RESILIENT NAVIGATION and TIMING FOUNDATION
Speaking Up for GPS/GNSS Users

April 25, 2025

VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

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

Dear Ms. Dortch:

The Resilient Navigation and Timing Foundation (hereafter RNTF) is a public benefit 501(c)(3) scientific and educational charity. We advocate for policies and systems to protect, toughen, and augment America's positioning, navigation, and timing (PNT), especially the Global Positioning System (GPS). Our organizational role is to also educate government, industry and end-users on the increasing role of GPS and PNT in a critical infrastructure and applications and its national, homeland and economic security implications.

As a 501(c)(3), RNTF is prohibited from supporting our members' commercial interests. We make every effort to provide the government and public with advice that is as impartial and objective as possible.

Our RNTF individual and corporate members represent experience across a broad spectrum of space-based and terrestrial PNT (T-PNT). This experience and interactive expertise gives us a unique and comprehensive perspective on issues and technology, as well as giving us insight on government/private sector coordination related to national PNT policy and systems.

The RNTF Board of Directors reflects the organization's civil and military PNT experience. The chairman of the RNTF board is a former Assistant Secretary of Transportation, the Honorable Greg Winfree. Our president, Dana Goward, is a retired senior Coast Guard officer and former member of the federal Senior Executive Service who served as the maritime navigation authority for the United States. Another board member is General William Sheldon, U.S. Air Force (ret), the former Commander of USAF Space Command. All three are also members of the President's National Space-based Positioning, Navigation, and Timing Advisory Board (PNTAB). The PNT Advisory Board is the principal expert group that informs both defense and civil agency leads for GPS and other PNT issues. This extends to future generation PNT, international PNT, spectrum allocation, and coordination among our international counterparts. The PNTAB regularly provides recommendations to government and periodically formalizes them in reports.

As the commission has observed, the PNT services provided by GPS have become invaluable to every sector of the economy. The economic and public safety impact of their loss would be devastating and is likely incalculable. The negative impact would certainly be far

greater than the billion dollars a day estimated by one government study that examined only a handful of sectors.[1]

We are very pleased to see the Commission's interest in improving America's security and positioning, navigation, and timing (PNT) architecture and want to support that effort as much as possible.

The extensive Notice of Inquiry (NOI) reflects the wide range of technology and policy issues surrounding establishment of a more robust, resilient, and secure PNT architecture for the United States. Considering the limited timeline for reply, and the availability of government, academic, and commercial technical resources that address all of the commission's technical questions, we are confining our comments as to how the Commission may best achieve its goals as stated in the notice.

Responses to many of the Commission's questions are attached. We especially want to highlight:

Our National Goal – Our goal must be to protect the nation by eliminating PNT as a critical vulnerability. A single point of failure. Every American uses GPS and participates in our economy, national security, and societal stability in some way. To minimize our PNT vulnerability and maximize security, every American must have easy access to utility-level resilient PNT. Barriers to adoption must be as low as possible and the government must do all it can to encourage adoption.

The government must ensure a resilient National Core PNT Architecture is established that includes GPS and one or more methods of nationwide PNT delivery that are as diverse from each other as possible.

PNT Markets – America has two markets for PNT.

- Specialized PNT serves high demand users. Numerous companies sell a range of highly accurate and/or resilient services by either enhancing the performance of GPS and other GNSS, or providing GPS-independent time, location, or PNT.

- Utility-level PNT is provided by GPS and serves all Americans. It supports infrastructure, IT and an abundance of applications. The reliability of GPS, popular perception that PNT is the responsibility of the government, and individuals' unwillingness or inability to pay for GPS alternatives have frustrated numerous companies attempting to establish services for the mass market. Indeed, in a filing with

[1] The Billion Dollar a Day Mistake https://www.gpsworld.com/the-billon-dollar-a-day-gps-mistake/ We also note that grossly underestimating the impact of GPS disruption or destruction has a highly negative impact upon risk analyses and the ability of leadership to make decisions based upon cost versus benefit. We know of at least one government-contracted report that found investment in a GPS alternative or backup would not be cost effective because of the low fiscal impact of an outage.

the Commission, an aspiring provider specifically stated there is no mass market. The government acting to protect the nation is the only way to establish this capability.

