DOT PNT Update:

Complementary PNT Demo
GPS Civil Monitoring Performance Spec

Dr Andrew Hansen

Civil GPS Signal Interface Committee
21-22 Sep 2020
DOT PNT Update (Cont.)

Overview

• Complementary PNT Technology Demonstration
• GPS Civil Monitoring Performance Specification, 3rd Ed.
Congressional Motivation on GPS Backup

• Sequential Legislation on Backup/Complementary PNT Service
  • Needs established for PNT: **FY17 NDAA Section 1618**
  • Demonstrate PNT technologies: **FY18 NDAA Section 1606**
  • Procure Complementary PNT system(s): **National Timing Resilience and Security Act of 2018**, places responsibility on DOT, no appropriation & two year timeline (HR 3409, Section 210)

• Volpe Center Completed PNT Technology Demonstration
  • NASA LaRC: two weeks, six vendors, eight scenarios, VIP demo day
  • JBCC: two weeks, five vendors, same eight scenarios + offset eLoran scenario (Wildwood LSU)
  • Government reference system based on GPS + atomic frequency standard
## PNT Technology Vendor Participation

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<tr>
<td>Echo Ridge LLC</td>
<td>LEO commercial S-band (2483.5 – 2500 MHz)</td>
<td>LaRC</td>
<td>N/A</td>
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<td>X</td>
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<tr>
<td>Hellen Systems, LLC</td>
<td>eLoran terrestrial RF (90-110 kHz)</td>
<td>JBCC</td>
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<td>NextNav LLC</td>
<td>UHF terrestrial RF (920-928 MHz)</td>
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<td>OPNT B.V.</td>
<td>fiber optic time service (white rabbit PTP)</td>
<td>LaRC</td>
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<td>Satelles, Inc.</td>
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<td>Serco Inc.</td>
<td>R-mode terrestrial RF (283.5-325 KHz)</td>
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<td>Seven Solutions S.L.</td>
<td>fiber optic time transfer (white rabbit PTP)</td>
<td>LaRC</td>
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<td>Skyhook Wireless, Inc.</td>
<td>802.11 terrestrial RF (900 MHz, 2.4 GHz, &amp; 5 GHz)</td>
<td>LaRC</td>
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<td>TRX Systems, Inc.</td>
<td>UWB &amp; IMU map matching (3.1-5 GHz)</td>
<td>LaRC</td>
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<td>UrsaNav Inc.</td>
<td>eLoran terrestrial RF (90-110 kHz)</td>
<td>JBCC</td>
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<td>GPS (stand-alone)</td>
<td>MEO government L-band (1575.42 and 1227.60 MHz)</td>
<td>All</td>
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Government Host Platforms, 2D and 3D
Government Reference System Performance

Reference System Timing Performance
Using GPS + Cesium Frequency Standard

Reference System Positioning Performance
Using GPS RTK
Example Dynamic Positioning Scenarios
Measures of Effectiveness (14): Capability Subset (9) – more quantitative

1. Technical Readiness: System (TRL 6-9)
2. Technical Readiness User Equipment (TRL 6-9)
3. Timing and Positioning Accuracy (meters, nanoseconds)
   • Largest 95% bound across the runs in a scenario
4. Spectrum Protection (protected, owned, leased, shared)
5. Service Deployment Effort (low, medium, high)
6. Service Coverage per Infrastructure
   • Count, e.g. number of transmitters, per unit coverage area
7. Service Synchronization (UTC, cascade, self-synchronizing)
   • Timing: UTC, cascade, self-synch
8. PNT Signal Robustness (strong, weak)
   • Emitted power limits, propagation loss, environments
9. Service Resilience (fail-safe, -over, -soft, -hard)
   • System response to changing or off-nominal operating conditions
10. PNT Distribution Mode (terrestrial RF, orbital RF, fiber, database)
   • Basic indicator/qualifier on information security

11. Interoperability (high, low)
   • Common platform, in-band/out-of-band, layered components
   • Compatibility with GPS user equipment

12. PNT Information Security (low, medium, high)
   • Authentication, encryption, open
   • Broadcast, point-to-point, controlled access, monitoring

13. Time to Implement Service (short, medium, long)
   • Infrastructure, standards, equipage

14. System/Service Longevity (short, medium, long)
   • Operational life of infrastructure
   • Compatibility with other PNT services & standards
   • Spectrum policy stability
Summary FY18 NDAA PNT Demonstration

- Completed PNT technology demonstration
  - NASA LaRC: two weeks, six vendors, eight scenarios, VIP demo day
  - JBCC: two weeks, five vendors, same eight scenarios + offset eLoran scenario (Wildwood LSU)
  - Government reference system based on GPS + atomic frequency standard + data collection
- Draft report describes scenarios, reference system, PNT technologies, and data analysis
- Demonstration output products:
  - Technical report with PNT roadmap and technology measures of effectiveness
  - Support to PNT strategy and interagency coordination on Complementary PNT

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<thead>
<tr>
<th>Date</th>
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<tr>
<td>Feb 19</td>
<td>Team Formed</td>
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<tr>
<td>Mar/Apr 19</td>
<td>Industry Round Table</td>
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<td>Jun 19</td>
<td>Vendor RFI</td>
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<td>Aug 19</td>
<td>FBO Rapid Acq</td>
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<td>Oct 19</td>
<td>Vendor Contract Award</td>
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<tr>
<td>Dec 19</td>
<td>Scenarios &amp; Field Sites Finalized</td>
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<td>Mar 20</td>
<td>Dry-run &amp; Demonstration</td>
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<td>May 20</td>
<td>Internal Data Analysis</td>
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<td>Aug 20</td>
<td>PNT EXCOM Briefing</td>
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<td>Interagency Coord</td>
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GPS Civil Monitoring Performance Specification

- GPS CMPS 3rd Ed. (Aug 2020) published on GPS.GOV
  - Goal of the document is to itemize specifications for all US Government public GPS commitments
- Motivating event was publication of GPS SPS Performance Standard 5th Ed. (Apr 2020)
- Additional events
  - GPS interface specifications, e.g. GPS IS 200, GPS IS 705, etc. have been updated multiple times
  - Detailed review of the CMPS 2nd Ed. exposed some ambiguous specifications
  - New understanding of verification needed to ensure each specification
  - Clarified interpretation of monitoring requirement for OCX contractor engagement
- Refined implementation of GPS annual reports on SPS PS from the GPS Enterprise
CMPS 3rd Ed. Changes from 2nd Ed. (2009)

- SPS PS Update (5th Ed., April 2020)
  - Multi-frequency combination of open signals (L1 C/A, L2C, L5)
  - New standards: Average Velocity, Constellation Average URE, Psat & Pconst
  - Changes to accuracy and availability standards (URE, UTCOE, Positioning)
  - Amended NANU notification standard (prior notification 95%)
- IS-GPS Updates
  - IS-GPS-200, -705, -800: timing accuracy
  - ICD-GPS-240: addition of SOF file
- Removal of untestable and cost-prohibitive requirements
- Proposed changes to monitoring detection/reporting times
- Numerous editorial changes
Questions?

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