Before the
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
Washington, DC 20504

In the Matter of	)	
	)	
Positioning, Navigation, and Timing Resilience	)	Docket No. 2020-17399
	)	

COMMENTS OF THE GPS INNOVATION ALLIANCE

The GPS Innovation Alliance ("GPSIA") submits these comments in response to the Notice of Request for Information ("RFI") issued by the Office of Science and Technology Policy ("OSTP") seeking input on the development of a National Research and Development Plan ("Plan") for Positioning, Navigation, and Timing ("PNT") Resilience.[1/] GPSIA welcomes OSTP's efforts to develop the Plan. Because PNT functions demand a high degree of accuracy and resiliency, the U.S. Global Positioning System ("GPS") continues to be the gold standard for PNT resiliency. OSTP should therefore ensure that the Plan continues to support GPS operations as its primary goal. OSTP may wish to explore other solutions, but those must be fully evaluated to ensure that they offer capabilities and a level of performance at least as good as GPS technologies.

I. INTRODUCTION

The GPSIA was formed in February 2013 to protect, promote, and enhance use of GPS and Global Navigation Satellite Systems ("GNSS") technologies. Members and affiliates of the GPSIA are drawn from a wide variety of fields and businesses reliant on GPS, including manufacturing, aviation, agriculture, construction, defense, transportation, first responders, surveying, and mapping. The GPSIA also includes organizations representing consumers who

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1/ *See Notice of Request for Information on Positioning, Navigation, and Timing Resilience*, Notice of Request for Information, 85 Fed. Reg. 48,273 (Aug. 10, 2020) ("*RFI*").

depend on GPS for boating and other outdoor activities, and in their automobiles, smartphones, and tablets. The GPSIA promotes the ever-increasing importance of GPS and other GNSS technologies to the global economy and infrastructure and is committed to furthering GPS innovation, creativity, and entrepreneurship.

The RFI explains that OSTP seeks comment on behalf of the National Science and Technology Council's Subcommittee on Resilience Science and Technology, which wishes to better understand PNT services and the research and development ("R&D") activities that could be beneficial for improving overall PNT resilience.[2/] It notes that PNT services are currently provided or augmented by a number of terrestrial and space-based systems, with the most notable and widely used being GPS. Nevertheless, it states that the Plan will focus on the R&D and pilot testing needed to develop additional PNT systems and services that are resilient to interference and manipulation and are not dependent upon GNSS. While GPS provides unrivaled PNT solutions, the GPSIA recognizes that research into alternative solutions may be beneficial and is therefore pleased to provide input on how R&D activities related to PNT resilience should be prioritized.

II. COMMENTS

A. PNT Services Provided by GPS Are Vital and Provide Numerous Benefits

OSTP seeks comment on current PNT efforts and challenges and how PNT services may be used in the future, including to enhance resilience.[3/] OSTP correctly recognizes that PNT has become an "invisible utility" that is integral to and enables a wide array of applications.[4/] OSTP seeks to draw a roadmap for successful adoption, integration, and operation of PNT services.

2/ *See RFI* at 48,273 (adding that "[t]he input received on these topics will assist the Subcommittee in developing recommendations for prioritization of R&D activities").

3/ *See id*.

4/ *See id*.

As GPSIA has explained in previous filings, PNT services are predominantly provided by GPS and support numerous industries in both the private and public sector. In the commercial sector, GPS is used for PNT services by the aviation, agriculture, automotive, construction, electricity, finance, public safety, and transportation industries, among others.[5/] GPS is also critical to the burgeoning unmanned aerial vehicle and driverless car industries.[6/] In addition, the Federal government relies heavily on GPS for vital military and other applications that depend on a high degree of accuracy and resiliency.[7/] GPS receivers can be found in countless public and private sector devices, including in mobile phones, automobiles, airplanes, tractors, boats, and high-precision surveying equipment.[8/] Recent estimates are that there are approximately 900 million GPS receivers in use in the U.S. today and three billion GPS receivers in the marketplace globally.[9/] As recently observed by Senator Joni Ernst, co-chair of the bipartisan Senate GPS Caucus, "GPS has evolved beyond just military use . . . . From driving directions in rideshare services to the electric power grid, GPS is utilized by businesses and consumers across the country."[10/]

The proliferation and use of GPS and other GNSS for the delivery of PNT functions have resulted in numerous gains to the U.S. economy. The economic value of GPS has grown to an

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5/ *See* Comments of the GPS Innovation Alliance, Docket No. 200429-0124, at 2-3 (filed July 13, 2020) ("GPSIA 2020 NIST Comments").