Fair and Open Competition – America has an abundance of non-profit and commercial entities capable and willing to provide utility-level PNT systems and services that can contribute to a resilient National Core PNT Architecture. Fair and open competition based on well articulated requirements is the only way to select one or more providers. Giving material support to one or more potential providers in the absence of a fair and open competition would be harmful to the nation's resilient PNT efforts.

Whole of Government Approach – We are gratified to see the Commission's understanding of the complexity of PNT policy issues and authorities, and its commitment to working with the administration and Congress. Based on 25 years of participation in and observation of federal PNT policy, we are convinced that unilateral action by any one federal entity will fail and likely be counterproductive.

Again, we are very pleased to see the Commission's concern and interest in resilient PNT. We are eager to provide additional information and assist the Commission's efforts in any way we are able.

Dana A. Goward, President

Attachments:

1 - Summary of recommendations and observations
2 – Obtaining information about alternative PNT technologies
3 - Incentivizing and Supporting Industry Efforts to Develop Solutions
4 - Risks from foreign GNSS
5 - Facilitating more capable and resilient PNT
6 - Ways to collaborate with industry and government
7 – Ways to Maintain US PNT Leadership and Mitigate Adversarial Disruptions
8 - Economic Considerations
9 - A Government Provided Utility or Market Forces?

1 - Summary of recommendations and observations

Obtaining information about alternative PNT technologies

Exercise care evaluating PNT Technologies,

Select PNT technologies through fair and open competition,

Maintain Commission expertise by establishing a small PNT staff, an advisory body of experts, and through regular participation in national PNT governance.

Incentivizing and Supporting Industry Efforts to Develop Solutions

The Commission must collaborate and coordinate with federal departments and agencies before supporting any development effort.

The Commission should devote minimal resources to fostering development of new PNT technologies.

Risks from foreign GNSS

We believe there is substantial evidence to show that reception of non-U.S. GNSS signals, per se, poses very little risk to consumers.

We recommend the Commission consider its authority to regulate receivers and, as appropriate:

- Help ensure the supply chain security of GNSS receivers to prevent import and/or use of compromised devices able to receive, assemble, and transmit malware, or provide false position and time on command, or otherwise inhibit operation of dependent systems or devices.
- Take additional steps to ensure Bei Dou devices capable of two-way communication with satellites are not imported or used within the United States.
- If Bei Dou or other GNSS devices capable of two-way communication ever become available and used the in the United States, help ensure they are clearly marked and users are fully aware of the system's ability to track users' location and interact with associated devices and systems.

Facilitating more capable and resilient PNT

The Commission should <u>not</u> provide material support to one PNT technology or company over others without a fair and open competition.

The Commission should engage with the administration and Congress in a whole-of-government effort to contract for and implement a limited number of easily adoptable non-GPS PNT technologies for federal and public use. This will also provide a resilient National Core PNT Architecture upon which others can innovate and build.

Ways to collaborate with industry and government

Maintain Commission expertise by establishing a small PNT staff, an advisory body of experts, and through regular participation in national PNT governance**.**

Ways to Maintain US PNT Leadership and Mitigate Adversarial Disruptions

Ensure enforcement officials are quickly able to detect and locate malicious and accidental interference with GPS and GNSS signals.

Empower federal, state, local, and tribal law enforcement to locate, terminate, and sanction interference with GPS.

Ensure Commission enforcement staff is sufficiently resourced to partner with other federal agencies and state, local, and tribal enforcement organizations.

Actively advocate for establishing a secure national GNSS augmentation system along the lines of HARS (High Accuracy Reference System) based on existing US national assets

Economic Considerations

Every American contributes to the economy and the nation's overall security and stability. Eliminating PNT as a critical economic and security vulnerability means every American must have unfettered access to utility-level resilient PNT.

A Government Provided Utility or Market Forces?

The goal of our national efforts must be to maximize national and economic security. This requires maximizing adoption. Maximum adoption requires the fewest possible barriers to entry and the greatest amount of government encouragement.

