NATIONAL TIMING RESILIENCE and SECURITY ACT
ROADMAP to IMPLEMENTATION

United States Department of Transportation
Report to Congress

January 2021

1.0 Executive Summary

The Frank LoBiondo Coast Guard Authorization Act of 2018 (P.L. 115-282; December 4, 2018) includes Sec. 514, "Backup National Timing System", also known as the "National Timing Resilience and Security Act of 2018". This Act requires the Secretary of Transportation to develop, construct, and operate a land-based backup timing system within two years, with a 20-year operational life, subject to the availability of appropriations.

While not an implementation plan, this report describes a roadmap to achieving this objective, leveraging the joint technical work conducted by the Departments of Transportation (DOT), Defense (DOD) and Homeland Security (DHS) over several years, and most recently in response to the requirements of the National Defense Authorization Acts (NDAA) for FY 2017 and FY 2018. Section 1618 of the FY 2017 NDAA (P.L. 114-328; December 23, 2016) requires DOD, DHS and DOT to "conduct a study to assess and identify the technology-neutral requirements to backup and complement the positioning, navigation, and timing capabilities of the Global Positioning System for national security and critical infrastructure", and to conduct an analysis of alternatives to determine the "best mix" of technologies.

Section 1606 of the NDAA for FY 2018 (P.L. 115-91; December 12, 2017) directs the Secretaries of DOD, DOT and DHS "to jointly develop a plan for carrying out a backup GPS capability demonstration . . . based on the results of the study conducted under section 1618" of the FY 2017 NDAA.

1.1 Reporting Requirement

The goal of P.L.115-282 is to reduce critical dependency on, and provide a complement to, GPS; and to ensure availability of uncorrupted and non-degraded timing signals, especially for national security and critical infrastructure purposes. The National Timing Resilience and Security Act requires "Not later than 180 days after the date of enactment of the National Timing Resilience and Security Act of 2018, the Secretary of Transportation shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives a report setting forth the following:

> (A) A plan to develop, construct, and operate the system required by subsection (a).
>
> (B) A description and assessment of the advantages of a system to provide a follow-on complementary and backup positioning and navigation capability to the timing component of GPS."

1.2 Key Elements of Roadmap to Implement Section 1618 of the FY 2017 NDAA, Section 1606 of the NDAA for FY 2018, and the National Timing Resilience and Security Act

- DOT-led Industry Roundtables: March - April 2019
- GPS Backup/Complementary PNT Demonstration Request for Information (RFI): May 2019
- FY'17 NDAA Report to Congress on Technology Neutral Requirements: April 2020

- Demonstration Plan and PNT Use Case Scenarios: April – November 2019[1]
- The DOT/OST-R/Volpe Center issued a Request for Quotation RFQ, titled Backup Global Positioning System (GPS) Technical Consulting Services—Technology Demonstration. – September 2019
- Evaluated Technology Demonstration proposals and awarded contracts – October 2019
- Engagement with PNT technology vendors to establish partnerships and prepare for vendor participation in a GPS backup/Complementary PNT demonstration: October 2019 – February 2020
- Conduct GPS Backup/Complementary PNT Demonstration: March 2020
- Analysis of Demonstration Results: April – July 2020
- National Space-Based PNT Executive Committee (EXCOM) Briefing: August 2020
- Delivery of FY'18 NDAA Complementary PNT and GPS Backup Technologies Demonstration Report to Congress – January 2021
- Implementation Program: Post-January 2021 based on Space-Based PNT EXCOM Decision
  - It is premature at this point to know precisely how technology(ies) adoption by owners/operators of critical infrastructure would be promoted/supported.

DOT is a co-chair and member of the National Executive Committee for Space-Based PNT, a provider and user of U.S. critical infrastructure (CI) services, and as the lead civil agency for PNT in the Federal Government under National Security Presidential Directive (NSPD)-39, 2004. In these capacities, DOT understands both the tremendous benefits of GPS, as well as its vulnerabilities. DOT is interested in promoting the adoption by owners and operators of critical infrastructure of PNT service technology currently available to ensure PNT resiliency.