6/ *See id.* at 3.

7/ *See id*.

8/ *See id*.

9/ *See* National Space-Based Positioning, Navigation, and Timing Advisory Board, Twenty-Fourth Meeting, at 14 (Nov. 2019), https://www.gps.gov/governance/advisory/meetings/2019-11/minutes.pdf; J. David Grossman, *Freedom to Innovate Promotes GPS Resiliency*, GPS WORLD (Aug. 1, 2019), https://www.gpsworld.com/freedom-to-innovate-promotes-gps-resiliency/.

10/ Press Release, Ernst: US Will Continue to Lead the Way as We Look to Take that Next Giant Leap for Mankind (July 20, 2019), https://www.ernst.senate.gov/public/index.cfm/2019/7/ernst-us-will-continue-to-lead-the-way-as-we-look-to-take-that-next-giant-leap-for-mankind.

estimated $1.4 trillion since it was made available for civilian and commercial use nearly four decades ago, and it creates an estimated $300 billion in U.S. economic benefits annually.[11/] In the past decade alone, GPS applications have helped generate more than $1.2 trillion for the U.S. economy and millions of jobs.[12/] Specifically, more than 3.3 million jobs rely on GPS technology, including approximately 130,000 jobs in GPS manufacturing industries and 3.2 million in the downstream commercial GPS-intensive industries.[13/] The contribution of GPS to the U.S. economy is so significant, it has been estimated that a disruption resulting in a loss of GPS service would have a $1 billion per-day impact on the U.S. economy.[14/]

The significance of GPS will only continue to grow, as new and emerging technologies, including unmanned aerial vehicles, precision agriculture, and even 5G networks, make greater use of GPS technology. Recent reports estimate that companies in the Space-based Communications and Geospatial Intelligence segments, which include GPS, offer the potential to generate over $1 trillion in equity value in those segments over the next decade.[15/]

11/ *See* RTI International, *Economic Benefits of the Global Positioning System (GPS)*, at ES-1 (June 2019) ("RTI Study"), https://www.rti.org/sites/default/files/gps_finalreport.pdf; Michael P. Gallaher, Economic Benefits of the Global Positioning System (GPS), Presentation at the Positioning, Navigation and Timing Advisory Board Meeting (Nov. 20, 2019) https://www.gps.gov/governance/advisory/meetings/2019-11/gallaher.pdf.

12/ *See* GPSIA 2020 NIST Comments at 3.

13/ *See* Nam D. Pham, Ph.D., *The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption*, at 1 (June 2011), http://www.saveourgps.org/pdf/GPS-Report-June-22-2011.pdf.

14/ *See* RTI Study at ES-4.

15/ *See* Space Capital and Silicon Valley Bank, *The GPS Playbook*, at 18 (Mar. 2020), https://www.svb.com/contentassets/c0e37e68e9894f5a9719b0dacadb1aaf/the-gps-playbook-2020.pdf.

B. GPS Offers Highly Resilient and Robust PNT Services

OSTP asks about the system architectures or concepts that could be conducive for PNT system resilience.[16/] It also asks about the features or capabilities in equipment or systems that could provide effective protections or mitigations against interference or manipulation.[17/]

Resiliency is among the core attributes of GPS, making it the preeminent technology for delivering PNT functions. Not only do GPS signals emanate from satellites located more than 12,000 miles above the earth's surface, making physical attacks on the system very difficult and unlikely, but GPS satellites have also been built with the highest levels of redundancy and resilience. This resilience carries into the user equipment sector, as exemplified by GPS-enabled timing devices, which employ high-stability oscillators to improve holdover performance – preserving the timing function of these devices in the unlikely event that GPS signals may be unavailable. Many GPS navigation devices also include resilient features like inertial navigation and map-matching algorithms to ensure that the position and navigation information they provide is sufficiently accurate to support a full range of functions. To enhance resilience, newer GPS devices have the ability to access multiple GNSS systems and technologies. And the most robust GPS receivers are augmented with either Inertial Measurement Units, high-accuracy clocks (oscillators), or other sensors that supplement the PNT solution during GPS outages, thereby reducing the likelihood of loss of service.[18/]

Significant progress has been made in recent years to modernize the GPS constellation and make it more secure and resilient through added accuracy, signal strength, and quality improvements. One of the most significant modernization efforts to GPS satellites includes the

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16/ *RFI* at 48,274 (Question 3(a)).