Public provision of new, utility-level PNT free to users will unquestionably encourage ubiquitous adoption more effectively than would be possible with a private fee-for-service model. It will be more efficient and effective at:

- Protecting national and economic security,
- Providing the service,
- Lowering the cost of user equipment, and
- Spurring innovation in new applications and systems.

Note that we strongly recommend this be done through contracts for services with commercial entities. This will facilitate quicker implementation, better enable innovation and upgrades, and will likely have a lower lifecycle cost.

Public provision of resilient utility-level PNT will not disincentive innovation. The federal government has provided Americans free-to-use RF-based utility-level PNT for

over 70 years. This has stimulated improvements and innovation to the point where U.S. companies lead the world in the variety of PNT technologies invented.

A federal contract for utility-level PNT to protect its systems and applications should be extended to protect the nation as a whole.

2 – Obtaining Information about alternative PNT technologies.

Para 3 "…We also seek information regarding alternative PNT technologies and solutions that may better achieve PNT resilience nationwide."

Exercise care evaluating PNT Technologies – The NOI asks about the details of a number of technologies and invites information about others not mentioned. When reviewing the information it receives the commission should consider the following:

- **Documentation** - The NOI makes a number of references to documents originated or sponsored by commercial offerors. While perhaps a good starting point for inquiries, more independent evaluations are, of course, preferrable. Peer reviewed papers presented at the Institute of Navigation are good resources. Also, two technologies mentioned in the NOI have been evaluated by government entities. The Broadcast Positioning System has been assessed by the National Institutes of Standards and Technology. eLoran is being transmitted from three locations by the Department of Defense. However, since that work may be classified, the Commission may wish to consult the research and development arm of the General Lighthouse Authorities of the United Kingdom and Ireland. We are happy to make introductions.

- **Demonstrations verses Evaluations** – Both the U.S. Department of Transportation (DOT) and the European Space Agency (ESA) have hosted demonstrations of various PNT technologies. While interesting and informative, neither was based on a set of requirements nor did they conduct adversarial testing to assess systems' ability to withstand interference.

  In the case of the DOT event the department described it as 'an opportunity for vendors to showcase their products in the best light.' As an example of how this played out, one vendor was allowed to place 12 transmitters in an approximately one-tenth of a square mile area. Another placed 18 in an approximately half square mile area. Such densities would clearly be impractical for other than fairly confined service areas.

  Both demonstration programs were also limited in the number and type of systems that could participate. Limited funding for the DOT demo meant that some vendors were not selected. And the ESA demo was limited to systems that could be inexpensively transported to a facility in Italy. This meant that long range transmitters requiring large towers and the like were not eligible.

Select PNT technologies through fair and open competition. Fair and open competition is the only way to find "the best" system or service. Such an acquisition would include:

- Clearly defined threshold and objective performance requirements to articulate and determine "the best" system performance, and
- Assuring "the best" balance of public benefit and cost.

Supporting one PNT provider in the absence of a competition and acquisition would achieve the opposite of the Commission's stated goal of incentivizing development of systems as it would drive the market toward the supported system.

Maintain Commission expertise by establishing a small PNT staff, an advisory body of experts, and through regular participation in national PNT governance.

PNT is and will continue to be an essential national utility, The technologies will continue to evolve. The Commission should maintain its expertise by creating a small PNT-focused office and/or an expert advisory body under the Federal Advisory Committee Act (FACA). An advisory group could be composed of unpaid Special Government Employees and representatives from industry with expertise and experience in PNT policy as well as terrestrial and space-based PNT.[2] Regular public meetings of this FACA group would provide the opportunity for private and commercial entities to interact with the Commission on PNT issues. Establishing this group would provide the commission continuous access to expertise and help it remain current with developments in the field.

The commission has been invited to participate in the National Space-based Positioning, Navigation, and Timing Executive Committee since the committee's creation in 2004 by National Security Presidential Directive 39. It is our understanding the Commission has rarely taken advantage of the opportunity. Participating in this and other national PNT governance structures will foster the "whole of government" approach the Commission desires.

