Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions	)	WT Docket No. 25-110
	)	
	)	

NOTICE OF INQUIRY

Adopted: March 27, 2025 **Released: March 28, 2025**

Comment Date: April 28, 2025
Reply Comment Date: May 13, 2025

By the Commission: Chairman Carr and Commissioner Starks issuing separate statements.

I. INTRODUCTION

1. Many features of America's economy and national security depend on the Positioning, Navigation, and Timing (PNT) data provided by the United States' satellite-based Global Positioning System (GPS). PNT solutions are used not only by the military and civilian government departments and agencies, but also by individuals, commercial entities, public safety officials, and critical infrastructure providers. Non-federal entities depend on a myriad of everyday applications such as driving directions, banking, supply chain and transportation management, emergency response, precision farming, surveying, construction, mining, and cellular networks synchronization and positioning. PNT applications largely rely on the use of radio spectrum, a valuable national resource, and the Commission is charged with managing non-Federal use of spectrum in the public interest.[1]

2. Over the past several years, leaders from President Trump to Chairman Cruz and Senator Markey have called for strengthening our PNT system.[2] After all, relying on GPS alone as the primary source of PNT data leaves America exposed to a single point of failure and leaves our PNT system open to disruption or manipulation by adversaries. Indeed, other countries, including China and Russia, have already launched efforts to develop robust, alternative PNT systems. It is therefore important for America to identify and cultivate technologies and solutions for civil use that can provide secure PNT sources to complement our U.S. GPS system. Doing so would help avoid overreliance on a single system and ensure that critical operations can continue even when GPS signals are disrupted, degraded, or

[1] *See* 47 U.S.C. § 151 (creating the FCC for the purpose of regulating interstate and foreign commerce by wire and radio); 47 U.S.C. § 301 (stating the Act's purpose of maintaining Federal Government control of the radio spectrum and requiring that no person transmit radio signals except pursuant to a license granted under the Act); 47 U.S.C. § 302a (empowering the Commission to regulate the interference potential of radio transmitters); 47 U.S.C. § 303 (empowering the Commission to adopt such regulations as it deems necessary to prevent interference between radio stations and to encourage more effective use of radio spectrum in the public interest).

[2] *See, e.g.*, Executive Order 13905, *Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Timing Services,* 85 Fed. Reg. 9359 (Feb. 12, 2020) (Executive Order 13905) (establishing a comprehensive national policy to promote the responsible use of positioning, navigation, and timing (PNT) services to strengthen critical infrastructure resilience); Press Release, Sen. Ted Cruz, Sens. Cruz, Markey's Bipartisan National Timing Resilience and Security Act Passes Senate (Nov. 14, 2018), https://www.cruz.senate.gov/newsroom/press-releases/sens-cruz-markey-and-rsquos-bipartisan-national-timing-resilience-and-security-act-passes-senate.

manipulated. Indeed, entities have submitted proposals for Commission action to facilitate the development of complementary PNT technologies.

3. Our goal in launching this *Notice of Inquiry* (*NOI*) is to build a record on specific actions the Commission can take to incentivize and support industry efforts to develop complementary PNT technologies and solutions for civil use that may be used in conjunction with GPS to form a resilient and secure PNT system of systems.[3] While we focus in this inquiry on complementary PNT given the predominant use of GPS in the United States, we also seek information regarding alternative PNT technologies and solutions that may better achieve PNT resilience nationwide.[4] As an initial matter, we discuss below the challenges with GPS, and we present a survey of various technologies that have been proposed to bolster the resiliency of PNT. Then, we invite stakeholders to comment on a wide range of topics regarding how the Commission can facilitate more capable and resilient PNT technologies and how the Commission can address potential risks from consumer devices connecting to foreign PNT systems.

4. We recognize that a whole-of-government approach is necessary to ensure that the country's use of PNT systems supports our national and economic security, and that other federal agencies have a primary role in protecting and updating GPS assets in the United States. We seek to supplement this work by focusing on the steps that the Commission can take to facilitate a PNT system of systems, using our authority to regulate non-Federal use of spectrum. As discussed below, we are looking for ways to collaborate with industry and our government partners to promote a more holistic view of PNT that might encompass not only GPS and other space-based PNT solutions, but also terrestrial-based PNT technologies.[5]

II. BACKGROUND

A. PNT in the United States

5. PNT is "any system, network, or capability that provides a reference to calculate or augment the calculation of longitude, latitude, altitude, or transmission of time or frequency data, or any combination thereof."[6] In other words, PNT services can include positioning (horizontal positioning on the x/y axes and vertical positioning on the z axis), timing (acquiring and maintaining accurate and precise time from a standard), and navigation (navigating from point A to point B).[7] Infrastructure sectors that rely on PNT have different requirements; that is, some sectors require very precise timing, such as finance and electricity, while in other sectors, such as aviation, agriculture, and location-based services, positioning or navigation is more important. PNT services are essential for many critical infrastructure

[3] For purposes of this *NOI*, we refer to the terms "resilient" PNT, or PNT "system of systems," as meaning a combination of PNT technologies or solutions that will ensure PNT for users and protect against the threats to and vulnerabilities of GPS.

[4] We define "complementary" PNT to mean the use of technologies or solutions that, together with GPS, provide more accurate PNT data, and "alternative" PNT to mean the use of technologies or solutions that would serve as a replacement to GPS in the event of outages or due to limitations of GPS. We define "augmentation systems" to mean complementary technologies or systems that enhance GPS data to improve PNT performance metrics overall. *See infra* para. 56 (seeking comment on whether we should define key terms).

[5] *See infra* paras. 16-62.

[6] Executive Order 13905, 85 Fed. Reg. at 9359; *see also* National Institute of Standards and Technology, *positioning navigation & timing*, https://csrc.nist.gov/topics/applications/positioning-navigation-timing (last visited Mar. 3, 2025).

[7] *See* U.S. Department of Transportation, *What is Positioning, Navigation and Timing (PNT)?*, https://www.transportation.gov/pnt/what-positioning-navigation-and-timing-pnt (last visited Mar. 3, 2025).

sectors in the United States, including emergency response, all modes of transportation, communications services, energy, manufacturing, and financial services, among others.[8]

6. While PNT can be delivered through a variety of technologies and methods, satellite-based GPS is the foundation and primary source of PNT in the United States.[9] The U.S. government has been operating its global navigation satellite system (GNSS), GPS, for decades.[10] Originally designed to provide PNT information to the military, GPS has provided PNT services to civilians as well.[11] The Department of Defense (DOD) develops, acquires, operates, sustains, and secures GPS, including the satellites, control segment, and military user equipment.[12] The National Space-Based Positioning, Navigation, and Timing Executive Committee (EXCOM), which reports to the White House, is the interagency body responsible for guiding and preserving whole-of-government interests in the provision of space-based PNT services, augmentations, and space-based alternatives.[13] Although GPS is the most prevalent space-based source of PNT capability, other nations have developed systems to provide PNT capability, including Europe (Galileo), China (BeiDou), Russia (GLONASS), India (IRNSS/NavIC), and Japan (QZSS).[14] While GPS and several other systems operate using satellites in medium Earth orbit (MEO), the use of signals from low Earth orbit (LEO) satellites are also a potential source for PNT

[8] Cybersecurity and Infrastructure Agency, *Critical Infrastructure Sectors*, https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors (last visited Mar. 3, 2025).

[9] Cybersecurity and Infrastructure Agency, *Positioning, Navigation, and Timing*, https://www.cisa.gov/topics/risk-management/positioning-navigation-and-timing (last visited Mar. 3, 2025).

[10] GNSS is the general term describing any satellite constellation that provides PNT services on a global or regional basis. *See* National Coordination Office for Space-Based Positioning, Navigation, and Timing, *Other Global Navigation Satellite Systems (GNSS)*, https://www.gps.gov/systems/gnss/ (last visited Mar. 3, 2025).

[11] *See* National Coordination Office for Space-Based Positioning, Navigation, and Timing, *The Global Position System*, https://www.gps.gov/systems/gps/ (last visited Mar. 3, 2025). In 1983, after the downing of Korean Air Lines flight 007, President Reagan declared that GPS would be made available for civilian use even before GPS became operational. *See Statement by Deputy Press Secretary Speakes on the Soviet Attack on a Korean Civilian Airliner* (Sept. 16, 1983), https://www.reaganlibrary.gov/archives/speech/statement-deputy-press-secretary-speakes-soviet-attack-korean-civilian-airliner-1.

[12] 10 U.S.C. § 2281 assigns the Secretary of Defense statutory authority to sustain and operate GPS for military and civil purposes. The statute directs the Secretary of Defense to provide civil GPS service on a continuous, worldwide basis, free of direct user fees. GPS consists of three segments: a space segment, consisting of approximately 31 orbiting satellites; a control segment that tracks and monitors the satellites; and the user segment which is the GPS receivers that receives the satellite signals. *See* National Coordination Office for Space-Based Positioning, Navigation, and Timing, *The Global Position System*, https://www.gps.gov/systems/gps/ (last visited Mar. 3, 2025), and *Space Segment*, https://www.gps.gov/systems/gps/space/ (last visited Mar. 3, 2025); *see also* U.S. Space Force, *Global Positioning System*, https://www.spaceforce.mil/About-Us/Fact-Sheets/Article/2197765/global-positioning-system/ (last visited Mar. 3, 2025). The Department of Defense funds the development, acquisition, operation, sustainment, and modernization of GPS. *See* White House, Memorandum on Space Policy Directive 7 (Jan. 15, 2021), https://trumpwhitehouse.archives.gov/presidential-actions/memorandum-space-policy-directive-7/ (SPD-7). Also, the Department of Transportation provides resources to DOD for assessment, development, acquisition, implementation, operation, and sustainment of GPS civil signal performance monitoring and any additional designated GPS civil capabilities that have exclusively civil (non-military) application consistent with interagency agreements. *Id*. GPS augmentations and other unique PNT capabilities are funded by any agency requiring those services or capabilities, including out-year procurement and operations costs.

[13] *See* Federal Aviation Administration, *Satellite Navigation – Global Positioning System (GPS)*, https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/gps (last visited Mar. 3, 2025). The DOD and the Department of Transportation (DOT) co-chair EXCOM. *Id.*

[14] National Coordination Office for Space-Based Positioning, Navigation and Timing, *Other Global Navigation Satellite Systems (GNSS)*, https://www.gps.gov/systems/gnss/ (last visited Mar. 3, 2025).

capabilities.[15] In addition to space-based PNT solutions, terrestrial-based sources of PNT, as described below, can provide PNT in certain environments where satellite signals are unavailable.[16]

B. GPS Challenges

7. *Reliance on GPS*. Today, virtually all Americans with cell phones have access to GPS, and individuals use GPS-based applications for essential everyday functions, such as directions, location-based transactions, and tracking the safety of family members. Moreover, communications networks themselves rely on GPS to provide fundamental connectivity to end users.[17] Cellular and public safety communications networks require a timing signal using PNT to maintain synchronization, enabling throughput of voice and data services across multiple carrier networks. If PNT is disrupted, individual carrier networks may be able to sustain timing internally, but will eventually lose synchronization with other networks and modern communications networks will not function properly.[18] This disruption has clear downstream impacts where first responders will not be able to communicate, particularly during times of disaster; Wireless Emergency Alert (WEA) services will be significantly impacted, to the point where residents in disaster impact areas may not receive WEA alerts at all; public safety answering points will not be able to respond properly to 911 calls; and consumers will not be able to communicate using mobile and Internet of Things (IoT) devices.