17/ *Id.* (Question 3(b)).

18/ *See also* GPSIA 2020 NIST Comments at 4-5.

launch of the GPS III series of satellites built by Lockheed Martin, the third satellite of which was launched in late June.[19/] Among the features that the GPS III satellites include are improved accuracy, reliability, and interoperability with the new unique fourth civil signal known as the LlC signal, which is shared by other international GNSS systems, like Europe's Galileo. The revolutionary L1C signal structure provides greater robustness and higher accuracy in multipath rejection, and its features are useful for a range of applications from low-cost consumer devices to high-end professional devices. The GPS III series of satellites also feature M-Code, a more-secure, harder-to-jam and spoof GPS signal for U.S. military and allied armed forces, bringing the number of M-Code-enabled satellites to 22 in the 31-satellite GPS constellation, with two additional satellites expected to be on orbit by early 2021.[20/] The new satellites provide modernized ground control, three times greater accuracy, and eight times improved anti-jamming capabilities over any previous GPS satellites in the constellation, making them the most powerful and resilient GPS satellites ever put in orbit.[21/]

C. While the Federal Government Should Continue to Support GPS, OSTP May Wish to Explore Other Solutions

OSTP asks about the knowledge or capability gaps that currently exist that, if filled, could contribute to improving resilience, and the R&D activities that are best suited to help fill these gaps.[22/] It also seeks comment on the role of the Federal government in encouraging and collaborating on these activities.[23/]

19/ *See* News Release, Third Lockheed Martin-Built GPS III Satellite Now Climbing To Orbit On Its Own Power, Lockheed Martin (June 30, 2020), https://news.lockheedmartin.com/2020-06-30-Third-Lockheed-Martin-Built-GPS-III-Satellite-Now-Climbing-To-Orbit-On-Its-Own-Power.

20/ *See id*.

21/ *See id*.

22/ *See RFI* at 48,274 (Question 5(a)).

23/ *See id.* (Question 5(c)).

Like any radiofrequency-based system, whether satellite or terrestrial wireless, GPS is susceptible to both natural and human-made threats. As noted above, because of the high location of GPS satellites in orbit, GPS is generally insulated from the types of natural threats to which terrestrial-based systems are susceptible. However, human-made threats, which typically consist of illegal GPS jammers and spoofers, are more difficult to predict and address. Those technologies are designed specifically to interfere with GPS signals and can be implemented for nefarious reasons by any individual and at any point in time, though are usually confined to localized areas. U.S. government agencies such as the Federal Communications Commission have taken steps to keep these illegal devices off the market by explicitly prohibiting the manufacture, importation, marketing, sale, and operation of GPS (and other wireless service) jammers and imposing significant fines on those that are found to have willfully and repeatedly interfered with GPS signals.[24/] But more vigorous enforcement is required, particularly as technology evolves. Accordingly, the Federal government must continue to protect GPS and ensure that sufficient resources are devoted to support the existing safeguards that have been put in place to prevent the use of these devices.

The Federal government may also wish to explore other resilient PNT solutions that complement GPS. But OSTP must ensure that the incorporation and support of any alternative solution in its Plan considers the following.

