The Volpe Center GPS Adjacent Band Compatibility Program Plan

GPS Adjacent Band Compatibility Workshop
Volpe Center, Cambridge MA

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Approach to DOT GPS Adjacent Band Compatibility Assessment

- Identify forums and provide public outreach to make sure the progress and work are as open and transparent as possible
- Develop an implementation plan that incorporates aspects from the DOT Assessment plan with a near term focus of current GNSS receivers
- Use the workshop as an opportunity to present the proposed implementation work plan (GPS receiver and use case focus) and gain feedback
- Need to protect all GPS applications

Elements of the DOT Assessment Plan

- Defining the Type of application planned for deployment in the adjacent-band
- Determining GPS receiver interference tolerance masks and use cases
  - Current GPS Receivers (Set 1 limits)
  - Modernized GPS/GNSS Receivers (Set 2 limits)
- Determining interaction scenario(s)
- Specifying the adjacent-band application transmitter power limits

DOT GPS Adjacent Band Compatibility Implementation to the Assessment Plan

- Implementation Near Term Goals:
  - Development of Interference Tolerance Masks
  - Development of Interaction Scenarios
  - Current GPS Receivers (Set 1 limits)
  - Specifying the adjacent-band application transmitter power limits

Implementation plan Outline

1. Document GPS use cases
2. Develop representative receiver masks for each application.
   A. Collect receiver specifications and available test data
   B. Develop a generic receiver model. Validate model against collected data and use it to Perform sensitivity analysis on receiver specs.
   C. Develop a plan for testing of GPS receivers
3. GPS Interaction scenarios and antenna characteristics
4. Collect future and multi-channel GNSS receiver specifications

1- Document Use Cases

- Compile use cases for GPS receiver categories identified in the TWG Report 2011 (Both augmented/unaugmented devices included in each category):
  - Aviation (Addressed separately by the FAA Plan)
  - Cellular
  - General location/navigation
  - High precision
  - Timing
  - Networks
  - Space-based

1- Document Use Cases (Cont'd)

- Identify characteristics of use cases. For each application determine:
  - Most likely geographic and topographic characteristics.
  - Range of heights for GPS receiver antenna.
  - Typical GPS receiver antenna pattern(s)
  - Expected Range of antenna boresight inclinations from zenith . This can be used in probabilistic analysis of interference
  - Mobility: Stationary vs. mobile (typical speeds).
- Solicit information from various agencies on selection of representative receivers within each category
- Gather feedback from various agencies on the use cases parameters

2A- Develop Receiver Masks – Data Collection

- Collect test data and specifications from GPS receiver manufacturers.
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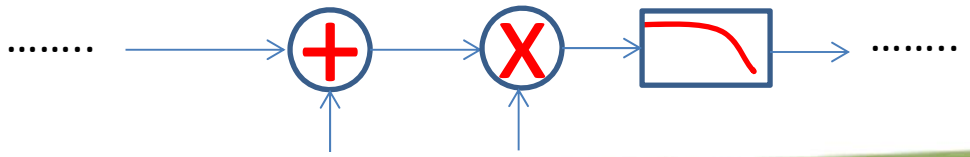
  - Define the type of test data needed as well as the most relevant receiver specs for the analysis (especially in absence of test data).
  - Possibly Establish an ongoing working group involving the receiver manufacturers and industry stakeholders to update them on the current state of the analysis and get feedback
  - Collect data provided by GPS receiver and antenna manufacturers
  - Follow up and interact with manufacturers to obtain additional information as well as resources they are willing to contribute for future testing

2B- Develop Receiver Masks – Analysis and Modeling

- Compile the manufacturer provided test data (such as 1 dB SNR Degradation mask vs. frequency). Determine the data sets are relevant to a particular application or use case

- Develop a single channel receiver model with the following objectives:
  - Perform sensitivity analysis for receiver parameters to create uncertainty bounds around masks manufacturers might have provided to get a more confident representation of acceptable interference level for a given use-case
  - Validate models against provided 1 dB masks (if any) and use it to extrapolate to other limits (Loss of lock, broadband sources…)
  - The representative receivers for which no masks are available but specs are provided the model can help get initial masks with uncertainty bound.
  - Investigate the effects of the different modulation schemes when the source might not be well represented by a wide band noise (such as handsets)
  - Project the relative performance of future receivers and investigate tradeoffs between spectral selectivity (to increase SNR) and reduced accuracy. As well as expected future noise performance etc…



2C- Develop a Test Plan

- Review available information on previous receiver testing effort
- Expand on the previous testing approach to cover a wider frequency range and assess the level of assistance expected from manufacturers and stake holders
- Outline the testing procedure and equipment needed.
  - Testing procedure and equipment needed for wired tests
  - Same for wireless tests (anechoic chambers test). Primarily for receivers for which the antenna input port is not accessible
- Identify and begin coordination with the testing facilities