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[15] *Cf.* Peter Gutierrez, *Using LEO Signals of Opportunity for PNT* (Jun. 10, 2024), https://insidegnss.com/using-leo-signals-of-opportunity-for-pnt/ (use of LEOs as signals of opportunity). Signals of opportunity (SoOPs) refers to the use of radio frequency (RF) signals that are not specifically designed for navigation but can be used for PNT; this could include signals from TV broadcasts, radio stations, or cellular networks. *See* Michael Jones, *Signals of opportunity: Holy Grail or a waste of time?* (Feb. 22, 2018), https://www.gpsworld.com/signals-of-opportunity-holy-grail-or-a-waste-of-time/; A.J.R. Lopez-Arreguin, S. Montenegro, *Signals of opportunity for space navigation: An application-oriented review*, Science Direct (2024), https://www.sciencedirect.com/science/article/pii/S2590123024000318. The BeiDou and IRNSS/NavIC systems incorporate geostationary (GEO) satellites.

[16] *See infra* paras. 24-30.

[17] The Communications Sector, one of sixteen critical infrastructure sectors identified in Presidential Policy Directive 21, is comprised of numerous systems, networks, and assets, and is heavily reliant on GPS for PNT data. *See* White House, Presidential Policy Directive on Critical Infrastructure Security and Resilience (Feb. 12, 2013) (PPD21), *https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil*. 42 USC § 5195c(e) defines "critical infrastructure" as the "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters." 42 USC § 5195c(e). PPD-21 identified sixteen critical infrastructure sectors and designated associated Federal Sector-Specific Agencies (SSAs). *See https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil*. For the Communications Sector it designated the Department of Homeland Security (DHS) as the SSA and DHS developed a sector-specific plan through a coordinated effort involving its public and private sector partners in these five segments. *Id.* The Communications Sector has five distinct segments: broadcast, cable, wireless, wireline, and satellite. *See https://www.cisa.gov/sites/default/files/publications/nipp-ssp-communications-2015-508.pdf*. On April 30, 2024, the White House National Security Council (NSC) published the National Security Memorandum on Critical Infrastructure Security and Resilience (NSM-22) which replaced PPD-21. Cybersecurity & Infrastructure Security Agency, *National Security Memorandum on Critical Infrastructure Security and Resilience, https://www.cisa.gov/national-security-memorandum-critical-infrastructure-security-and-resilience* (last visited Mar. 21, 2025). Among other things, NSM-22 redesignated SSAs as Sector Risk Management Agencies (SRMAs). *Id.*

[18] *See* Resilient Navigation and Timing foundation, Response to Request for Public Comment, Bureau of Industry and Security, Office of Technology Evaluation, U.S. Department of Commerce (Oct. 28, 2021), https://rntfnd.org/wp-content/uploads/RNTF-Supply-Chain-Comments-Info-and-Comms-Technology.pdf.

8. Other critical infrastructure sectors are equally reliant on GPS for PNT data and services. For example, wastewater and water treatment facilities rely on PNT for geolocation of infrastructure assets and for timing signals used by Supervisory Control and Data Acquisition (SCADA) systems for data logging and time-based controls.[19] The disruption of PNT services could make it difficult for water utilities to locate valves, pumps, and other assets during emergencies, and facilities may not be able to control the flow of water or the concentration of water treatment chemicals.

9. Importantly, GPS remains the principal source of PNT for the U.S. military and its partners.[20] GPS is the backbone of the U.S. military's space-enabled, precision strike warfare capabilities and is central to making space power the leading-edge of "information age" military power.[21] It increases the precision and effectiveness of military operations and generates information and data integral to areas such as command, communications, computing, intelligence, reconnaissance, targeting, and weapons delivery.[22]

10. *Potential for Disruption or Manipulation of Space-based PNT*. The equipment used in the GNSS satellite system, the end-user equipment that receives the satellite signals, and the location of the end-user device affect the reliability and accuracy of the information transmitted and received. Because the GNSS satellite signals are high-frequency and low power, GPS is often unavailable indoors and in other areas with limited satellite reception, such as underground or in urban canyons where tall buildings obstruct or reflect the signals. The farther away that transmitters are, the more the signals attenuate due to distance, and weaker signals are less able to penetrate physical barriers, which limits the availability of precise location information indoors, in tunnels, and underground.

11. Beyond challenges related to GNSS equipment and physical obstacles, a growing concern for the accuracy and reliability of PNT information is radiofrequency (RF) interference with the satellite signals, whether the interference is accidental or intentional. Malicious interference by foreign adversaries, in particular by jamming or spoofing,[23] is a significant and growing threat to the reliable provision of space-based PNT.[24] Indeed, space-based PNT can be vulnerable to a variety of threats, including navigation warfare (NAVWAR) operations by our foreign adversaries.[25] In 2021, the National Security Telecommunications Advisory Committee reported that GPS is susceptible to jamming,

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[19] *See* Environmental Protection Agency, Responsible Use of Positioning, Navigation, and Timing Services in the Water and Wastewater Sector (2022) at https://www.epa.gov/system/files/documents/2023-03/EPA%20PNT%20Fact%20Sheet%20817-F-22-005_508_Final.pdf.

[20] *See* U.S. Government Accountability Office, GPS Modernization: Delays Continue in Delivering More Secure Capability for the Warfighter (Sept. 9, 2024), https://www.gao.gov/products/gao-24-106841.

[21] Marc J. Berkowitz, America's Asymmetric Vulnerability to Navigation Warfare: Leadership and Strategic Direction Needed to Mitigate Significant Threats at 1, 8 (Jul. 18, 2024), https://nssaspace.org/wp-content/uploads/2024/07/NAVWAR-FINAL.pdf.

[22] *Id.* at 8, citing Department of Defense, Defense Science Board Task Force, The Future of the Global Positioning System (2005), https://dsb.cto.mil/wp-content/uploads/reports/2000s/ADA443573.pdf.

[23] Jamming is intentional interference with authorized radio communications. *See* Federal Communications Commission, *Jammer Enforcement,* https://www.fcc.gov/general/jammer-enforcement (last updated Apr. 2020). Spoofing is when a malicious actor transmits a counterfeit GPS signal that overpowers the legitimate signal and causes the receiving device to use false information instead. *See* Dana A. Goward, *America Is at Risk of High Impact GPS Jamming and Spoofing from Space* (Oct. 24, 2024), https://spacenews.com/america-risk-high-impact-gps-jamming-spoofing-from-space/. Both jamming and spoofing in the United States are violations of federal law.

[24] *See infra* paras. 50-52.

[25] *See* Marc J. Berkowitz, America's Asymmetric Vulnerability to Navigation Warfare: Leadership and Strategic Direction Needed to Mitigate Significant Threats at 1, 18, (July 18, 2024) https://nssaspace.org/wp-content/uploads/2024/07/NAVWAR-FINAL.pdf.

manipulation, and spoofing by malicious actors.[26] U.S. national security leaders continue to warn against this increasing threat.[27]

12. Since GPS became available for civilian use, numerous studies have assessed the positive economic impact of GPS and the negative consequences of GPS disruptions.[28] A 2020 report to Congress prepared by the U.S. Department of Homeland Security (DHS) describes GPS as the definitive PNT source in the United States due to its capabilities, availability, and lack of end-user fees, which the report found has led to an overreliance on GPS.[29] DHS concluded that GPS disruptions would have negative impacts that would likely exceed $1 billion a day.[30] Disruption to GPS could affect military operations as well as critical infrastructure operations maintaining our economy, including the communications, energy, transportation, and emergency service sectors.[31]

C. Whole-of-Government Approach to PNT Resiliency

13. Given the importance of PNT services to the country's public and private interests, numerous federal agencies are heavily involved in improving PNT resiliency. In December 2018, President Trump signed into law the bipartisan National Timing Resilience and Security Act which directs the Secretary of Transportation to provide for the establishment, sustainment, and operation of a land-based, resilient, and reliable alternative timing system to GPS satellites.[32] Much of the recent work on PNT resiliency is in response to President Trump's Executive Order 13905 setting implementation deadlines for various parts of the federal government, including directing the Director of the Office of Science and Technology Policy, within one year, to "coordinate the development of a national plan,

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[26] *See* National Security Telecommunications Advisory Committee, NSTAC Report to the President on Communications Resiliency at 21 (2021), https://www.cisa.gov/sites/default/files/publications/NSTAC%20Report%20to%20the%20President%20on%20Communications%20Resiliency.pdf.

[27] Indeed, the commander of the USSF, Gen. Stephen N. Whiting, stated that risks are accelerating from Russia and China, in particular. *See* Joseph Clark, *Space Commander Outlines Roles of Partnerships Amid Growing Threats* (Sept. 26, 2024), https://www.spacecom.mil/Newsroom/News/Article-Display/Article/3918449/space-commander-outlines-role-of-partnerships-amid-growing-threats/.

[28] *See, e.g.*, National Institute of Standards and Technology, Economic Benefits of the Global Positioning System (GPS) at 14-1-14-4 (2019), https://www.nist.gov/system/files/documents/2020/02/06/gps_finalreport618.pdf.

[29] *See* Department of Homeland Security, Report on Positioning, Navigation, and Timing (PNT) Backup and Complementary Capabilities to the Global Positioning System (GPS), National Defense Authorization Act Fiscal Year 2017 Report to Congress: PNT Requirements, and Analysis of Alternatives at iv, (2020), https://www.cisa.gov/sites/default/files/publications/report-on-pnt-backup-complementary-capabilities-to-gps_508.pdf.

[30] *Id.* at 3, citing Alan O'Connor et al., Economic Benefits of the Global Positioning System (GPS) (Research Triangle, NC: RTI International, 2019), ES-4.

[31] *Id.*; *see also* Letter from Alison Martin, Vice President, Innovation and Strategy, Legal and Regulatory Affairs, National Association of Broadcasters, to Marlene H. Dortch, Secretary, FCC, WT Docket No. 25-110, GN Docket No. 16-142, Attach. at 6 (filed Mar. 12, 2025) (NAB March 12, 2025 *Ex Parte* Letter).

[32] *See* National Timing Resilience and Security Act, Pub. L. No. 115-282, 132 Stat. 4276 (codified at 49 U.S.C. § 312), *see also* https://rntfnd.org/2018/12/06/sen-cruz-markey-cong-garamendis-statements-on-national-timing-security-resilience-act-signing/. Co-sponsored by U.S. Senators Ted Cruz (R-Texas) and Ed Markey (D-Mass.), the National Timing Resilience and Security Act ensures the availability of uncorrupted and non-degraded timing signals for military and civilian users in the event that GPS signals are corrupted, degraded, unreliable, or otherwise unavailable. *Id.* 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. *See* https://www.transportation.gov/sites/dot.gov/files/2021-01/NTRSA%20Report%20to%20Congress_Final_January%202021.pdf.

which shall be informed by existing initiatives, for the R&D and pilot testing of additional, robust, and secure PNT services that are not dependent on [GNSS]."[33] In August 2021, the White House released the national plan required by Executive Order 13905 that focused on greater PNT service resilience, including GPS resilience, and on the development of additional PNT capabilities and services, and identified research and development objectives for federal agencies.[34] Additionally, on January 15, 2021, the White House released SPD-7, which was intended to "maintain United States leadership in the service provision, and responsible use of global navigation satellite systems, including GPS and foreign systems."[35]

14. Among the significant work that federal agencies and groups are accomplishing,[36] DOT has engaged in a number of efforts to improve PNT resiliency,[37] including conducting demonstrations in March 2020 of PNT technologies that could offer complementary PNT service in the event of GPS disruption,[38] developing a recent Strategic Plan and a Complementary PNT Action Plan,[39] and soliciting

[33] Executive Order 13905, 85 Fed. Reg. at 9360-61 ("The plan shall also include approaches to integrate and use multiple PNT services to enhance the resilience of critical infrastructure. Once the plan is published, the Director of OSTP shall coordinate updates to the plan every 4 years, or as appropriate.").