2.0 Introduction

The Frank LoBiondo Coast Guard Authorization Act of 2018 (P.L. 115-282) includes Sec. 514, "Backup National Timing System", also known as the "National Timing Resilience and Security Act of 2018". This Act requires that, "Subject to the availability of appropriations, the Secretary of Transportation shall provide for the establishment, sustainment, and operation of a land-based, resilient, and reliable alternative timing system" within two years, with a nominal 20-year operational life; along with other detailed requirements.

DOT has been working with the Department of Defense (DOD) and the Department of Homeland Security (DHS) on GPS backup/Complementary PNT activities for several years, most recently in response to requirements in the National Defense Authorization Acts (NDAA) for FY 2017 (P.L. 114-328, Sec. 1618) and FY 2018 (P.L. 115-91, Sec. 1606).

For clarification a GPS backup capability provides equal or lesser performance in terms of accuracy, availability, coverage, etc., whereas a Complementary PNT capability may provide

[1] Sec. 1606 of P.L. 115-91 specifies that the authority to carry out the backup GPS capability demonstration under " shall terminate on the date that is 18 months after the date of the enactment of this Act." The target dates specified in Section 1.2 of this Report are subject to Congressional authorization to continue carrying out the demonstration.

performance in environments where GPS performance typically is limited (e.g., indoors, underground, etc.).

The goal of P.L. 115-282 is to reduce critical dependency on, and provide a complement to, GPS; and to ensure availability of uncorrupted and non-degraded timing signals, especially for national security and critical infrastructure purposes. Specific actions in the National Timing Resilience and Security Act LoBiondo legislation requires the Secretary of Transportation to prepare a plan to develop, construct, and operate the GPS backup system within 180 days, and to submit an implementation plan and submit the plan to the Committee on Commerce, Science, and Technology, of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives.

This report describes a roadmap to achieving this goal, leveraging the work of the FY 2017 and FY 2018 interagency NDAA efforts.

3.0 Key Elements of the Roadmap to Implement the National Timing Resilience and Security Act

This section outlines the key elements to the Department's implementation of the requirements of the National Timing Resilience and Security Act.

3.1 DOT GPS Backup/Complementary PNT Industry Roundtables

An important aspect for DOT in evaluating considerations for implementation of a GPS backup/Complementary PNT capability, as required by the National Timing Resilience and Security Act (P.L. 115-282), is to incorporate input from external stakeholders with regard to PNT technologies that are at a high level of technical readiness, as well as scenarios exemplifying satisfaction of user needs in the event of a GPS disruption.

To begin to obtain this information, DOT held two industry roundtable discussions in early 2019 to receive input on technology options to consider as part of a DOT-led demonstration program, as well as identification of technologies that would likely be adopted into end user equipment to ensure PNT resiliency.

3.1.1 PNT Technology Vendor Roundtable

DOT hosted an industry roundtable on March 20, 2019 with Chief Executive Officers and Chief Technology Officers from a number of PNT technology vendors potentially interested in demonstrating GPS backup and/or Complementary PNT technologies. Thirteen vendors representing both space-based and terrestrial technologies participated in the industry roundtable.

Key takeaways from this technology vendor roundtable:

- An ecosystem of PNT technologies exists; no single system can meet all user application needs when GPS service is degraded or denied.
- Radiofrequency spectrum (protected from interference) is required for effective deployment of GPS backup/Complementary PNT technologies.
- Commercial PNT systems are available, and deployed to meet specific needs/applications.
- GPS dependence is a by-product of design choices driven by cost, reliability, and efficiency considerations. These are key considerations for implementation of GPS backup/Complementary PNT technologies.
- Size, weight, and power of GPS backup/Complementary PNT end user equipment and availability/cost of that equipment will be a key factor for user adoption.
- Industry supports DOT conducting a demonstration of GPS backup/ Complementary PNT technologies that includes industry participation in the demonstration.
- Recommendation that analysis of DOT results be based on tiered levels of PNT service.

3.1.2 Wireless Industry Roundtable

DOT hosted a second industry roundtable on April 8, 2019 with members from eight companies representing the wireless industry to understand considerations for network deployment and end user equipment adoption of GPS backup/Complementary PNT technologies.

