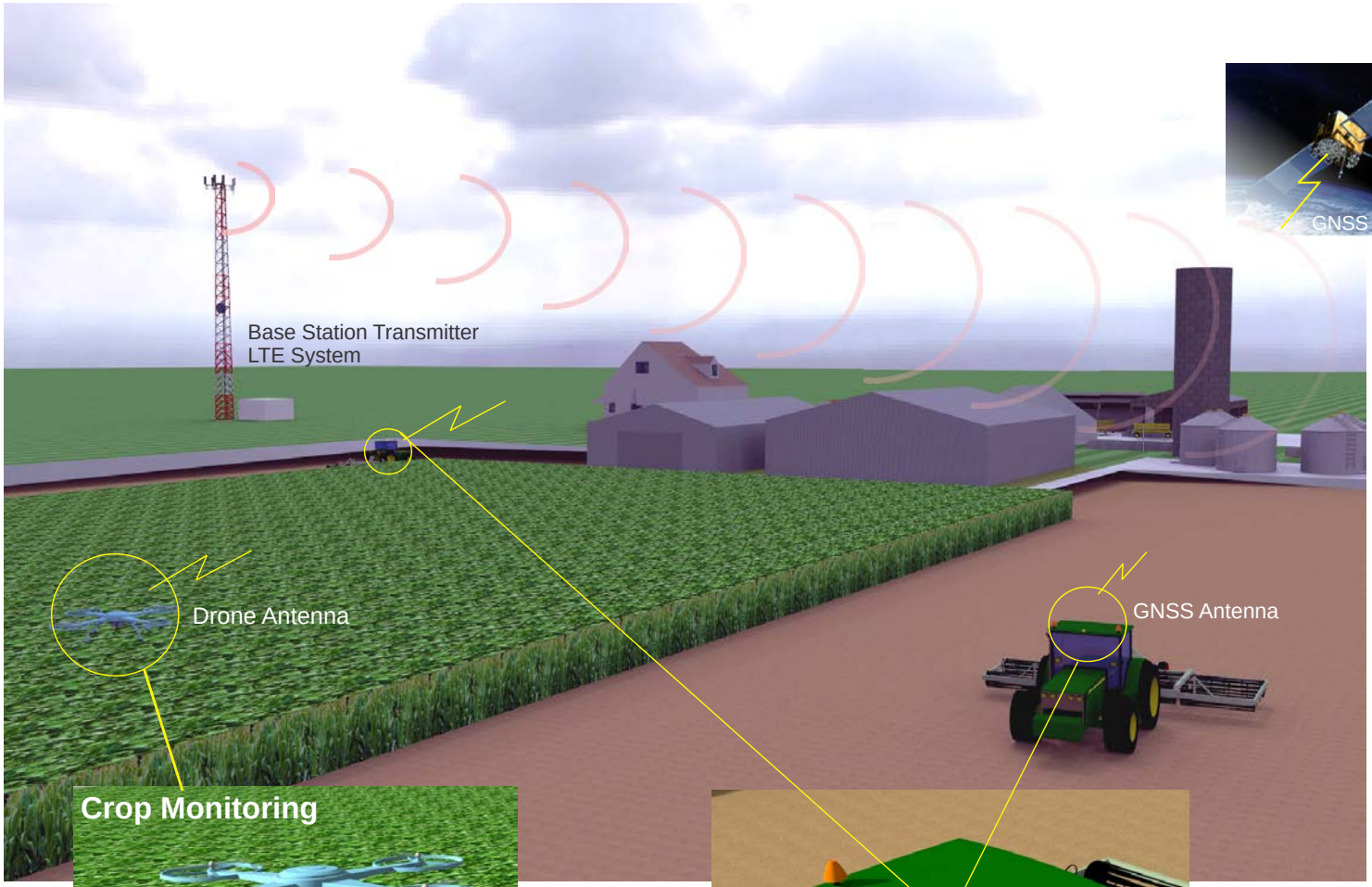
Photo courtesy of John Deere

High Precision Farming

Photo courtesy Bennymarty/ThinkStock

Drone/Crop Monitoring

Agriculture/Farming Scenario



Agriculture/Farming Summary

- Categories included are HPR and GLN/GAV
- Precision Farming (HPR)
  - Vital Needs: Economic
  - Lateral distances down to 10 feet from the base station
  - Vertical heights within 0-20 of feet above the ground
- Crop Health Monitoring (GLN/GAV)
  - Vital Needs: Economic
  - Lateral distances down to 10 feet from the base station
  - Vertical heights up to (and above) the base station height