[34] National Science and Technology Council, National Research and Development Plan for Positioning, Navigation, and Timing Resilience at i (2021), https://bidenwhitehouse.archives.gov/wp-content/uploads/2021/08/Position_Navigation_Timing_RD_Plan-August-2021-1.pdf.

[35] *See* SPD-7 at Sec. 3(a)(iii). SPD-7 states that "[t]he widespread and growing dependence on GPS by military, civil, and commercial applications, systems, and infrastructure make the performance of many of these systems inherently vulnerable if disruption or manipulation of GPS signals were to occur." This policy complements the guidance set forth by President Trump in his 2020 Executive Order 13905, which states that "the disruption or manipulation of [PNT] services has the potential to adversely affect the national and economic security of the United States. *See* Executive Order 13905, 85 Fed. Reg. at 9359; *see also* White House, National Space Policy of the United States of America (Dec. 9, 2020), https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf. The 2020 National Space Policy was intended to maintain U.S. leadership in the provision and responsible use of GNSS and established guidance for PNT programs in the United States. *Id.*

[36] This section focuses on recent federal government actions and is not intended to be comprehensive. Any omission of the relevant work of a particular federal government agency, committee, or component on PNT resiliency is inadvertent, and should be identified in comments to this *NOI*.

[37] U.S. Department of Transportation, *Positioning, Navigation and Timing (PNT) & Spectrum Management*, https://www.transportation.gov/pnt (last visited Mar. 3, 2025); *see also* U.S. Department of Transportation, U.S. DOT Volpe Center Annual Review — January 2025 at 31, 73-77 (2025), https://rosap.ntl.bts.gov/view/dot/79090.

[38] *See* U.S. Department of Transportation, *National Timing Resilience and Security Act Roadmap to Implementation*, *Report to Congress* (Jan. 2021), https://www.transportation.gov/sites/dot.gov/files/2021-01/NTRSA%20Report%20to%20Congress_Final_January%202021.pdf. These demonstrations were conducted pursuant to section 1618 of the National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, 130 Stat. 2595, which directs DOD, DOT, and DHS 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," as well as section 1606 of the National Defense Authorization Act for FY 2018, Pub. L. 115-91, 131 Stat. 1725, which directs 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." In evaluating the results, DOT found that "the best strategy for achieving resilient PNT service is to pursue multiple technologies to promote diversity in the PNT functions that support transportation and other critical infrastructure sectors." *See* U.S. Department of Transportation, *Complementary PNT and GPS Backup Technologies Demonstration Report* (Jan. 2021), at xxxviii, https://rosap.ntl.bts.gov/view/dot/55765.

[39] U.S. Department of Transportation, *Positioning, Navigation, and Timing Strategic Plan* , https://www.transportation.gov/pnt/dot-positioning-navigation-timing-pnt-strategic-plan (last updated Jan. 17, 2025); U.S. Department of Transportation, *Complementary PNT Action Plan* at 2-3 (2024),

(continued….)

proposals from vendors to test complementary PNT services under the Rapid Phase of its Complementary PNT Action Plan in February 2024.[40] After nine vendor contracts were awarded in July 2024,[41] a follow-on Complementary PNT Rapid Action Plan Phase II solicitation was issued by DOT in November 2024 to obtain proposals from vendors with operationally ready complementary PNT services.[42] Similarly, the USSF has invested in proposals through its AFWERX Challenge Program, focusing on alternative space-based PNT solutions as well as "fusing" multiple PNT sources, among other goals.[43] In February 2024, DHS's Cybersecurity and Infrastructure Security Agency (CISA) provided guidance to improve the resiliency of PNT information systems and PNT operational technologies acquired by federal government agencies that distribute or use PNT services.[44] The DHS Science and Technology Directorate is researching new ways to increase PNT resilience through the IEEE Conformity Assessment Program.[45] In February 2021, the National Institute of Standards and Technology (NIST) published a Foundational PNT Profile that applies the Cybersecurity Framework to the use of PNT services to help organizations make deliberate, risk-informed decisions on their use of PNT services.[46] NIST published Revision 1 to

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https://www.transportation.gov/sites/dot.gov/files/2024-03/DOT%20Complementary%20PNT%20Action%20Plan_Final_Updated_March%202024.pdf (last updated March 2024).

[40] *Id.*

[41] US Department of Transportation, *Department of Transportation Awards $7 million for Complementary Positioning, Navigation and Timing Technologies* (July 3, 2024), https://www.transportation.gov/briefing-room/department-transportation-awards-7-million-complementary-positioning-navigation-and. Recipients included NextNav Inc. and Locata Corporation, vendors testing terrestrial PNT technologies.

[42] U.S. Department of Transportation, *Complementary Positioning, Navigation, and Timing (CPNT) Services Rapid Phase II*, https://www.transportation.gov/pnt/complementary-positioning-navigation-and-timing-cpnt-services-rapid-phase-ii (last updated Nov. 27, 2024).

[43] AFWERX Challenge, *About the Program*, https://afwerxchallenge.com/about-us (last visited Mar. 3, 2025); *see also* AFWERX Challenge, *Overview*, https://afwerxchallenge.com/spacewerx26/altpnt/overview (last visited Mar. 3, 2025) ("The goal of the SpaceWERX Alternative Positioning, Navigation, & Timing (AltPNT) Challenge is to understand the art of the possible for alternate sources of PNT information that will augment and complement Modernized Global Positioning System (GPS) capabilities to produce highly reliable, resilient multi-source military PNT.").

[44] Cybersecurity and Infrastructure Security Agency, *Federal PNT Services Acquisitions Guidance*, https://www.cisa.gov/sites/default/files/2024-03/Federal%20Positioning%20Navigation%20and%20Timing%20%28PNT%29%20Services%20Acquisitions%20Guidance%20%28508%29_0.pdf (last visited Mar. 3, 2025); *see also* Cybersecurity and Infrastructure Security Agency, *Positioning, Navigation, and Timing*, https://www.cisa.gov/topics/risk-management/positioning-navigation-and-timing (last visited Mar. 3, 2025); Cybersecurity Infrastructure and Security Agency, *Understanding Vulnerabilities of Positioning, Navigation, and Timing*, https://www.cisa.gov/sites/default/files/publications/fact_sheet_pnt_vulnerabilities_508.pdf (last visited Mar. 3, 2025) (CISA is focused on increasing the security and resiliency of PNT functions as one of its "top priorities").

[45] Department of Homeland Security, *Resilient PNT Standard IEEE Conformity Assessment Program Fact Sheet* (Sept. 24, 2024), https://www.dhs.gov/science-and-technology/publication/resilient-pnt-standard-ieee-conformity-assessment-program-fact-sheet.

[46] National Institute of Standards and Technology, *Responsible Use of Positioning, Navigation, and Timing Services*, https://www.nist.gov/pnt (last visited Mar. 3, 2025); *see also* National Institute of Science and Technology, *Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of Positioning, Navigation, and Timing (PNT) Services* at 1-2 (Feb. 11, 2021), *https://csrc.nist.gov/news/2021/nistir-8323-foundational-pnt-profile*. NIST is responsible for developing a Cybersecurity Framework for government and private industry and part of the United States Department of Commerce. *Id*.

this Foundational PNT Profile in January 2023.[47] In May 2024, the DOD, through the Defense Science Board, issued a report on alternative PNT services, which recognized that GPS may not always be available.[48]

15. Further efforts by federal agencies exploring PNT technologies and solutions that can serve as a backup for GPS include the Federal Aviation Administration's (FAA) use of terrestrial radio frequency navigation aids (RF navaids) as a backup for GPS for aviation travel enroute, departures, and arrivals at the busiest airports.[49] Other federal agencies have been working with several existing and emerging technologies to develop PNT applications. Many are low Technology Readiness Level (TRL) that are undergoing preliminary research and development. Others are repurposing existing technology from other applications to exploit PNT usage.[50]

III. DISCUSSION

16. We support the development of PNT solutions that can serve as a complement or alternative to GPS, with the goal of achieving a robust and resilient PNT system of systems. Given its importance to national security and the vital role GPS plays in ensuring the safety of everyday citizens and the continued flow of goods and services, we intend to focus our efforts to rapidly support new and complementary or alternative PNT solutions that will maintain U.S. global leadership in this area and mitigate harmful GPS disruptions caused by foreign adversaries. Moreover, we note that the United States' progress in developing complements to GPS may not be as far along as those currently underway in China, Russia, and other nations that have had greater success in deploying PNT solutions, including terrestrial back-up to satellite-based services. China, for example, has been focusing on developing a multi-pronged system of systems based on satellite, terrestrial broadcast, and fiber solutions.[51]

17. To obtain a complete picture of possibilities, we seek comment on a full range of PNT technologies or solutions, existing and in development, applicable considerations from a domestic and

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[47] National Institute of Science and Technology, *Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of Positioning, Navigation, and Timing (PNT) Services, Rev. 1* (Jan. 2023), https://csrc.nist.gov/pubs/ir/8323/r1/final

[48] Defense Science Board, Positioning, Navigation, and Timing Control Executive Summary at 1-2 (2024), https://dsb.cto.mil/wp-content/uploads/2024/07/DSB_PNT-Control_ExecutiveSummary_5-1-24.pdf.

[49] Very High Frequency Omnidirectional Radio Range (VOR), Distance Measuring Equipment (DME), and the Instrument Landing System (ILS) are terrestrial RF navaids operated and maintained by the FAA. DME provides an Area Navigation (RNAV) backup to GPS for high altitude enroute, departures, and arrivals at the busiest airports for aircraft (air carrier and commercial) equipped for DME navigation. The VOR Minimum Operational Network (MON) provides a backup to GPS for aircraft not equipped for DME navigation. The ILS provides vertically guided approach service at airports with air carrier operations and at VOR MON airports. *See* FAA, *Navigation Programs-Ground-Based Navigation (GBN)* (June 4, 2024), https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gbng.

[50] As part of the US DOT Maritime Administration's (MARAD) PNT Pilot Project, the U.S. DOT Office of the Assistant Secretary for Research and Technology (OST-R) Volpe National Transportation Systems Center (Volpe Center) produced a Market Research summary of emerging complementary technologies. Candidates include Inertial Sensors, AI-based recognition of real-time imagery, Long Wavelength Infrared (LWIR), and Ultra-Wide Band (UWB), and Magnetic- and/or Gravity-Aided Navigation. An additional candidate is Ground Penetrating Radar, currently used for rail track inspections but undergoing research as a PNT source.

[51] *See, e.g.,* Marc J. Berkowitz, *America's Asymmetric Vulnerability to Navigation Warfare: Leadership and Strategic Direction Needed to Mitigate Significant Threats* at 1 (Jul. 18, 2024), https://nssaspace.org/wp-content/uploads/2024/07/NAVWAR-FINAL.pdf; Dana Goward, China finishing "High-precision Ground-based Timing System" – a worry for the United States, GPS World (Sept. 5, 2023), https://www.gpsworld.com/china-finishing-high-precision-ground-based-timing-system-a-worry-for-the-united-states/; John Plumb, *PNT Resilience for an Era of Great Power Competition*, Center for Strategic & International Studies (CSIS) (Oct. 31, 2024), https://www.csis.org/analysis/pnt-resilience-era-great-power-competition.

international perspective, as well as the actions the Commission can take to support their implementation.[52] While this *NOI* focuses on complementary PNT, we also welcome comment on alternative RF-based technologies and solutions. We invite commenters to discuss not only technologies or solutions and the status of development but also costs and benefits. Our intent is to develop a set of actionable solutions to the GPS challenges we identify within the scope of our statutory authority.