[2] Until recently, NASA sponsored the National Space-based Positioning, Navigation, and Timing Advisory Board. A group of experts in terrestrial, space-based, and autonomous PNT advising the Commission could be useful.

3 - Incentivizing and Supporting Industry Efforts to Develop Solutions

Para 3. "…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."

The Commission must collaborate and coordinate with federal departments and agencies before supporting any development effort. Our rationale is that:

- This will help avoid duplication of effort and ensure the commission has the benefit of other government experts concerning the viability and desirability of a proposed project, and
- Some technologies that may be part of a system-of systems architecture do not involve use of radio frequencies and are beyond the commission's purview. This is especially true of many needing further validation or development. These include various forms of magnetic and magnetic flux, visual/map matching, advanced inertials, celestial, quantum timekeeping, and quantum sensing.

The Commission should devote minimal resources to fostering development of new PNT technologies.

Scientific and technological progress is always desirable. However:

- The U.S. government has been studying, evaluating, and supporting development of these technologies nearly continuously for the last two decades.
- The availability of complementary and alternative PNT technologies is not the problem. America already has a wealth of e technologies available as services or for outright acquisition.
- The nation's challenge is that the federal government, with a few minor exceptions, has not acted to protect its own IT systems and applications with one or more complementary or alternate technologies. This has caused users to:
    - Discount government warnings about vulnerabilities,
    - Be unsure as to which systems and services are effective, and most importantly,
    - Be unsure as to which systems and services will be available for the long term and therefore worth the time and money to incorporate into their enterprises.
- The commission's support of any development effort in the absence of a fair and open competition would be seen as unfair, especially if it involves a technology or system offered by only one company.

4 - Risks from foreign GNSS

Para 3 "…how the Commission can address potential risks from consumer devices connecting to foreign PNT systems."

We believe there is substantial evidence to show that reception of non-U.S. GNSS signals, per se, poses very little risk to consumers. We have documented this on our website and included a link to a peer-reviewed paper.[3]

As we postulate in our web-post, if an adversary were to attempt to transmit malware with a GNSS signal, they would likely do so, not with their own signals, but with a GPS-like signal (spoofing). In this scenario, not using foreign GNSS would provide no protection.

Malware transmitted with GNSS signals can only be effective if a receiver has been previously compromised. Only a compromised device would be able to assemble a virus and infect operating systems and applications to which it was connected.[4]

A related concern has also been expressed in some quarters about Bei Dou's ability for two-way communication with user devices. Such devices must be larger and more powerful than normal GNSS user equipment to transmit signals into space. It should be apparent to users from markings, instructions, and the physical configuration of the equipment when they are in possession of a two-way Bei Dou device.

We recommend the Commission consider its authority to regulate receivers, and as appropriate:

- **Help ensure the supply chain security of GNSS receivers** to prevent import and/or use of compromised devices able to receive, assemble, and transmit malware, or provide false position and time on command, or otherwise inhibit operation of dependent systems or devices.
- **Take additional steps to ensure Bei Dou devices capable of two-way communication with satellites are not imported or used within the United States**, and
- If Bei Dou or other GNSS devices capable of two-way communication ever become available and used the in the United States, help ensure they are clearly marked and users are fully aware of the system's ability to track users' location and interact with associated devices and systems.

[3] See our post and associated Institute of Navigation paper at https://rntfnd.org/2024/04/25/can-we-use-their-satellites-fear-and-loathing-in-medium-earth-orbit/

[4] ibid

5 - Facilitating more capable and resilient PNT

Para 3 "How the Commission can facilitate more capable and resilient PNT technologies…"

The Commission should not provide material support to one PNT technology or company over others without fair and open competition. This would stifle innovation. By driving investors and customers toward the favored company and away from the large number of companies offering and/or developing other technologies.

The Commission should engage with the administration and Congress in a whole-of-government effort to contract for and implement a limited number of easily adoptable non-GPS PNT technologies for federal and public use. This will also provide a resilient National Core PNT Architecture upon which others can innovate and build. As we discuss elsewhere, this is unquestionably in the best interest of our national and economic security.