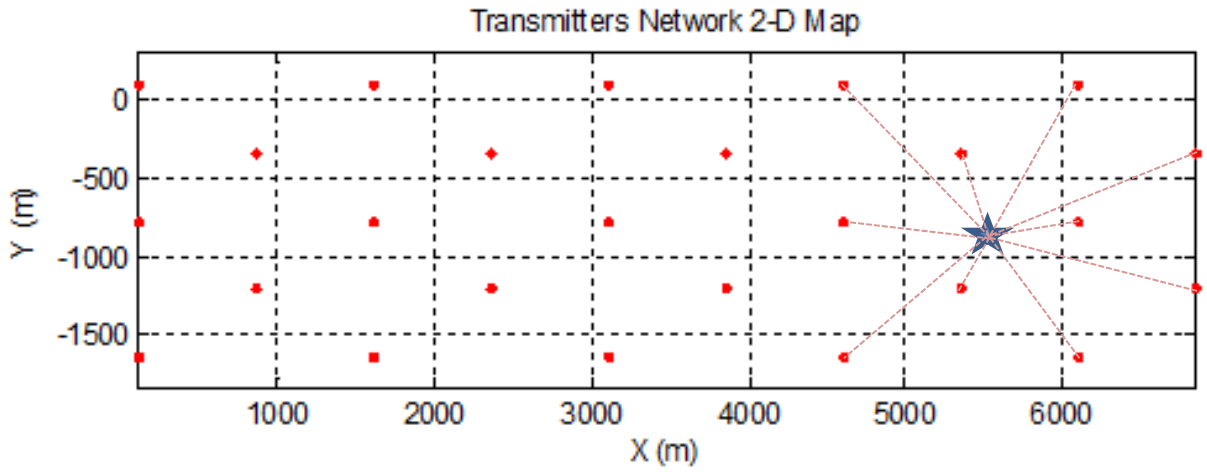
3- GPS Interaction Scenarios and Antenna Characteristics

- Identify adjacent band use cases:
  - Deployment scenarios: Mobile vs. fixed emitters, height range
  - Modulation type, Bandwidth
  - Pulsed (such as a radar system) or more continuous ATC network.
  - Antenna characteristics: antenna pattern, antenna gain, efficiency

- All feedback to date indicates that an LTE type network is the most likely application to target the adjacent band. This will therefore be the primary focus of the analysis pending additional feedback.

3- GPS Interaction Scenarios and Antenna Characteristics (Cont'd)

- Implement a transmit network model including: base stations layout, network parameters and antenna characteristics.
- Implement deterministic and probabilistic propagation models
- Calculate RFI levels in a coverage area of interest.



3- GPS Interaction Scenarios and Antenna Characteristics (Cont'd)

- Define metrics to determine acceptable interference levels given a known receiver mask (with uncertainty bounds).
  - Probability of harmful interference level vs. location from nearest interfering source

- Within the parameters of an interaction scenario optimize a network for compatibility (that is, investigate the possibility of best case scenario): Trade offs of network density (base station separations) and transmit powers, antenna pattern and tilt level among others…

4- Collect Future and Multi-Channel GNSS Receiver Specifications

- Perform literature search on modernize GPS and future Multi GNSS receivers
- This effort is expected to be a combination of modeling and testing with more emphasis on the modeling and analysis in the absence of actual receivers to test.
- Obtain information from receiver manufacturers and/or through the working group as well as subject matter experts on the future of the receiver architecture, filtering, oscillators and antenna technology to guide the modeling-based assessment
- Extend the test plan and perform testing as these new receivers become available.

Potential Issues to Address Going Forward

- Obtaining sufficient input on receiver use cases ← Involving agencies, receiver manufacturers and stake holders early on
- Identify appropriate public forums to for each receiver type to vet the analysis inputs and results ← Possibly Establish a Working Group
- Consensus on defining the type of adjacent band application(s) to analyze ← In absence of additional input, NTIA guidance is to assume and LTE type application, Model can be extended to look at other applications when such need becomes necessary
- Obtaining common agreement on the representative receivers for each type ← Will be work in progress
- Obtaining sufficient test and analysis results to determine the performance of each representative receiver ← First Partial mitigation via modeling and sensitivity analysis. Second Partial mitigation: Develop and execute the test plan for select receivers.
- Reaching agreement on common antenna characteristics ← In absence of input from manufacturers use what is available in literature and later on perform antenna testing
- Metric definition on what is considered harmful interference for each receiver type
- Agreement on the interaction model: propagations and aggregation approach
- Obtaining input on Identifying and addressing other potential sources of interference

← This is expected to be part of the ongoing WG discussions

Questions?