A. Survey of PNT Technologies and Solutions

18. Below, we briefly describe some examples of both space-based and terrestrial-based PNT technologies and solutions, followed by a set of common questions and then a set of specific questions regarding space-based or terrestrial-based technologies. By including a particular RF-based PNT technology or solution as an example in this informal survey, we do not intend to endorse that technology or solution, and any omissions should be identified in comments to this *NOI*.[53]

1. Space-based PNT Technologies and Solutions

19. As discussed above, GPS is the United States' primary source of PNT and is space-based, relying on MEO satellites that communicate with a control segment and receivers to calculate PNT data. Among complements to GPS, Wide Area Augmentation System (WAAS) is a GPS augmentation technology that has been developed for civil aviation.[54] WAAS works by receiving GPS signals at ground GPS receivers, removing errors, and then transmitting that information back to geostationary (GEO) communications satellites, that then transmit to the aviation receivers that utilize both GPS and WAAS information.[55] Other GPS augmentation systems have been developed as well.[56]

20. As noted, other countries have GNSS similar to GPS, such as Galileo, GLONASS, and BeiDou, that operate on the same frequencies as well as additional frequencies and frequency bands.[57] We understand that new satellites that may use additional frequencies are being developed to provide GNSS services that are more accurate and provide better coverage, among other benefits, than some

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[52] In our discussion, we use the term "technology" to mean the tool, base algorithm, or theory that is the basis of a solution, system, or product that is the comprehensive approach of addressing a problem, which—in this *NOI*—is finding a complement to GPS to achieve resilient PNT.

[53] The scope of this *NOI* is generally limited to a discussion of PNT technologies and solutions that rely on RF signals to complement GPS. It does not include PNT derived solely from natural phenomena such as those based on gravity, the Earth's magnetic field, celestial navigation, or terrain-based information. For a discussion of non-RF sources of PNT, *see*, *e.g.*, Theresa Hitchens, *'No Silver Bullet': Military Will Need Multiple Systems to Back Up GPS* (May 14, 2024), https://breakingdefense.com/2024/05/no-silver-bullet-military-will-need-multiple-systems-to-back-up-gps/. We note that non-RF terrestrial systems such as fiber-optic systems can also offer precise timing. *See generally* National Institute of Standards and Technology, Responsible Use of Positioning, Navigation, and Timing Services, https://www.nist.gov/pnt (last visited Mar. 3, 2025).

[54] Federal Aviation Administration, *Satellite Navigation - Wide Area Augmentation System (WAAS)*, https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas (last visited Mar. 3, 2025).

[55] Federal Aviation Administration, *Satellite Navigation - WAAS - How It Works*, https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/howitworks (last visited Mar. 3, 2025).

[56] *See* National Coordination Office for Space-Based Positioning, Navigation, and Timing, *Augmentation Systems*, https://www.gps.gov/systems/augmentations/ (last visited Mar. 3, 2025).

[57] DLR, *Global Navigation Satellite Systems – What's Up?* at 2 (2019), https://www.gps.gov/governance/advisory/meetings/2019-06/montenbruck.pdf (presentation to the PNT Advisory Board on status of GNSS systems at the time and the signals being used).

current GNSS satellite signals.[58] Existing GNSS systems have challenges involving the low power level of the signals that may be impacted by the environment surrounding the receiver. GNSS also may be at risk from blocking and jamming that disrupts the signals.

21. Any foreign-licensed GNSS provider must seek and receive Commission approval before a person in the United States is permitted to operate equipment that uses the foreign GNSS provider's network.[59] In 2018, the Commission, pursuant to an established process, granted a waiver of the Commission's licensing requirements to the European Union (EU) for its Galileo GNSS.[60] The order authorized non-federal U.S. receive-only earth stations to operate with specific signals of the Galileo GNSS without obtaining a license or grant of market access, and it attached conditions to ensure that the public would benefit from increased reliability, availability, and resiliency of PNT services.[61] Currently, Galileo is the only non-U.S. GNSS constellation that has sought and received Commission approval for operation in the United States.[62]

22. Many private companies are developing LEO satellite systems for commercial applications, such as SpaceX and Amazon.[63] LEO satellites have certain advantages such as lower latency, and due to the greater number of satellites in orbit, provide better positioning accuracy as compared to MEO satellites, but they are still vulnerable to jamming and atmospheric interference. These LEO systems are not being deployed and developed to provide PNT as their primary service offering, but rather to provide broadband services, supplemental coverage from space, and other commercial applications.[64] They typically operate in the V-, Ku-, and Ka-bands.[65]

23. Other LEO systems have been deployed or are being developed that are focused primarily on providing PNT services.[66] Iridium's Satellite Time and Location (STL) service broadcasts

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[58] National Coordination Office for Space-Based Positioning, Navigation, and Timing, *GPS Modernization*, https://www.gps.gov/systems/gps/modernization/ (last visited Mar. 3, 2025); *see also* Secretary of the Air Force Public Affairs, *Space Force Awards Four 'Quick Start' Resilient GPS Agreements* (Sept. 23, 2024), https://www.spaceforce.mil/News/Article-Display/Article/3914829/space-force-awards-four-quick-start-resilient-gps-agreements/ (describing a new resilient GPS satellite system being developed); The Mainichi, *Japan Successfully Launches Flagship H3 Rocket for More Precise GPS* (Feb. 3, 2025), https://mainichi.jp/english/articles/20250203/p2g/00m/0sc/002000c (Japan putting into orbit a quasi-zenith satellite to improve coverage and enhance positioning accuracy of GPS data for various applications).

[59] The Commission exercises authority over GNSS receiving devices under part 25 and part 15 of its rules. *See, e.g.*, 47 CFR §§ 15.5, 25.115(b)(9), 25.137.

[60] *See Waiver of Part 25 Licensing Requirements for Receive-Only Earth Stations Operating with the Galileo Radionavigation-Satellite Service*, IB Docket No. 17-16, Order, FCC 18-158, 33 FCC Rcd 11322 (rel. Nov. 16, 2018).

[61] *Id.*, 33 FCC Rcd at 11327-29.

[62] In granting the waiver, the Commission noted that while the United States and the European Commission had cooperated extensively to ensure that the Galileo signals are interoperable and compatible with GPS as memorialized in a formal agreement, there were no agreements in place between the United States and the foreign entities responsible for other GNSS networks. *Id.* at 11322, n.1, 11346, n.199.

[63] *Space Exploration Holdings, LLC*, GN Docket No. 23-135a, Order and Authorization, DA 24-1193, 2024 WL 4921382, at *1, paras. 2, 6 (SB Nov. 26, 2024) (SpaceX); Kuiper Systems LLC, Technical Appendix ICFS File No. SAT-LOA-20211104-00145, Call Sign S3105 (Nov. 21, 2021) (Amazon).

[64] However, the LEO systems could be used as signals of opportunity. *See supra* note 15.

[65] *Id*.

[66] *See, e.g.*, United Nations Office for Outer Space Affairs, *Working Group: Systems, Signals and Services*, https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/wg-s-workshop-leo-pnt-2023.html (last visited Mar. 3, 2025) (presentations from companies working on LEO-based PNT solutions).

timing and location signals through Iridium's LEO satellites' paging channel.[67] STL operates in the L-band with signals typically transmitted between 1616 MHz and 1626 MHz, and it relies on exterior or interior antennas to receive the STL signal.[68] Trustpoint is planning a commercial LEO GNSS operating in the C-band with as many as 300 LEO satellites.[69] In August 2024, TrustPoint won U.S. Space Force SpaceWERX contracts to demonstrate a GPS alternative that is more resilient and reliable.[70] Xona is developing a LEO-based PNT service called Pulsar with up to 258 satellites to provide centimeter-level PNT services for U.S. and international markets using the L-band and C-band.[71]

2. Terrestrial-based PNT Technologies and Solutions

24. In contrast to space-based PNT technologies and solutions, the terrestrial RF-based PNT technologies and solutions surveyed here use radio signals from and/or to terrestrial radios on the ground and may use multilateration to locate an object. When available in a particular geography, these types of solutions can result in stronger receive signal strengths than space-based PNT technologies due to less signal propagation loss, be less vulnerable to intentional interference and space environment events, and function in certain locations where satellite signals are unavailable.[72] We highlight some examples of potential complements to GPS and invite commenters to identify other promising sources of PNT data.

25. *Broadcast Positioning System*. The Broadcast Positioning System (BPS) uses features of ATSC 3.0, an international standard for broadcast television, to deliver precise timing information within television broadcast signals to enable the calculation of PNT data.[73] Dedicated spectrum and

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[67] Iridium, *Roadmap for Our PNT Solutions*, https://satelles.com/technology/stl-pnt-solutions/ (last visited Mar. 3, 2025); Iridium, *Iridium® Positioning, Navigation, & Timing*, https://satelles.com/wp-content/uploads/pdf/Iridium-PNT-Fact-Sheet.pdf (last visited Mar. 3, 2025). Iridium STL service was originally developed by the company Satelles, which Iridium acquired in 2024. Press Release, Iridium, *Iridium Completes Satelles Acquisition; Introduces Iridium Satellite Time and Location (STL)* (Apr. 2, 2024), https://investor.iridium.com/2024-04-02-Iridium-Completes-Satelles-Acquisition-Introduces-Iridium-Satellite-Time-and-Location-STL.

[68] Iridium, *Iridium Satellite Time and Location® Antenna Placement Guide*, https://satelles.com/wp-content/uploads/pdf/STL_Antenna_Placement_Guide.pdf (last visited Mar. 3, 2025).

[69] Paul Anderson, et al, A New Paradigm of Commercial GNSS Services: The Case for LEO PNT at C-Band, Part 1 at 2250-71 (2024), https://doi.org/10.33012/2024.19671; *see also* TrustPoint, Inc., TrustPoint System/Service Overview: Prepared for Workshop on Low Earth Orbit (LEO) PNT Systems Supporting International Committee on GNSS (ICG) (2023), https://www.unoosa.org/documents/pdf/icg/2023/ICG_WG-S_LEO-PNT_Workshop_June_2023/ICG_LEO-PNT_Workshop_2023_03.pdf.

[70] Press Release, Air Force Research Laboratory, SpaceWERX Launches Second Innovate to Accelerate Cohort Focused on Aerospace Technology (Aug. 9, 2024), https://www.afrl.af.mil/News/Article-Display/Article/3868266/spacewerx-launches-second-innovate-to-accelerate-cohort-focused-on-aerospace-te/; *see also supra* note 43 (detailing the SpaceWERX Alternative Positioning, Navigation, & Timing Challenge).

[71] *See* Xona Space Systems, Inc., Legal Narrative, SAT-LOA-20230711-00165 (July 11, 2023).

[72] Terrestrial PNT is less vulnerable to intentional interference because terrestrial PNT, in general, has more redundancy between the links within the network. In addition, systems such as BPS and mobile solutions include encryption which increases resiliency because they deter hacking attempts.