6 - Ways to collaborate with industry and government

Para 4 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."

See our earlier comments and recommendations in item 1 regarding "**Maintain Commission expertise by establishing a small PNT staff, an advisory body of experts, and through regular participation in national PNT governance."**

7 – Ways to Maintain US PNT Leadership and Mitigate Adversarial Disruptions

Para 16 "…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."

Para 17 "Our intent is to develop a set of actionable solutions to the GPS challenges we identify within the scope of our statutory authority."

As the Commission observes in the NOI, actors within the executive branch and Congress have much more authority and capability to impact these issues. In addition to the recommendations earlier in this document, we recommend the Commission:

Ensure enforcement officials are quickly able to detect and locate malicious and accidental interference with GPS and GNSS signals.

Both malicious and accident interference are a concern.

The FBI has long reported that interference GPS devices is a favorite tool of criminals[5] and some high visibility cases have been reported in the media.[6]

Accidental interference is undoubtably more common, though. A sampling study sponsored by the European Space Agency found hundreds of thousands of signals that could interfere with reception of GNSS. It also identified over 300 "families" of jamming devises, though only about 14% of the adverse signals were deemed intentional.[7]

Low-level, accidental interference occurs daily in the United States causing a myriad of minor inconveniences, inefficiencies, and mishaps. Occasionally they become visible and threaten broad impacts as was the case at the Denver and Dallas airports in 2021, and with the near-loss of a passenger airliner in 2019.[8]

We understand the Department of Transportation and Department of Defense have partnered and are implementing a national GPS interference detection network.[9] The Commission should help ensure the system is sufficient to support rapid enforcement and mitigation efforts at every level of government and society.

Empower federal, state, local, and tribal law enforcement to locate, terminate, and sanction interference with GPS.

Interference with GPS signals is a significant, geographically dispersed violation of federal law. Intentional interference is often associated with other illegal acts and, when detected, could

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[5] https://info.publicintelligence.net/FBI-CargoThievesGPS.pdf
[6] See for examples https://rntfnd.org/2024/11/26/gps-spoofing-helps-in-1000000-theft-of-celebrity-tequila/ and https://www.dco.uscg.mil/Featured-Content/Proceedings-Magazine/
[7] https://www.gps.gov/governance/advisory/meetings/2018-05/dumville.pdf
[8] https://rntfnd.org/2023/03/28/near-loss-of-aircraft-major-disruptions-at-denver-and-dallas-one-page-grabbers/
[9] https://www.gps.gov/governance/advisory/meetings/2024-12/van-dyke.pdf

provide enforcement officials probable cause for search and further investigation. The Commission will likely never have the organic enforcement resources to adequately respond to all detected incidents.

The Commission should educate law enforcement agencies at every echelon about GPS interference, its association with other criminal activity, and the availability of relatively inexpensive interference detection devices.[10]

The Commission should also explore and implement ways to extend its enforcement authority with regard to GPS interference to state, local, and tribal law enforcement. This will be a tremendous "force multiplier."

Ensure Commission enforcement staff is sufficiently resourced to partner with other federal agencies and state, local, and tribal enforcement organizations.

The above actions will constitute a significant recurring additional workload for the Enforcement Bureau. It must be properly resourced.

Actively advocate for establishing a secure national GNSS augmentation system along the lines of HARS (High Accuracy Reference System) based on existing US national assets.[11] In addition to improving GNSS accuracy, HARS data can improve jamming and spoofing resistance by providing cryptographically signed broadcast ephemeris (satellite positions). Furthermore, US sovereign generated ephemeris can promote safe use of foreign GNSS systems by incorporating service "malfeasance" warnings and by eliminating use of foreign GNSS data streams, suspect or otherwise.

[10] See for example https://www.navtechgps.com/products/

[11] https://www.gps.gov/governance/advisory/recommendations/2023-05-white-paper-GPS-HARS.pdf https://www.gps.gov/governance/advisory/meetings/2024-12/ECAS.pdf provide recommendations from the National PNT Advisory Board

8 - Economic Considerations

Para 42. "Economic Considerations. We seek comment on the economic considerations associated with developing and deploying complementary PNT technologies."

