

DOT PNT Update:

Complementary PNT Demo

GPS Civil Monitoring Performance Spec

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Civil GPS Signal Interface Committee

21-22 Sep 2020



U.S. Department of Transportation

Volpe Center

Advancing transportation innovation for the public good

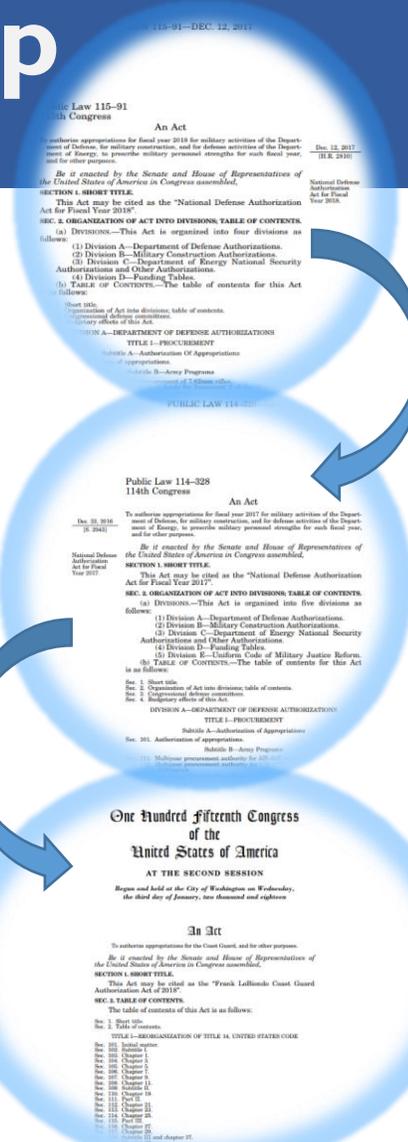
DOT PNT Update (Cont.)

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

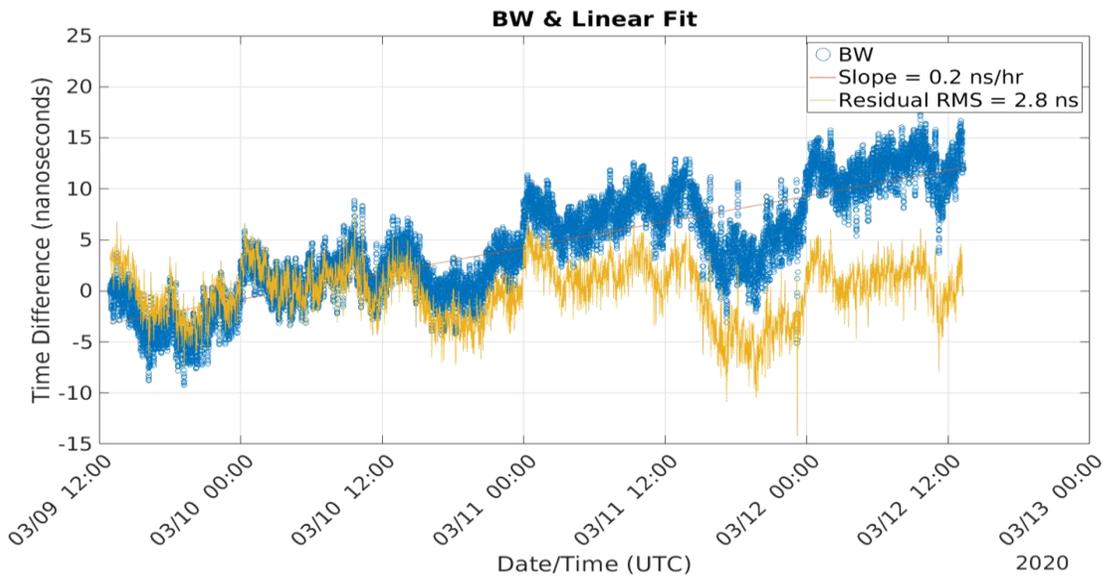
Vendor	PNT Technology	Demo Site	72-Hr Bench Static Timing	Static Outdoor Timing	Static Indoor Timing	Static Basement Timing	Reference Station Offset (eLoran Timing)	Dynamic Outdoor Positioning with Holds	Static Outdoor Positioning	Static Indoor Positioning	Airborne Positioning
Echo Ridge LLC	LEO commercial S-band (2483.5 – 2500 MHz)	LaRC					N/A	X			
Hellen Systems, LLC	eLoran terrestrial RF (90-110 kHz)	JBCC	X			X	X				
NextNav LLC	UHF terrestrial RF (920-928 MHz)	LaRC	X	X	X	X	N/A	X	X	X	X
OPNT B.V.	fiber optic time service (white rabbit PTP)	LaRC	X				N/A				
PhasorLab Inc.	802.11 terrestrial RF (2.4 GHz)	JBCC	X	X	X		N/A	X	X		X
Satelles, Inc.	LEO commercial L-band (1616-1626.5 MHz)	JBCC	X	X	X	X	N/A		X		
Serco Inc.	R-mode terrestrial RF (283.5-325 KHz)	JBCC					N/A	X	X		
Seven Solutions S.L.	fiber optic time transfer (white rabbit PTP)	LaRC	X				N/A				
Skyhook Wireless, Inc.	802.11 terrestrial RF (900 MHz, 2.4 GHz, & 5 GHz)	LaRC					N/A	X	X	X	X
TRX Systems, Inc.	UWB & IMU map matching (3.1-5 GHz)	LaRC					N/A	X	X	X	
UrsaNav Inc.	eLoran terrestrial RF (90-110 kHz)	JBCC	X		X	X	X				
GPS (stand-alone)	MEO government L-band (1575.42 and 1227.60 MHz)	All	X	X			X	X	X		X