[73] ATSC 3.0 is the next generation terrestrial broadcast system intended to improve the television viewing experience and is defined in a collection of standards and recommended practices from the Advanced Television Systems Committee, an international non-profit organization that creates voluntary standards for digital television. *See* ATSC, *Spotlight ATSC 3.0*, https://www.atsc.org/nextgen-tv/ (last visited Feb. 27, 2025). ATSC 1.0 is the current broadcast standard, and the Commission permits ATSC 3.0 broadcast on a voluntary basis. *See, e.g., Authorizing Permission Use of the "Next Generation" Broadcast Television Standard*, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 9930 (2017). ATSC 3.0 capable equipment, including TVs and converter boxes, is in its early stages. *See The Future of Television Initiative Report*, National Association of Broadcasters, GN Docket 16-142 at 4-5 (Jan. 17, 2025) (*Future of Television Initiative Report*). BPS has been deployed on an experimental basis in Washington, DC on WHUT, in Baltimore, MD on WNUV, and in Denver, CO (continued….)

infrastructure are not required since existing TV broadcasting infrastructure is leveraged to generate PNT data. Specifically, when a television station transmits its precise horizontal location along with a time stamp, standardized receivers determine their location based on their calculation of the time difference of arrival (TDOA) of the received signals.[74] The accuracy of BPS depends on factors such as the number of transmitters, the distance between the transmitter and the receiver, the geometry of the locations of the transmitters in relation to the receiver, and the environment.[75]

26. Because television station transmitters are close to the Earth's surface and broadcast signals are strong, most have the ability to penetrate buildings and other structures in contrast to GNSS signals. Further, according to the National Association of Broadcasters, broadcast signals are not as vulnerable to the intentional interference that is problematic for space-based PNT systems.[76] In addition, television broadcast signals operate on a variety of frequencies at once, making them more difficult to jam.[77] Broadcasters have been developing and testing the use of ATSC 3.0 to provide PNT capabilities since 2021.[78]

27. *eLoran*. Enhanced long-range navigation (eLoran) is a terrestrial radio navigation and timing system operating in the 90 kHz to 110 kHz range used primarily in maritime and aviation contexts designed to operate independently of GPS.[79] A Loran system consists of ground-based transmitters located across vast geographic regions that emit low-frequency radio signals that propagate over long distances.[80] The system operates using hyperbolic navigation, a method of positioning based on TDOA

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on KWGN. *See* Tariq I. Mondal, Dr. Jeffrey A. Sherman, and David A. Howe, Time Transfer Performance of the Broadcast Positioning System ™ (BPS™), Proceedings of the 2025 International Technical Meeting (Jan. 2025) at 5, https://www.nab.org/bps/ITM25-0009.pdf.

[74] TDOA technology measures the difference in time between the reception of synchronized radio signals from multiple transmitters which are triangulated.

[75] *See generally* Tariq Mondal, Robert D. Weller, P.E., and Sam Matheny, Broadcast Positioning System (BPS) Using ATSC 3.0, Proceedings of the 2021 NAB BEIT Conference (Oct. 2021), https://www.nab.org/bps/Broadcast_Positioning_System_Using_ATSC30.pdf.

[76] *See* National Association of Broadcasters, Protecting Critical Infrastructure: Augmenting GPS with the Broadcast Positioning System (BPS) (2024) (NAB White Paper) at 3, https://www.nab.org/bps/BPS_Protecting-Critical-Infrastructure.pdf.

[77] *Id.*

[78] *See* NAB White Paper at 4. NAB notes that the success of BPS as a ubiquitous source of PNT in the United States depends on when the ATSC 3.0 standard becomes available nationwide. National Association of Broadcasters, *Broadcast Positioning System (BPS): Securing U.S. Infrastructure*, https://www.nab.org/bps/ (last visited Feb. 27, 2025). NAB states that ATSC 3.0 is currently available in over 75 markets, with signals reaching more than 75% of U.S. households. *See* NAB White Paper at 4. The NAB-led ATSC 3.0 taskforce, the Future of Television Initiative, released a final report regarding the ATSC 3.0 transition on January 17, 2025. *See The Future of Television Initiative Report*. The Commission's ancillary or supplementary rules govern service offerings outside traditional TV broadcast operations. *See* 47 CFR § 73.624(c) ("TV broadcast stations are permitted to offer services of any nature, consistent with the public interest, convenience, and necessity, on an ancillary or supplementary basis. The kinds of services that may be provided include, but are not limited to computer software distribution, data transmissions, teletext, interactive materials, aural messages, paging services, audio signals, subscription video, and any other services that do not derogate TV broadcast stations' obligations under paragraph (b) of this section.").

[79] 47 CFR § 2.106(a). *See* Table of Frequency Allocations at 2; *see also* 47 CFR § 2.106(c)(104). US Note 104 stipulates that "In the band 90-110 kHz, the LORAN radionavigation system has priority in the United States and its insular areas. Radiolocation land stations making use of LORAN type equipment may be authorized to both Federal and non-Federal licensees on a secondary basis for offshore radiolocation activities only at specific locations. . . ."

[80] *See* GlobeAir, *Long Range Navigation (LORAN)*, https://www.globeair.com/g/long-range-navigation-loran (last visited Mar. 11, 2025). The United States developed the original Loran system during World War II which was used by ships and aircraft, and the U.S. Coast Guard operated a Loran system for many years leading up to its (continued….)

technology.[81] Accuracy of this technology depends on factors such as signal propagation conditions and transmitter station spacing.[82]

28. Using fixed terrestrial beacons, eLoran signals are stronger and more resilient to jamming and spoofing as compared to GNSS signals.[83] The signals are also better able to penetrate indoors, underwater, and underground.[84] Unlike BPS which could rely in large part on existing infrastructure, a reliable, accurate eLoran system would likely require the construction of additional larger, high-power transmitters to provide accurate positioning nationwide.[85] Although Congress allowed the original Loran system to terminate rather than upgrading it to eLoran, there has been some renewed interest in reviving eLoran to serve as a potential complement or alternative to GPS.[86]

29. *NextNav Inc.* The Commission is also interested in exploring options that rely on, or incorporate, solutions provided by NextNav Inc. (NextNav). Currently, NextNav offers a solution that operates in the 919.75-927.75 MHz spectrum band that provides horizontal positioning and timing.[87] In 2021, NextNav demonstrated the timing precision and resilience of its PNT technology in a DHS assessment that tested timing redundancy in multiple scenarios, including GPS outages, spoofing, and jamming instances.[88] NextNav's terrestrial transmitter network enables positioning by multilateration using signals from three or more transmitters.[89] In addition, NextNav has tested a solution that combines

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termination in 2010. *See* National Coordination Office for Space-Based Positioning, Navigation, and Timing, *LORAN-C Infrastructure & E-LORAN*, https://www.gps.gov/policy/legislation/loran-c/ (last visited Mar. 11, 2025).

[81] *Id*.

[82] The system is generally capable of providing positioning accuracy within 10-20 meters. There has been reported location accuracy of approximately 8 meters. *See* Stanford Engineering - GPS Lab, *Enhanced Long-Range Navigation (eLORAN)*, https://gps.stanford.edu/research/early-gpspnt-research/enhanced-long-range-navigation-eloran (last visited Mar. 11, 2025).

[83] *See* Matteo Luccio, *eLoran: Part of the Solution to GNSS Vulnerability* (Nov. 3, 2021), https://www.gpsworld.com/eloran-part-of-the-solution-to-gnss-vulnerability/.

[84] *Id*.

[85] *See* Alan Grant & Dana Goward, *10 Answers About eLoran* (Apr. 11, 2022), https://www.gpsworld.com/10-answers-about-eloran/.

[86] Currently, the United States is primarily focused on eLoran research and development, e.g., a demonstration in early 2024 at an Air Force base in Idaho. *See* Airman Keagan Lee, *Innovation Cell Hosts eLoran Demonstration* (Feb. 20, 2024), https://www.mountainhome.af.mil/News-Photos-Videos/Article-Display/Article/3681900/innovation-cell-hosts-eloran-demonstration/.

[87] *See* NextNav, *NextNav TerraPoiNT: Accurate, Secure, Resilient 3D PNT Solutions*, https://nextnav.com/terrapoint/ (last visited Mar. 11, 2025). NextNav filed a petition for rulemaking requesting that the Commission initiate a proceeding to reconfigure the 902-928 MHz band. *See* NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz) (filed Apr. 16, 2024) (NextNav Petition). The Wireless Telecommunications Bureau and Office of Engineering and Technology sought comment on the petition. *See* Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking, Public Notice, DA 24-776, WT Docket No. 24-240 (rel. Aug. 6, 2024). That proceeding remains ongoing and independent of this inquiry. This *NOI* takes no position on, nor addresses the merits of, NextNav's petition.

[88] Gillian Smith, *NextNav Demonstrates World's First GPS-Free PNT Network in Department of Homeland Security Trial,* NextNav (Aug. 16, 2021), https://nextnav.com/nextnav-demonstrates-worlds-first-gps-free-pnt-network-in-department-of-homeland-security-trial/.

[89] *Id.* NextNav also has a technology that provides vertical location using barometric sensors to determine altitude. *See* NextNav, *NextNav Pinnacle: Accurate, Floor-Level Vertical Location*, https://nextnav.com/pinnacle/ (last visited Mar. 11, 2025).

its PNT system with existing LTE and 5G networks signals to deliver 3D positioning and timing information.[90] NextNav claims that its PNT technology will enable the rapid deployment of a nationwide terrestrial PNT network to back up and complement GPS.[91] NextNav also claims that its solution would provide location accuracy that would provide a better service experience and meet the Commission's horizontal indoor location requirement and 3-meter z-axis requirement.[92] We are interested in hearing from commenters about the various solutions that NextNav is providing or could provide.

30. *Mobile Broadband Systems*. We note that support for consumer user equipment (UE) positioning is integrated into existing 3rd Generation Partnership Project (3GPP) mobile broadband systems (e.g., LTE, 5G networks).[93] This includes methods that use time, phase, signal strength, and angle measurements from broadcast and/or point-to-point reference signals between a target UE (e.g., smartphone) and nearby terrestrial base stations and UEs. UE positioning support is designed to meet regulatory requirements for emergency call positioning, as well as other commercial use cases, including machine-control/transportation.[94] Hybrid positioning methods that utilize measurements from terrestrial infrastructure (e.g., 5G base stations) in combination with GNSS have been shown to significantly improve positioning accuracy in urban macro environments.[95] For future 6G systems, 3GPP is considering standardization of resilient GNSS-independent positioning solution to provide positioning services when GNSS services may be unavailable or degraded.[96]

3. General Considerations for PNT Technologies

31. We ask commenters to describe the benefits and challenges of particular PNT technologies or solutions based on factors such as: the geographic coverage; the availability of existing equipment as well as costs to the user; the use of spectrum resources; the extent to which the technology should be viewed as a complement to or substitute for GPS and other PNT technologies; performance such as range and precision; resiliency as well as vulnerabilities and limitations of the technology; international considerations; and the cost and incentives to develop, deploy, and maintain the technology or service.

32. *Geography*. We seek comment on the geographic scope of complementary PNT technologies and solutions. Would coverage be nationwide, or would these technologies and solutions be localized? Would a technology be expensive to deploy nationwide, but potentially cover the majority of

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[90] *See* Maddie Saines, *NextNav Tests 3D PNT Service Leveraging Cellular Infrastructure* (Aug. 2, 2023), https://www.gpsworld.com/nextnav-tests-3d-pnt-service-leveraging-cellular-infrastructure/.

[91] *See* NextNav Petition at 10-14.

[92] *See id*. at 26-28.

[93] *See* 3GPP, *NG Radio Access Network (NG-RAN); Stage 2 Functional Specification of User Equipment (UE) Positioning in NG-RAN*, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3310 (last visited Mar. 11, 2025). 3GPP is a group of seven telecommunications standard development organizations that create technical standards for cellular communications. *See* 3GPP, *About 3GPP*, https://www.3gpp.org/about-us (last visited Mar. 11, 2025).