Key takeaways from this wireless industry roundtable:

- Modern communications networks require precise time and frequency standards to operate efficiently, with GPS being the most deployed source of precise frequency control and absolute time distribution.
- +/- 1.5 microseconds is the current baseline for time holdover. 5G will push the limit into the 100s of nanoseconds.
- Wireless network providers are aware of GPS vulnerabilities and support the findings and recommendations of the Communications Security, Reliability and Interoperability Council (CSRIC) V Working Group 4 Subgroup B on "*Network Timing Single Source Risk Reduction Final Report*" (December 2016).
- Existing and emerging technologies can meet commercial timing requirements, at a cost, and with their own set of limitations and risks, depending on how long GPS is disrupted.
- Use of local holdover capabilities can mitigate short-term disruptions.
- There is no clear indication that network providers will be willing to pay a subscription fee for a GPS backup timing capability.

3.2 DOT GPS Backup/Complementary PNT Demonstration RFI

Section 1606 of the National Defense Authorization Act for Fiscal Year 2018 (P.L. 115-91), directed the Secretary of Defense, the Secretary of Transportation, and the Secretary of Homeland Security to jointly develop a plan for carrying out a backup GPS capability and

complementary PNT demonstration and authorized $10 million to conduct the demonstration, an amount that was appropriated in the FY 2018 Omnibus Appropriations (Consolidated Appropriations Act, 2018; P.L. 115-141 March 23, 2018).

Further, the FY 2018 NDAA Section 1606 language specifies that the costs to develop and execute the Plan shall be consistent with the responsibilities established in National Security Presidential Directive 39 titled "U.S. Space-Based Positioning, Navigation, and Timing Policy." The term "backup GPS capability demonstration" means a proof-of-concept demonstration of capabilities to backup and complement the positioning, navigation, and timing capabilities of the Global Positioning System for national security and critical infrastructure.

DOT conducted a field demonstration of technologies in March 2020 with a Technology Readiness Level (TRL) of 6 or higher that are capable of providing backup positioning, navigation, and/or timing services to critical infrastructure in the event of a disruption to GPS. This demonstration encompassed technologies capable of providing complementary PNT functions to GPS by either expanding PNT capabilities or extending them to GPS-denied or degraded environments.

Based on feedback from the two industry roundtables, DOT developed a Request for Information (RFI) to seek levels of interest and additional information from PNT technology vendors on participation in the demonstration. DOT worked with DHS and DOD to develop the RFI, which requested information for DOT's use in developing a plan to demonstrate candidate technologies capable of serving as a backup and/or complement to GPS in order to ensure resilient PNT services for U.S. critical infrastructure (CI) operations. The RFI requested that a vendor interested in participating provide information about its proposed technology and include at minimum:

1. A description of the technology(ies) and CI application(s), including cybersecurity and other security measures inherent in the system, and statement of whether the technology(ies) is/are for timing only, location only, or both timing and location.
2. Identify the TRL for the proposed technology(ies).
3. Identify whether the vendor is willing to participate in the demonstration by providing material (hardware and user equipment when applicable), engineering (technology deployment, configuration, and data collection support), and logistical support during the preparation and execution phases of the demonstration.
4. Identify whether this support is contingent on the government providing funding.
5. Provide information about the needed infrastructure (e.g., power, network, etc.) that would be necessary to deploy the vendor technology(ies) at a DOT-furnished demonstration site.
6. Identify any constraints on participation such as lead-time, demonstration timelines, funding, infrastructure (HVAC, power, shelter, and equipment space, etc.).
7. Identify radiofrequency bands and transmit power levels in terms of peak Effective Isotropic Radiated Power (EIRP). This is needed during the planning phase depending on the selected demonstration site(s).
8. Identify where the technology(ies) is/are currently deployed and in use, if applicable. Provide location, date of deployment, and if the deployment is available for examination.

The RFI was issued on May 3, 2019, with responses due June 3, 2019.[2] Twenty-one unique responses to the RFI were received by the deadline (see Table 1). The responses confirmed that there existed a large number of diverse candidate technologies that could participate in a GPS backup/complementary PNT capability demonstration.