Government Host Platforms, 2D and 3D

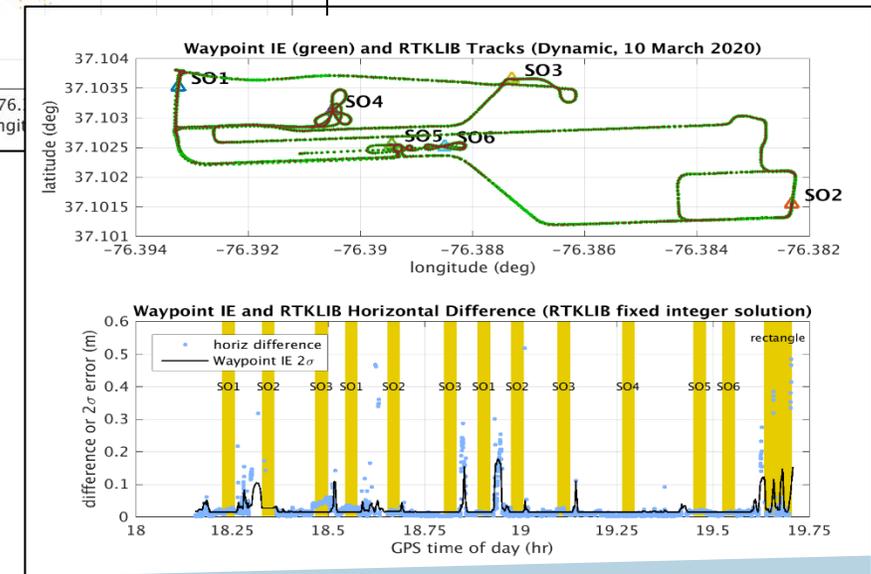
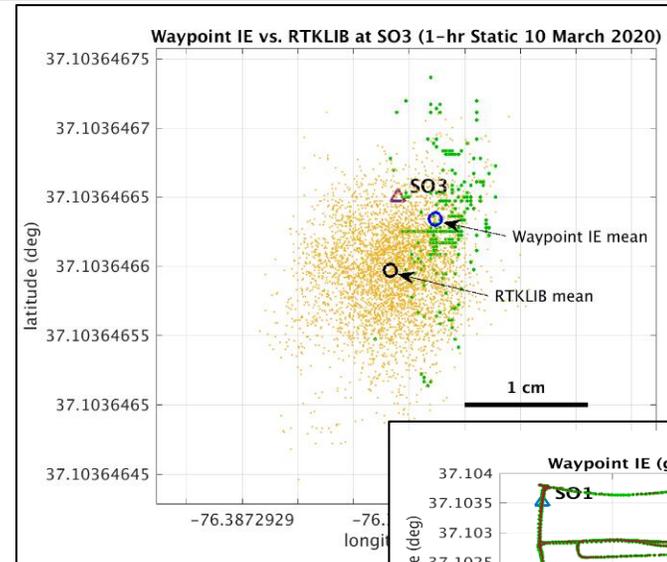


Government Reference System Performance

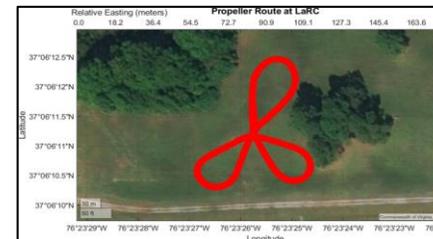
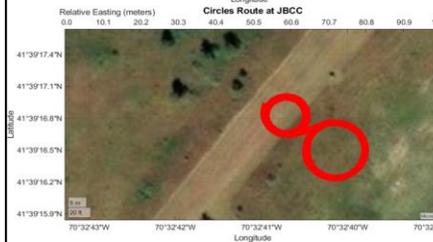
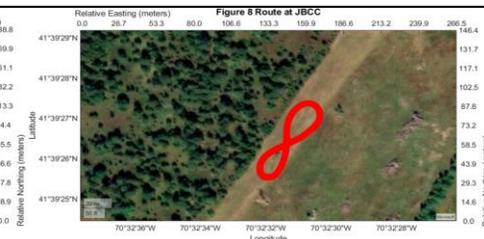
Reference System Timing Performance
Using GPS + Cesium Frequency Standard



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

Measures of Effectiveness (14): Suitability Subset (5) – more qualitative

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)

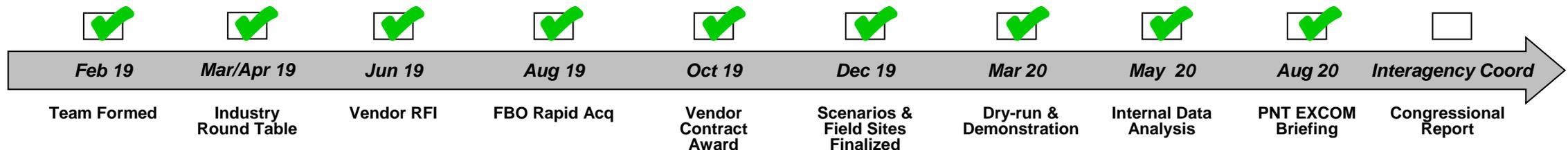
- Infrastructure, standards, equipage

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



GPS Civil Monitoring Performance Specification

- GPS CMPS 3rd Ed. (Aug 2020) published on GPS.GOV
<https://www.gps.gov/technical/ps/2020-civil-monitoring-performance-specification.pdf>
 - 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)
<https://www.gps.gov/technical/ps/2020-SPS-performance-standard.pdf>
- 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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