[94] *See* 3GPP, *Study on Positioning Use Cases*, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3280 (last visited Mar. 11, 2025).

[95] *See* 3GPP, *Study on NR Positioning Support*, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3501 (last visited Mar. 11, 2025).

[96] 3GPP TR 22.870 V0.2.0, Technical Report, 3rd Generation Partnership Project; Technical Specification Group TSG SA; Study on 6G Use Cases and Service Requirements; Stage 1 (Release 20), Section 8.4 (February 2025).

the United States? Would a particular technology be able to be deployed nationally or internationally in a cost-effective manner?

33. *Infrastructure and End-User Equipment*. Does the solution use existing end-user and network equipment and infrastructure, or would new or upgraded end-user equipment and infrastructure be required? What is the extent of a potential provider's current infrastructure build-out? If new infrastructure deployment is necessary, what is the anticipated timing for that deployment? If new or upgraded end-user equipment is required, how could the Commission promote widespread adoption of the required equipment? What are the considerations for consumer/user acceptance? In this regard, commenters should consider both the transmitting equipment and the end-user receiving equipment, and whether standardized equipment is required. What kind of equipment and infrastructure are required (e.g., towers, satellites, antennas, etc.)? We also seek information on the likely cost of implementing a particular PNT technology in end-user devices. What is the length of time a particular PNT solution is estimated to take until it is ready for commercial deployment?

34. *Spectrum Resources.* What spectrum resources would be needed for the PNT technology to be implemented, and are those resources currently allocated or regulated for those purposes? Can this technology perform on currently licensed or unlicensed frequencies? Is the proposed PNT technology capable of spectrum sharing? What are the bandwidth, propagation, and other technical requirements of the PNT technology that would affect the spectrum resources that would be needed for that technology? If the proposed PNT technology projects a future need for spectrum resources, what is the anticipated level of congestion over time and when might the proposed PNT technology require additional spectrum? How resilient is the proposed PNT technology to radio frequency interference from other technologies? Does the proposed PNT technology pose interference implications for other spectrum users? If so, how could the impact of any such interference be mitigated?

35. *Integration*. More broadly, we seek comment on how we should view the developed and developing PNT technologies and services; that is, as individual technologies, as sources of data for use in larger PNT systems, or as pieces that can be combined together into complete PNT systems? Are there particular PNT technologies that work better together to provide a complete PNT solution? We seek comment on the dependence of new PNT technologies on existing PNT technologies for time reference or other data.[97] We also seek comment on whether and to what extent PNT technologies would leverage decentralized protocol-level solutions. Commenters should explain whether a PNT technology would be complementary (e.g., it would supplement and improve GPS) or is an RF-based alternative to GPS. What elements of the proposed PNT technology need to be interoperable with existing technologies? What are the existing challenges? Do today's standards allow interoperability or is more work needed? If so, what are the gaps? In particular, does the proposed PNT technology adhere to current standards or do those standards need to evolve to incorporate new requirements? Will these changes affect backward compatibility in any regard? How well might the proposed PNT technology transition to alternative sources of PNT if the GPS or non-GPS source of PNT becomes spotty or unavailable? What is the level of compatibility associated with transitioning to another source of GPS? As technology evolves, is the PNT technology likely to become obsolete, and if so, when? Will software or firmware updates enable the technology to be effective longer?

36. *Resiliency*. We seek comment on considerations related to the resiliency of a proposed PNT technology against jamming and interference, including atmospheric interference. For example, how would a proposed PNT technology, including its infrastructure and RF signals, be resilient against environmental effects and natural phenomena? What features of complementary or alternative PNT

[97] For example, crystal oscillators are commonly used as internal clocks in many devices (e.g., smartphones), but are susceptible to inaccuracy over time due to drift and other factors. These inaccuracies can cause errors in positioning measurements, as well as complicate system design. GPS disciplined oscillators (GPSDOs) use GPS broadcast signals as a reference to minimize oscillator inaccuracies but could be vulnerable to GPS outages or jamming.

systems would harden them against natural and manmade hazards and threats? How would these systems resist disruption if used within moving vehicles?

37. *Performance*. Among factors to evaluate a particular PNT technology or service include issues like signal strength, building penetration, range of the technology, and the accuracy achieved. We seek comment on the levels of accuracy that can be achieved, with regard to positioning, navigation, and timing, as applicable. Does it matter if the object being tracked is stationary or mobile? How does achievable precision and accuracy compare against existing and other solutions being developed? Does a particular technology work better in an urban environment or better in a rural environment? Is a particular technology better suited for any given component of PNT – positioning, navigation, or timing? Does a particular PNT technology work better for a particular use case, such as agriculture or navigation?

38. What other factors should the Commission consider when evaluating a particular PNT technology or service? What type of key performance indicators (KPIs) should be considered when evaluating a particular PNT technology or solution? Are there new performance metrics that need to be developed or considered? Are there particular PNT technologies or services that the Commission is better equipped to support? What role should the government play in testing and evaluating commercial PNT services? Commenters should address KPIs, reliability, and security of particular technologies and their vulnerability to disruption, either intentional or unintentional.

39. *Public Safety and 911 Equipment.* We ask commenters to discuss what downstream cost implications the deployment and implementation of any of the proposed technologies by commercial and public safety entities (e.g., state and local government authorities) have on 911 systems and first responder equipment, including Public Safety Answering Point equipment, Computer Aided Dispatch, records systems, responder vehicles, and mobile data systems.

40. *International*. We seek comment on international considerations involving any of the PNT services, technologies, or solutions discussed herein or in comments. Some of the PNT services, technologies, and solutions would operate across international boundaries, especially space-based ones. We note that with respect to space-based PNT, there is some ongoing work internationally, under the umbrella of the United Nations Office for Outer Space Affairs, to promote voluntary cooperation on matters of mutual interest related to compatibility and interoperability of civil satellite-based positioning, navigation, timing, and value-added services.[98] Other international organizations are also involved in the development of an international framework for harmonization of spectrum use and protection of certain PNT services from cross-border interference.[99]

41. We seek comment on various ways of providing PNT and associated international considerations, including any relevant bilateral or multilateral cross-border coordination arrangements, international best practices, and other information that would help us understand better the international commitments as well as challenges and the trends in the regional and global PNT marketplace. We seek comment on the ongoing international work and the need for future work streams, including international standards, existing or in development, that apply to PNT. We also seek comment on international consultation processes, including the ITU Resolution 609 process,[100] and any suggestions for

[98] *See, e.g.*, United Nations Office for Outer Space Affairs, *International Committee on Global Navigation Satellite Systems (ICG)*, https://www.unoosa.org/oosa/en/ourwork/icg/icg.html (last visited Mar. 11, 2025). There also are other activities at the International Telecommunication Union (ITU).

[99] *See, e.g.*, ITU Radio Regulations, Articles 1.43 and 4.10; ITU Resolution 604 (WRC-2000); ITU Resolution 609 (Rev. WRC-07); Resolution 676 (WRC-23), Resolution 681 (Rev. WRC-23); ITU-R Reports M.2168, M.2262, RS.2311, RS.2537.

[100] *See* https://www.itu.int/ITU-R/go/space-resolution609/en (last visited Mar. 11, 2025). To protect aeronautical radionavigation service systems (ARNS) from harmful interference, ITU Resolution 609 requires that the equivalent power flux density (epfd) produced by all radionavigation-satellite service (RNSS) space stations operating in the 1164-1215 MHz frequency band, shall not exceed the aggregate epfd level of -121.5 dB(W/m2) in any 1 megahertz (continued….)

improvements. Commenters should address international considerations when describing the pros and cons of any PNT service, technology, or solution. Commenters should also address any international or regional harmonizations and interoperability efforts involving various PNT technologies and solutions discussed herein or in their comments.

42. *Economic Considerations*. We seek comment on the economic considerations associated with developing and deploying complementary PNT technologies. GPS is an example of what economists term a "non-rivalrous" good because the consumption of GPS by one person does not reduce the amount available to others.[101] While it is possible to exclude users from some non-rivalrous goods, such as GPS, allowing free access to such a good has the advantage that it allows more people to benefit from consuming the good. This was the case in the adoption of GPS technology. When DOD opened up the GPS technology to civilian use, it did so without charging for use.[102] Since then, the technology has been widely adopted and has generated significant economic benefits, through both direct consumption benefits and positive spillover effects on many different areas of the U.S. economy.[103]

43. In general, the Commission prefers to rely on market forces to determine the most efficient technologies to serve the public interest. Given that these PNT technologies are considered non-rivalrous and the marginal cost of adding users is zero, however, we ask whether it would be most efficient for the government to fund and deploy the new PNT technologies and then make them available for free private use. For instance, might public provision of PNT technologies that are free for end-users encourage ubiquitous adoption more effectively than private provision? Conversely, could public provision diminish incentives to improve and invest in superior PNT technologies in the future? More generally, what are the unintended consequences of public provision? What are the trade-offs between public and private provision?

44. Alternatively, if private entities develop and deploy these new technologies, will the market be able to determine the most efficient technologies, in the specific context of the development of PNT technologies? If there are multiple entities promoting their own PNT solutions, will the market identify the single technology or small set of technologies that could most efficiently address the needs of both government and private users? Alternatively, should we rely on one or more industry standard setting bodies to identify the most promising PNT technologies? If so, which industry standards bodies are best positioned to make this kind of decision? If multiple complementary or alternative PNT applications are to be deployed, how could interoperability be facilitated through the standards process or other means?

45. If private entities are relied upon to develop and deploy the new PNT technology, how will that entity or entities fund its initial investment in research and development and network infrastructure, and how will it recover its investment over time? If those entities choose to charge for access to the alternative PNT network, will this result in efficient adoption and use of the new technology given the non-rivalrous nature of PNT technology? Relatedly, to the extent that the Commission or an industry standard-setting body were to adopt a single terrestrial PNT standard and grant a single entity

(Continued from previous page)
band for all angles of elevation. The resolution further states that, in order to achieve this objective, administrations operating or planning to operate RNSS systems shall agree cooperatively, through consultation meetings, to an equitable shared aggregate epfd level.

[101] *Alabama Power Co. v. FCC*, 311 F.3d 1357, 1369 (11th Cir. 2002) ("*nonrivalrous* . . . means that use by one entity does not necessarily diminish the use and enjoyment of others. A common example of a nonrivalrous good is national defense.").

[102] *See* 10 U.S.C. § 2281(b) (directing DOD to "provide for the sustainment and operation of the GPS Standard Positioning Service for peaceful civil, commercial, and scientific uses on a continuous worldwide basis free of direct user fees").

[103] *See supra* paras. 1, 7-9, 12.

exclusive rights to use that standard, would that confer market power on the entity holding the exclusive rights which it could exploit?[104] Would the exercise of such market power be sufficiently constrained by the continued presence and use of GPS and other PNT technologies? Or would the Commission or some other body need to consider adoption of additional safeguards against the exploitation of this market power?

46. Given the potential difficulties in funding the development and deployment of alternative PNT technologies by private entities, should the Commission consider ways to minimize deployment costs? For example, would a new PNT technology be more likely to be deployed if it could be deployed on top of an existing network infrastructure, such as existing television stations or 5G NR networks?

47. Assuming that we want to maximize coverage in the United States of a new PNT technology, should we encourage a single entity to bear the cost of deploying any necessary infrastructure or should we encourage multiple parties to deploy it? If we seek to facilitate the deployment of PNT technology by multiple parties, how do we ensure that it is efficiently and ubiquitously deployed? Once a PNT solution is established, for example by the adoption of an industry standard, will equipment manufacturers voluntarily incorporate the new technology in their equipment or will the Commission need to provide incentives to incorporate this new technology into devices? If so, what form should those incentives take?