Table 1. Respondents to DOT RFI on GPS Backup/Complementary PNT

Number	Submitter
1	Alion Science and Technology Corporation
2	Arbiter Systems, Inc.
3	CTIA – The Wireless Association
4	GlobalStar, Inc. and Echo Ridge, LLC
5	GPS Innovation Alliance
6	Hellen Systems, LLC
7	InfiniDome Ltd.
8	Intelligent Material Solutions, Inc.
9	iPosi, Inc.
10	Jackson Labs Technologies, Inc.
11	Locata Corporation Pty Ltd.
12	Lockheed Martin Corporation
13	Merlin Technology Inc.
14	NextNav, LLC
15	OPNT B.V.
16	Qualcomm Technologies, Inc.
17	Satelles, Inc.
18	Seven Solutions S.L.
19	Skyhook Wireless, Inc.
20	Ursa Navigation Solutions, Inc. (d.b.a. UrsaNav, Inc.)
21	Viziv Technologies, LLC

3.3 Demonstration Test Plan and Use Case Scenarios

The Volpe Center, through a competitive acquisition process, selected 11 candidate technologies to demonstrate positioning and/or timing functions in the absence of GPS:

- Two vendors demonstrated Low Earth Orbit satellite PNT technologies, one L-band, one S-band
- Two vendors demonstrated fiber-optic timing systems, both based on the White Rabbit Precision Time Protocol (PTP) technology
- One vendor demonstrated localized database map matching database, Inertial Measurement Unit (IMU), and ultra-wideband (UWB) technologies

[2] 84 FR 19154, available at https://www.govinfo.gov/content/pkg/FR-2019-05-03/pdf/2019-09092.pdf.

- Six vendors demonstrated terrestrial RF PNT technologies across, Low-Frequency (LF), Medium-Frequency (MF), Ultra-High Frequency (UHF), and WiFi/802.11 spectrum bands

Five of the technologies were demonstrated at Joint Base Cape Cod (JBCC) and six were demonstrated at NASA Langley Research Center (LaRC). This demonstration was a scenario-based implementation consisting of a series of scenarios modeled on critical infrastructure use cases under various operating conditions.

The purpose of the timing scenarios was to assess the time transfer capability of participating vendor systems to a static location. The scenarios assessed four attributes considered relevant to transportation, communication, and other infrastructure applications requiring synchronization with a time source traceable to a GPS or Coordinated Universal Time (UTC) time standard:

1. Coverage (for wireless time transfer service only); service availability and uniformity within an appropriate area
2. Accuracy and stability across an appropriate area
3. Long-term accuracy and stability of time transfer to a fixed location
4. Time transfer availability and accuracy to a fixed location under challenged GPS signal conditions

Five timing scenarios were developed to assess vendor systems based on these four attributes: 72-Hour Bench Static Timing, Static Outdoor Timing, Static Indoor Timing, Static Basement Timing, and eLORAN Reference Station Offset.

The purpose of the positioning scenarios was to exemplify the following five positioning system attributes, which are relevant to multimodal transportation and other critical infrastructure applications:

1. Coverage: Service availability within a defined region
2. Two-dimensional (2D) and three-dimensional (3D) dynamic positioning: Service availability and accuracy under constant and changing dynamic variables (e.g., linear/angular velocity and acceleration under normal and challenged GPS signal conditions)
3. Static positioning: Service availability and accuracy
4. Static positioning: Long-term service availability and accuracy under normal conditions
5. Static positioning: Long-term service availability and accuracy under challenged GPS signal conditions

Four positioning scenarios were developed to assess vendor systems based on these five attributes: Dynamic Outdoor Positioning with Holds, 3D Positioning, Static Outdoor Positioning, and Static Indoor Positioning.

Additional information is included in the FY'18 NDAA Complementary PNT and GPS Backup Technologies Report to Congress.

4.0 Summary

This report lays out the roadmap for DOT to meet the objectives of the National Timing Resilience and Security Act, leveraging the ongoing interagency technical work of the FY 2017 and FY 2018 NDAA efforts.

As a co-chair and member of the National Executive Committee for Space-based PNT, a provider and user of U.S. critical infrastructure (CI) services, and as the lead civil agency for PNT in the Federal Government, DOT understands the tremendous benefits of GPS, as well as its vulnerabilities. DOT seeks to promote adoption by owners and operators of critical infrastructure of PNT service technologies currently available to ensure PNT resiliency.