PNT is essential to the U.S. economy. And while beyond the Commission's remit, it is also essential to national security in several ways, including the security of the nation's economy and supporting systems.

Every American contributes to the economy and the nation's overall security and stability. Eliminating PNT as a critical economic and security vulnerability means every American must have unfettered access to utility-level resilient PNT.

The more Americans that do not have resilient PNT, the more the nation and economy are at risk. At least one feature of the future National Core PNT Architecture must be "nonrivalrous," capable of an infinite number of users (RF-based) and with no-to-very low barriers to adoption.

Protecting national security and economy

Creating national PNT resilience will require a similar, if not as intense, federal process for development and adoption as was used for GPS:

1. Designation, empowerment, and adequate resourcing for a lead federal agent.
2. Contract(s) for one (or a few) PNT services or systems to protect federal infrastructure and applications. – This, along with GPS, will create a National Core PNT Architecture. It will provide a basic level of protection for unsophisticated users and a framework upon which commercial and other entities can build for more sophisticated users.
3. Federal departments and agencies begin to integrate the National Core PNT Architecture into their system and applications.
4. Appropriate departments and agencies underwrite and encourage academic and commercial efforts to better integrate PNT signals and services, reduce size, weight, power requirements, and cost of National Core PNT Architecture user equipment.
5. The federal government uses its levers of influence to encourage, and where appropriate require, adoption of National Core PNT Architecture or other demonstrably resilient PNT capability.

9 - A Government Provided Utility or Market Forces?

Para 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 nonrivalrous 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.

Government funding and deploying new utility-level PNT by contracting for systems and/or services will be more efficient and effective in several important ways:

> **Protecting national and economic security.** Our goal must be to protect the nation and its economy. That can only be done if utility level resilient PNT is available and adopted as widely as possible. Adoption will be significantly lower with commercial fee-based services.
>
> **Providing the service**. The government contracting for resilient PNT systems and/or services through a fair and open competition will leverage economies of scale, production, and execution not otherwise available.
>
> **Lower Cost of User Equipment.** A government provided or sponsored service will not have proprietary signals or equipment. This will enable multiple manufacturers to build compatible equipment with various features and compete for buyers.
>
> **Spurring innovation in new applications and systems.** As has been the case with GPS, new applications and system improvements will be developed by academia and the commercial sector for a nonproprietary, public PNT utility.

We appreciate the Commission's preference for relying on market forces. Yet, like some other products and services, such as water and electricity, there are two "markets."

Utility-level PNT. George Washington signed the Lighthouses Act less than six months after he took office. The government's provision of navigation and then timing services in support of the nation's economy and security has been unabated since. See "PNT as a Public Utility – Historical Context" in text box below.

Government provision of Loran and then GPS for military, federal, and public use was very efficient in providing the service.

More importantly, they were very efficient at having the services adopted and used. Non-proprietary signal and equipment specifications empowered a myriad of equipment manufacturers and application developers.[12] Government sponsorship and use of the signals gave assurance that signals would be available for years to come.

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[12] This led to dramatic increases in performance and dramatic decreases in the cost of user equipment. Admittedly the advent of inexpensive semiconductors just as GPS was becoming operational greatly helped.

For over a decade we have observed a variety of companies attempting and failing to find a mass market for utility-level GPS alternatives. We believe this is because GPS has been very reliable and the public's belief that PNT is the government's responsibility and should continue to be free. Contributing factors undoubtedly include that the federal government has not protected most of its systems and applications with non-GPS PNT, and, for some, an unwillingness to go to the expense of integrating a PNT service into their enterprises without an assurance that service will be available for a decade or more.

There are many companies that can provide non-GPS PNT as a widely adopted utility. In this market, as a practical matter, the only buyer is the federal government representing the public writ large.

Specialized PNT – America already has a thriving market in which numerous commercial entities sell equipment and services to improve upon (augment) GPS and provide non-GPS navigation and/ or timing. These are purchased by demanding users whose requirements go beyond what is provided by GPS, the current PNT utility.

When there is a non-GPS PNT utility, numerous commercial providers will undoubtedly develop new equipment and services to use and improve upon it.