4. Specific Considerations related to Space-Based or Terrestrial-Based PNT Technologies

48. We seek comment on space-based PNT technologies and services that could complement or augment existing PNT services or provide an alternative PNT service in the United States. Are there GPS augmentation technologies or systems that would benefit from Commission action? Are there opportunities for the Commission to promote greater interoperability of foreign GNSS or other PNT applications with traditional GPS bands and applications for global, national, and/or local coverage and operation, including indoor operation? Would greater interoperability with other GNSS constellations (such as Galileo) increase resilience and resistance to jamming and spoofing? Commenters should discuss whether foreign GNSS have different or similar benefits and challenges to the United States' GPS technology, notwithstanding security concerns involving foreign GNSS that are discussed below. What can the Commission do to support and study the use of new technologies or frequencies for GNSS? Further, we seek comment on the viability of LEO or GEO systems to provide PNT services or data, either an additional primary function or a secondary source of data for PNT services.[105]

49. Similarly, we seek comment on the ancillary or opportunistic use of terrestrial-based technologies that could generate or collect data to support PNT technologies and solutions. As an example, in 5G systems, positioning methods use measurements from broadcast signals or point-to-point signals intended for communication purposes. How can the Commission incentivize developers to generate and collect PNT data, if useful, such as the efficient "re-use" of 5G signaling for PNT applications? We also seek comment on the use of crowd-sourced data in PNT technologies (e.g., Wi-Fi-based positioning). Should PNT technologies for mission critical applications be restricted in their use of crowd-sourced data due to vulnerabilities such as data poisoning? On the other hand, how can crowd-sourced data be used to enhance existing PNT technologies such as GPS? In general, how might

[104] This situation resembles the problem of standard essential patents, where a patent that is not that important *ex ante*, may become significantly more important if it is adopted in an industry standard. *See, e.g.*, Josh Lerner & Jean Tirole, *Standard Essential Patent*, 123 J. Pol. Econ. 547 (2015); Joseph Farrell, John Hayes, Carl Shapiro & Theresa Sullivan, *Standard Setting, Patents, and Hold-Up,* 74 Antit. L. J. 603 (2007).

[105] *See, e.g.*, Nabil Jardak & Ronan Adam, Practical Use of Starlink Downlink Tones for Positioning (Mar. 18, 2023), https://pmc.ncbi.nlm.nih.gov/articles/PMC10056358/; *see also* Peter A. Iannucci & Todd E. Humphreys, Economical Fused LEO GNSS (Sept. 2020), https://rnl.ae.utexas.edu/images/stories/files/papers/iannucci2020fused.pdf.

equipment, especially for mission critical applications, be better designed to incorporate more robust and diverse positioning capabilities, to opportunistically deliver better positioning reliability for such services?

B. Additional Issues related to Security Risks

50. Given the importance of PNT capabilities to national security, we seek comment on whether there are additional actions that the Commission could take within the scope of its authority to facilitate the security of PNT services and technologies provided to consumers. For example, we seek general comment on the extent to which mobile wireless devices or fixed receivers (such as in surveying or precision agriculture) in the United States are receiving and processing signals from unauthorized non-U.S. GNSS, and whether these signals are being received and processed in violation of the Communications Act, the Commission's rules, or any other statute, rule, or policy. As noted above, Galileo is currently the only non-U.S. GNSS constellation that has sought and received Commission approval for operation in the United States.[106] That said, the Commission is aware that mobile wireless devices in this country are capable of and are receiving unauthorized GNSS signals from Russia's GLONASS and China's BeiDou systems.[107] Accordingly, the Commission launched an inquiry into the matter in order to collect information regarding the extent to which devices may be receiving and processing unauthorized signals and what security threats, if any, may result.[108] What role do the chipset vendors and the mobile wireless providers play in this process in terms of liability or rule applicability? What roles do standards or certification bodies play? Do mobile wireless service providers request chipset configurations that can access GLONASS, BeiDou, or other foreign signals? We also seek comment on the extent to which users or third-party software applications can gain core access to a device. Do device manufacturers, chipset manufacturers, and commercial wireless providers take measures to disable such access? If they take steps to disable the ability of third parties to process unauthorized non-U.S. GNSS signals, what additional security measures are put in place in the devices to prevent unauthorized access or changes by third parties to modify the devices to bypass those security measures?

51. We also seek specific comment on what security threats, if any, these unauthorized signals carry, particularly those coming from our foreign adversaries' GNSS. Some argue that restricting the receipt of signals from foreign GNSS puts the United States at a competitive disadvantage, shifting away from a policy of interoperability and risking fragmenting the global GNSS chipset and receiver device marketplace.[109] Would there be benefits to permitting GNSS signals from foreign constellations (in addition to Galileo) to be received, and if so, what are they? Would the addition of foreign GNSS signals result in better, more accurate PNT data? Would there be competitive advantages to PNT users located in the United States if foreign GNSS signals are permitted? What should the Commission's role be when it comes to the use of foreign GNSS while ensuring that the U.S. communications marketplace is

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[106] *See supra* para. 21.

[107] *See* Letter from Chairwoman Jessica Rosenworcel, Federal Communications Commission, to Representative Mike Gallagher, U.S. House of Representatives (May 14, 2024) (*Gallagher Letter*) (noting that the receipt of unauthorized GNSS signals is in violation of Commission rules); *see also* Benedict Collins, *U.S. Government Probing Security Risks of Mobile Devices Using Russian or Chinese Satellites* (Mar. 15, 2024), https://www.techradar.com/pro/us-government-probing-security-risks-of-mobile-devices-using-russian-or-chinese-satellites.

[108] *Gallagher Letter* at 2.

[109] *See, e.g.*, David Grossman & Lisa Dyer, *Don't Sacrifice U.S. Leadership on GPS to Protect Against Unproven Security Risks* (May 24, 2024), https://breakingdefense.com/2024/05/dont-sacrifice-us-leadership-on-gps-to-protect-against-unproven-security-risks/; *see also* GPS Innovation Alliance, *GPSIA Statement on Foreign GNSS Satellite Signals Used in Receivers* (Mar. 19, 2024), https://www.gpsalliance.org/newsroom/gpsia-statement-foreign-gnss-satellites.

free from foreign threats? What abilities, if any, do foreign adversaries have to selectively affect the signals from their PNT systems being broadcast into other countries? For example, is it possible for GLONASS, BeiDou, and other foreign systems to degrade the signals into North America while leaving their signals into Asia or other areas unaffected? What updated information is available regarding BeiDou's ability to "track" wireless users in the United States given that BeiDou may be using satellite-based messaging services/communication channels?[110] What steps can and should the Commission take to mitigate any threats that exist from foreign adversary systems, such as GLONASS and BeiDou?

52. In addition, pursuant to the Secure and Trusted Communications Networks Act of 2019,[111] and the Commission's rules,[112] the Public Safety and Homeland Security Bureau (PSHSB) publishes and regularly updates a list of communications equipment and services produced or provided by specified entities (Covered List).[113] We seek comment broadly on any potential nexus between the Commission's Covered List and equipment that is currently or prospectively used in PNT solutions. The Covered List identifies equipment that has been determined, by a competent national security entity, to pose an unacceptable risk to the national security of the United States or the security and safety of United States persons.[114] Because of this risk, radiofrequency equipment on the Covered List is not eligible for equipment authorization by the Commission; therefore, such equipment may not be imported, marketed, sold, or operated in the United States unless it was authorized before the Commission's implementing rules became effective.[115] We ask whether any PNT solution (space-based or terrestrial) currently uses equipment identified on the Commission's Covered List,[116] and seek comment on whether and how the Commission should address such use. For example, should we consider prohibiting any communications equipment that now, or in the future, has been placed on the Covered List? Should we consider prohibiting any device or product from a company named on the Department of Commerce's Entity List,[117] DOD's List of Chinese Military Companies,[118] or similar Executive Branch or Legislative Branch

[110] A Staff Research Report conducted by the U.S.-China Economic and Security Review Commission in 2017 expressed concerns regarding "inherent security vulnerabilities in BeiDou-equipped receivers enabling the People's Republic of China to "track" smartphone users." This malware could be inherent to already manufactured chips or be downloaded to a device using the BeiDou satellite-based messaging service. *See* U.S-China Economic and Security Review Commission, China's Alternative to GPS and its Implications for the United States at 8 (2017), https://www.uscc.gov/sites/default/files/Research/Staff%20Report_China%27s%20Alternative%20to%20GPS%20and%20Implications%20for%20the%20United%20States.pdf.

[111] Secure and Trusted Communications Networks Act of 2019, Pub. L. No. 116-124, 133 Stat. 158 (2020) (codified as amended at 47 U.S.C. §§ 1601-1609) (Secure Networks Act).

[112] 47 CFR §§ 1.50002, 1.50003.

[113] *See* Federal Communications Commission, *List of Equipment and Services Covered by Section 2 of The Secure Networks Act*, https://www.fcc.gov/supplychain/coveredlist (last updated Sept. 3, 2024) (Covered List).

[114] Secure Networks Act § 2(b)(1); 47 CFR § 1.50002(b)(1).

[115] *See Protecting Against National Security Threats to the Communications Supply Chain through the Equipment Authorization Program*, et al., ET Docket No. 21-232, Report and Order, Order, and Further Notice of Proposed Rulemaking, 37 FCC Rcd 13493 (2022).

[116] *See* Covered List; *see also* Secure Networks Act; 47 CFR § 1.50000 et seq.

[117] *See, e.g.,* Bureau of Industry and Security, *Supplement No. 4 to Part 744 – Entity List* (May 19, 2023), https://www.bis.doc.gov/index.php/documents/about-bis/newsroom/press-releases/3273-2023-05-19-bis-press-release-russia-rules-and-joint-bis-fincen-alert/file.

[118] *See, e.g.*, U.S. Department of Defense, *Entities Identified as Chinese Military Companies Operating in the United States in Accordance with Section 1260H of the William M. ("Mac") Thornberry National Defense Authorization Act for Fiscal Year 2021 (Public Law 116-283)* (Oct. 5, 2022) https://media.defense.gov/2022/Oct/05/2003091659/-1/-1/0/1260H%20COMPANIES.PDF.

lists of foreign adversary entities?[119] Are there other products or categories of products that we should explicitly prohibit as viable PNT solutions?

C. Potential Commission Efforts to Promote PNT Resiliency

53. In assessing the development of PNT technologies and services by private industry described above, we seek comment on specific actions that the Commission can take to support the development of diverse, robust, and reliable PNT.

1. Changes to Policy, Rules, or Allocations

54. We seek comment on the Commission's existing policies and rules applicable to PNT and on whether we should amend existing rules or adopt new rules, consistent with the Commission's rulemaking authority under current statutes, to promote adoption of complementary and alternative PNT services, such as allocation rules for a particular band, service rules, or equipment authorization rules to allow certain PNT technologies. We seek comment on service or operational rules that should be adopted or amended. Can existing and developing PNT technologies operate within current Commission rules and policies? Commenters should specify existing rules that support PNT and identify what, if any, amendments should be adopted to further support PNT services. Are changes needed to frequency allocations, service rules, equipment authorization rules, or other aspects of the Commission's rules? What new rules would support PNT services, and why are they needed? We also seek comment on whether there are any market inefficiencies that could be addressed by changes to the Commission's rules. How can the Commission encourage the development of PNT security and reliability? Could this involve the adoption of performance standards or other rules for PNT equipment?