First, OSTP must ensure that any alternative solution offers capabilities and a level of performance on par with GPS technologies in terms of its ability to provide the accuracy,

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[24/] *See, e.g., Gary P. Bojczak, Whitehouse Station, New Jersey*, Notice of Apparent Liability, 28 FCC Rcd 11589 (2013) (imposing a forfeiture of $31,875 against an individual for operating a GPS jammer that caused harmful interference to a ground-based augmentation system operated by the Port Authority of New York and New Jersey and designed to increase the precision of GPS-based navigation at Newark Liberty International Airport, one of the busiest airports in the country).

integrity, continuity, and availability of GPS. As GPSIA has explained,[25/] GPS is well known for unparalleled *accuracy*, consistently exceeding the performance guaranteed for the Standard Positioning Service, which allows GPS to make assessments of less than a centimeter depending on the application. GPS offers *integrity* by providing timely warning of problems in the system or equipment and shutting itself off when it is unable to meet accuracy requirements, and this integrity remains consistent throughout its service volume.[26/] PNT services delivered by GPS are also *continuous*. GPS can provide the required level of service without unscheduled interruption and remain consistent over time without being susceptible to daily or seasonal weather changes that may affect other systems.[27/] GPS is also always *available* for use when it satisfies accuracy and integrity requirements, with 100 percent coverage throughout its service volume.[28/] The evaluation of complementary technologies must consider *all* of these attributes, without focus on any one core feature.

Second, OSTP must recognize that each PNT application has unique requirements driven by its intended function, environment, and design factors. For instance, the centimeter-level precision required for farmers is very different from the location information a typical consumer needs when using a smartphone to map directions. And those requirements differ from the vertical positioning capability needed by the aviation industry. Similarly, a GPS receiver used for synchronizing financial transactions has different demands than a GPS receiver found in an autonomous vehicle – with the former focused on timing while the latter requires positioning to help maintain lane-level guidance. As the White House recently noted in a Statement of

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25/ *See* Comments of the GPS Innovation Alliance, Docket No. DOT-OST-2016-0227, at 7-9 (filed Jan. 30, 2017) ("GPSIA 2017 DOT Comments").

26/ *See id.* at 9-10.

27/ *See id.*

28/ *See id.* at 10.

Administration Policy, "Global Positioning System (GPS) resilience and back-up requirements differ greatly by infrastructure sector, and there is already a strong private sector market of multiple and varied PNT back-up solutions to address the need."[29/] Any alternative solution to manage security risks and disruptions to PNT services should likewise be tailored to the diverse ecosystem of applications – there is no one-size-fits-all solution.

Third, OSTP must ensure that any alternative solution can be successfully integrated into current or future devices. A proposed back-up system may not be a suitable or realistic back-up solution if the particular technology does not lend itself to widespread or cost-effective integration into existing infrastructure. A truly complementary technology must be accessible to the millions of individuals that use and rely on such devices.

Finally, any alternative solution must be complementary to GPS – meaning its susceptibility to failure should be different than any manner in which GPS could be interrupted. There should be sufficient redundancy so there is no risk that a single point of failure will affect both systems.

Even if alternative solutions satisfy the requirements above, they will likely require, as GPSIA has explained,[30/] considerable development and Federal resources over time to reach their maximum potential as true PNT complements to GPS. Not only will they require initial installation costs, but they will also require recurring maintenance and replacement costs as well as costs for upgrades. That is why, while GPSIA supports the exploration of other solutions, it urges OSTP to recognize that the Federal government's resources should first be directed to ensuring that the existing GPS constellation is maintained and improved.

29/ Executive Office of the President, *Statement of Administration Policy*, at 22 (July 30, 2020), https://www.whitehouse.gov/wp-content/uploads/2020/07/SAP-H.R.-7617-1.pdf.

30/ *See* Comments of the GPS Innovation Alliance, Docket No. DOT-OST-2019-0051, at 2 (filed June 3, 2019); GPSIA 2017 DOT Comments at 4.

III. CONCLUSION

GPSIA appreciates OSTP's efforts to improve the resiliency and accuracy of PNT systems. OSTP's Plan should recognize that GPS is the gold standard in PNT resiliency, and its capabilities continue to improve with each successive generation of satellites. OSTP may wish to explore other systems to complement GPS and GNSS. But those systems must be evaluated to ensure that they offer equivalent capabilities, are tailored to the diverse ecosystem of applications currently served by GPS-based PNT devices, are capable of integration into current or future devices, and are complementary to GPS such that they truly complement the robust and reliable services already provided by GPS.

Respectfully submitted,

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September 9, 2020