The demanding requirements of specialized users makes it unlikely that government provision of a non-GPS PNT utility will significantly impact this market.

Historic Context - PNT as a Public Utility

Publicly provided, free-to-user, navigation services were established by the First Congress with the creation of the U.S. Lighthouse Establishment as a part of the Treasury Department in 1789. Public support for safe and accurate navigation continued with construction of additional lighthouses, establishment of federal buoyage, and other visual aids throughout the 1800's. The 20th century saw development of electronic aids to navigation, culminating in Loran and then GPS.

Support for safe and efficient navigation has been seen as so integral to the nation's prosperity that the Department of Commerce seal has always included a merchant ship and lighthouse.

Similarly, the U.S. Naval Observatory has been providing a time signal since 1865. Initially in support of celestial navigation for all manner of vessels in the Potomac, the service expanded to telegraph, and radio broadcast. The National Institutes of Standards and Technology has been providing radio broadcast time services since 1923.

When Loran became available for civil use in the United States after WWII, it was also used as a time service by a variety of infrastructure and applications. By way of illustration, just prior to the U.S. terminating Loran-C in 2010, a major telecommunications company asked for an

extension to allow it to convert its timing system to GPS, and a major bank complained it had to scramble to find a new source for the time locks on its vaults.[13]

Since at least 1996 it has been explicit U.S. government policy to encourage adoption and peaceful use of GPS worldwide.[14] This policy has been supported by every subsequent administration and was rearticulated by the George W. Bush administration in 2004[15] and the Trump administration in 2021.[16]

These policies were deliberately and actively supported by nearly every department and were incredibly successful. For centuries America has prospered immeasurably (and tax revenues have increased proportionally) because of free-to-user navigation and timing services provided by the federal government.

Para 43 (cont'd) … might public provision of PNT technologies that are free for end-users encourage ubiquitous adoption more effectively than private provision?

Public provision of PNT (we recommend it be through government service contracts) will unquestionably encourage ubiquitous adoption more effectively than a private fee-for-service model. The goal of our national efforts must be to maximize national and economic security. This requires maximizing adoption. Maximum adoption requires the fewest possible barriers to entry and the greatest amount of government encouragement.

Para 43 (cont'd) Conversely, could public provision diminish incentives to improve and invest in superior PNT technologies in the future?

Pubic provision of resilient utility-level PNT will not disincentive innovation. The federal government has provided Americans free-to-use RF-based utility-level PNT for over 70 years. This has stimulated improvements and innovation to the point where U.S. companies lead the world in the variety of PNT technologies invented.

Para 44 to 47 – Establishment of National Core Resilient Without Government Participation

The Commission asks additional policy-related questions in NOI paragraphs 44 through 47. These seemed to be based on the premise that the government will not establish a resilient National Core PNT Architecture by contracting for long term services or acquiring a system.

As we have indicated in responses to some earlier questions, we do not believe other methods are efficient or even practical.

[13] Recollection of the author who served as maritime navigation authority for the U.S. from 2010 to 2013.
[14] https://clintonwhitehouse4.archives.gov/WH/EOP/OSTP/html/gps-factsheet.html
[15] https://www.gps.gov/policy/docs/2004/
[16] https://www.gps.gov/policy/docs/2021/

Standards Development Organizations - There will be a role for standards bodies regardless of how the government elects to proceed. These groups provide consistent and deterministic approaches to problem solving and documentation. They typically do exceptional work, especially when given clear direction and goals. A majority of members are often expert representatives from concerned commercial entities. These representatives also have a responsibility to safeguard the commercial interests of their employers. Active participation in such bodies by government experts helps ensure the public interest is met.

At a minimum, the federal government must acquire one or more resilient PNT services to protect its own applications and systems. We strongly recommend the government not construct its own systems. Rather, hold a fair and open competition for long-term services to support its enterprise. This will harness the power and innovation of the commercial sector, enable more rapid implementation and deployment, and will likely have a lower life-cycle cost.

A federal contract for utility-level PNT to protect its systems and applications should be extended to protect the nation as a whole.