55. Next, we seek comment on whether any of our existing rules impede PNT investment, research, and development. Commenters should identify existing regulatory barriers hindering the continued development of PNT services. We ask commenters to identify regulations that are outdated or unnecessarily burdensome to the development and deployment of PNT services, and whether the Commission should update, forbear from applying, or eliminate any of these existing rules in order to best support PNT technologies and solutions.

56. In order to move toward adopting or changing our rules to facilitate the development of PNT services, we seek comment on whether or not we should adopt specific definitions for key terms that ensure a consistent framework. If so, we seek comment on which specific terms to define, how to define them, and how best to incorporate them into our rules.[120]

57. Are there other actions that the Commission can take to facilitate the development and deployment of new PNT technologies such as changes in spectrum policy? What actions can the Commission take to support the efforts of federal agencies to improve PNT resiliency and increase the capabilities of PNT systems? Are there certain spectrum bands particularly well-suited for delivering PNT as compared to other bands? What are the trade-offs? Assuming that the new PNT technology operates on radio spectrum, can the technology take advantage of already-licensed spectrum or must spectrum be allocated specifically? If we decide to support a PNT solution that requires dedicated spectrum, should we grant a single nationwide license or multiple geographically limited licenses? What are the relative costs and benefits of the different licensing structures? Would existing spectrum users need to be relocated or can they co-exist with a variety of PNT technologies? To the extent a particular technology requires the use of a particular spectrum band, does that increase the difficulty of deploying it internationally? Are there allocation issues associated with RF-based PNT technologies and solutions? How can the Commission promote resiliency, security, and effective coexistence with other spectrum users between PNT technologies, and reduce the threat of jamming and spoofing? What are the

[119] 15 U.S.C. § 9901(c)(2). *See also* 15 U.S.C. § 9901(c)(4) (defining "foreign adversary" more narrowly than the Executive Branch list to only include China, Russia, Iran, and North Korea).

[120] *See supra* note 4.

technological and economic trade-offs of commenters' preferred approaches noting some of the considerations described above?

58. We note that the Commission has typically pursued a policy of technology neutrality, and we seek comment on whether changes are appropriate to ensure our rules remain technologically and competitively neutral as PNT technologies and services are developed. Commenters should identify whether any of our existing rules unfairly advantage or disadvantage one PNT technology over another. We ask commenters to identify these rules and suggest changes that would address these concerns. What changes are necessary to ensure our rules remain technologically neutral? Commenters should identify other challenges that entities deploying PNT services may face in complying with existing authorization, operational, and service rules.

2. Legal Authority

59. The Commission has broad authority under Title III of the Act to manage the use of radio spectrum, to prescribe the nature of wireless services to be rendered, to modify existing licenses when doing so would promote the public interest, and to encourage the deployment on a reasonable and timely basis of advanced telecommunications capability.[121] We also have broad authority to oversee and promote the 911 system as the universal emergency telephone number within the United States and a mandate to promote its use and reliability.[122] Further, section 7 of the Act provides that it is a national policy to encourage the provision of new technologies and services to the public, and directs the Commission to timely consider whether any new technology or service proposed in a petition, application, or on its own motion is in the public interest.[123] We welcome comment on other sources of Commission authority to promote or support RF-based PNT development.

3. Support for Public-Private Partnerships

60. The Commission seeks comment on existing public-private partnerships that it should support to develop PNT technology and services. What are the opportunities for public-private partnerships in developing or advancing PNT technologies and solutions? Are there existing public-private partnerships that the Commission should begin to support for the development of PNT technologies and services? Should the Commission support research and development of PNT technologies through public-private partnerships? If so, what role or functions should the Commission perform? Are there academic partnerships that the Commission should consider joining or starting? What approaches would further foster end user adoption?[124]

61. Testbeds are sometimes used by the Commission and by industry at the direction of the Commission, to test and develop new technologies. Should testbeds for private industry be established to support the development and deployment of PNT technologies and services? If so, what role should the Commission play, either on its own or in partnership with other organizations, to encourage the development of PNT technology and demonstrate its capabilities? Are there distinct features of PNT technologies and services that should be explored through such testbeds or demonstration projects? How can the Commission incentivize stakeholder participation in testbeds and/or demonstration projects? Would different types of testbeds be needed depending on the specific purpose being tested?

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[121] *See, e.g.*, 47 U.S.C. §§ 301, 302a, 303, 309, 1302(a).

[122] *See*, *e.g.*, 47 U.S.C. §§ 251(e)(3), 615-615c.

[123] 47 U.S.C. § 157.

[124] For example, we note that DOT has encouraged partnerships between PNT technology vendors and critical infrastructure owners and operators to facilitate adoption and use of Complementary PNT technologies. *See* Inside GNSS, "DOT Issues Follow-Up Solicitation for Complementary PNT Testing and Evaluation" (Feb. 14, 2024) https://insidegnss.com/dot-issues-follow-up-solicitation-for-complementary-pnt-testing-and-evaluation/.

62. The Commission has established Innovation Zones under the experimental license rules.[125] These designated zones provide opportunities for qualified licensees to test new advanced technologies and prototype networks outside a traditional small campus or laboratory setting. Could Innovation Zones, either those already established or new zones, provide opportunities to test and verify the security and operational benefits associated with PNT technologies and services? Are there adjustments that we might need to make to these Innovation Zones to better enable PNT technologies and services testing? We seek comment on these issues.

IV. PROCEDURAL MATTERS

63. *Ex Parte Rules*. The proceeding this *NOI* initiates shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules,[126] with a limited exception described in the following paragraph. Although the Commission's rules provide that Notice of Inquiry proceedings are generally exempt from the disclosure requirements that typically apply in rulemakings, we here find pursuant to 47 CFR § 1.1200(a) that it is in the public interest to adopt rulemaking-like permit-but-disclose procedures in order to provide maximum transparency and in light of our intent to expeditiously consider potential Commission actions based on the record collected here. Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (*e.g.*, .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

64. Because Commission staff regularly participate in interagency discussions where potential approaches to PNT are explored, oral and written *ex parte* presentations to and from staff of other Federal agencies will be exempt from any disclosure requirements during this Notice of Inquiry phase.

65. Pursuant to sections 1.415, 1.419, and 1.430 of the Commission's rules, 47 CFR §§ 1.415, 1.419, 1.430, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS). Commenters should refer to WT Docket No. 25-110 when filing in response to this Notice of Inquiry.

- *Electronic Filers*: Comments may be filed electronically using the Internet by accessing the ECFS: https://www.fcc.gov/ecfs.

[125] *FCC Announces Two New Innovation Zones & Amends One Existing Innovation Zone for Program Experimental Licenses*, ET Docket No. 19-257, Public Notice, 36 FCC Rcd 12866 (2021).

[126] 47 CFR §§ 1.1200 *et seq.*

- *Paper Filers*: Parties who choose to file by paper must file an original and one copy of each filing.
    - Filings can be sent by hand or messenger delivery, by commercial courier, or by the U.S. Postal Service. **All filings must be addressed to the Secretary, Federal Communications Commission.**
    - Hand-delivered or messenger-delivered paper filings for the Commission's Secretary are accepted between 8:00 a.m. and 4:00 p.m. by the FCC's mailing contractor at 9050 Junction Drive, Annapolis Junction, MD 20701. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes and boxes must be disposed of before entering the building.
    - Commercial courier deliveries (any deliveries not by the U.S. Postal Service) must be sent to 9050 Junction Drive, Annapolis Junction, MD 20701.
    - Filings sent by U.S. Postal Service First-Class Mail, Priority Mail, and Priority Mail Express must be sent to 45 L Street NE, Washington, DC 20554.

66. *People with Disabilities*: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530.

67. *Further Information*. For additional information on this proceeding, contact Melissa Conway of the Wireless Telecommunications Bureau, at Melissa.Conway@fcc.gov or (202) 418-2887.

V. ORDERING CLAUSES

68. Accordingly, IT IS ORDERED, pursuant to sections 1, 2(a), 4(i), 201(b), 301, 302(a), 303(g), 332, and 403 of the Communications Act of 1934, as amended, the Wireless Communications and Public Safety Act of 1999, as amended, and the Twenty-First Century Communications and Video Accessibility Act of 2010, 47 U.S.C. §§ 151, 152(a), 154(i), 201(b), 251(e), 301, 302a(a), 303(g), 332, 403, 615-615c, and section 1.430 of the Commission's rules, 47 CFR § 1.430, that this *Notice of Inquiry* IS ADOPTED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

STATEMENT OF
CHAIRMAN BRENDAN CARR

Re: *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, WT Docket No. 25-110 (Mar. 27, 2025).

For all the space weather fans out there, May 10, 2024, was a pretty epic evening. That's because the Northern Lights were clearly visible across large swaths of the country for the first time in decades—lighting up the sky in a mix of greens and reds and purples.

Many of our country's farmers will never forget that day for a different reason. The massive solar storm that produced those Northern Lights also shut down planting operations across the American Midwest by knocking out GPS. As Kevin Kenney, a Nebraska farmer, put it, "All the tractors are sitting at the ends of the field right now shut down because of the solar storm ... No GPS."

Agriculture is just one facet of modern American life vulnerable to GPS disruptions. Our electric grid. Our financial systems. Our ports. Our communications networks. Our military. Our driving directions. You name it. All rely on GPS to provide Positioning, Navigation, and Timing, or PNT, data. To punctuate the point that GPS is everywhere, I would note that the other main items on the Commission's agenda today are about Next-Generation 911 and location accuracy, services that depend on GPS.

For years, federal leaders have been pushing for action to ensure we have a resilient system in place to provide Positioning, Navigation, and Timing data in case GPS is disrupted or degraded—including through intentional, malicious acts. In 2018, Senators Ted Cruz and Ed Markey passed a bipartisan law to create a reliable alternative timing system to GPS satellites. In 2020, President Trump issued an Executive Order calling on federal agencies to enhance PNT resilience.

Other countries are moving quickly to stand up GPS alternatives. For instance, China and Russia have backups for PNT services, and it will serve our own national security and economic interests to ensure that the U.S. has one too.

Achieving that goal will require a whole-of-government approach. Today, the FCC is stepping up to do its part. But we couldn't do it alone. I want to thank NTIA in particular for communicating the interests of federal stakeholders and ensuring that this proceeding allows us to build a complete and thorough record.

With this inquiry, we will explore other PNT systems that can be complements or alternatives to GPS, with an emphasis on complementary systems. Beyond answering technical questions, we hope this effort will engage stakeholders across government and industry to encourage the development of new PNT technologies and solutions.

Finally, I would like to thank the FCC staff for their hard work on this item, especially Barbara Esbin, Roger Noel, Linda Chang, Melissa Conway, and David Hu of the Wireless Telecommunications Bureau.

STATEMENT OF
COMMISSIONER GEOFFREY STARKS

Re: *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, WT Docket No. 25-110 (Mar. 27, 2025).

The Commission regularly addresses issues at the intersection of technological innovation and national security. This Notice of Inquiry (NOI) holds the potential to make progress on both fronts. Positioning, navigation, and timing (PNT) services underpin the modern economy while providing a vital function for America's military. Though the Global Positioning System (GPS) continues to serve its users effectively, the lack of alternative systems is a vulnerability that necessitates action.

As other countries make progress developing and deploying new PNT systems, it's imperative that the United States keep pace. This NOI asks the right questions about what we need to ensure that any system or system of systems we deploy to advance America's PNT needs are resilient, efficient, and secure.

I want to thank the staff of the Wireless Telecommunications Bureau for work on this item. It has my full support.