Construction/Infrastructure

- Benefits of GPS:
  - Precise machine control for many different type of heavy equipment (e.g. dozers, excavators, pavers, scrapers, compactors)
  - Placement of blades/heavy machinery give precise results (less rework)
  - Improved process control through equipment location monitoring
  - Virtual staking (view points on a screen vs. physical stakes)
  - Time saving from traditional surveying
- Surveyor setup (3d geodetic control area) and monitor machine control operations

Construction/Infrastructure Scenarios - Basic Components

Photo courtesy of WSP Canada Inc

GPS HPR receiver used in construction/surveying

Photo courtesy of WSP Canada Inc

GPS HPR receiver used in construction/surveying

Photo courtesy Medvedkov/ThinkStock

Construction/Surveying

Photo courtesy ThinkStock

GPS HPR receiver used in construction guidance

Photo courtesy AbeSnap23/ThinkStock

LTE Cellular Tower

Photo courtesy Kadmy/ThinkStock

Surveying

Construction/Infrastructure Scenario

Construction/Infrastructure (HPR) Summary

- Construction/infrastructure (HPR)
- Vital Needs: Economic
- Lateral distances down to 1 – 2 city blocks from the base station
- Vertical heights up to (and above) the base station height

Emergency Services

- Medical and police personnel are increasingly using GPS to locate patients both during emergencies and regular activities
- Police resource tracking (increased awareness of where their officers are located)
- Drones/UAV/UAS will take on increasing importance in dealing with natural and other disasters/incidents

Emergency Services Scenarios - Basic Components

Photo courtesy Tiero/ThinkStock

Drone/Emergency Response/Disasters

Photo courtesy StockSolutions/ThinkStock

Ankle Bracelet Monitoring

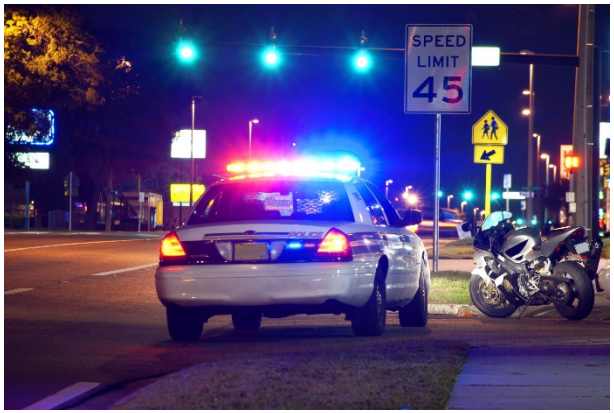


Photo courtesy Mokee81/ThinkStock

Police/Emergency Response/Resource Tracking

Photo courtesy Mrdoomits/ThinkStock

Emergency Response/ Resource Tracking

Photo courtesy AbeSnap23/ThinkStock

LTE Cellular Tower

Photo courtesy ThinkStock

Drone/Emergency Response/Disasters

Emergency Response Scenario

Emergency Response Summary

- Two categories included GAV and GLN
  - UAS/UAV/Drone (GLN/GAV)
  - Emergency Services/Asset Tracking (GLN)
  - Emergency Response/Asset Tracking (GLN)
- Lateral distances down to 10 feet from the base station
- Vertical heights up to (and above) the base station height
- Vital Needs:
  - Public safety / Safety of life
  - National Security

Other Considerations

GPS/GNSS Receiver Modification

- Receiver modification to reduce susceptibility to out of band emissions?
- Many receivers are sealed and modification are complicated if not impossible
- Even if you can modify the receivers, how do identify “all” users?
- May result in loss of augmentation (e.g., Mobile Satellite Service delivered corrections) capability

Photo courtesy Scanrail/ThinkStock

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Photo courtesy Comstock/ThinkStock

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* http://www.deere.com/en_US/docs/html/brochures/publication.html?id=004d03e7#14

** http://www.trimble.com/mappingGIS/pro6-Pro-Series-Receivers.aspx?tab=Features_and_Benefits

Summary

- Every possible use case is not covered - as there are thousands of use cases
- Cases illustrated are applications that happen routinely and can bound the results/impact of base station transmitters
- Inverse and propagation modeling will utilize the height and location limits of the these use case application to determine worst case base station transmit power levels

Questions?