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

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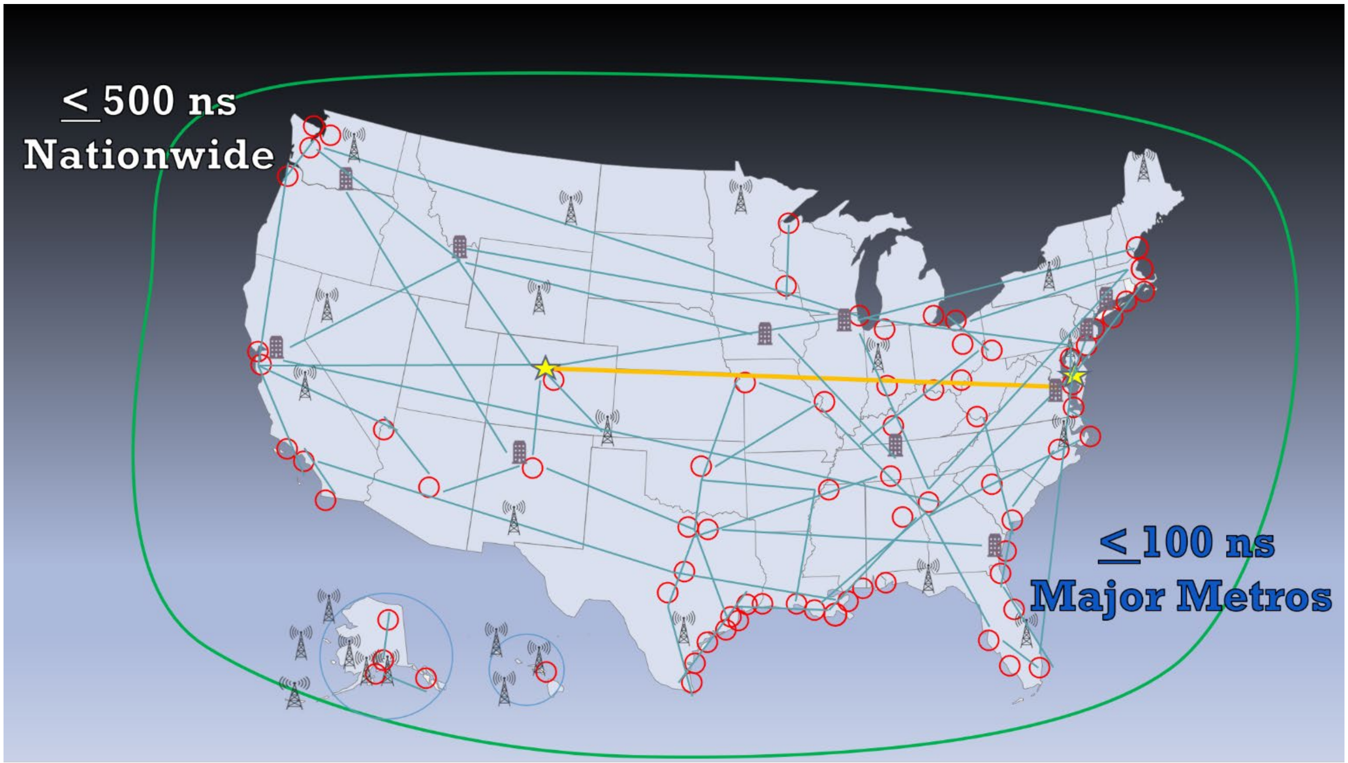

A Resilient National Timing Architecture – Now for an RFP!

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In October 2020 we published the white paper "A Resilient National Timing Architecture." In it we described system attributes of a timing infrastructure important for today's applications and systems, and essential to the development and operations of tomorrow's. Such an architecture would also fulfill the requirements of the National Timing Resilience and Security Act of 2018.[1] We also addressed various policy issues concerning funding, implementation, and adoption.

We posited in the white paper that the quickest and most economical method to establish a national timing architecture is for the government to let one or more contracts for services. Doing so would leverage state of the market capabilities and the expertise of industry. It would also avoid the need for major federal capital investment and the multi-year process delays that would entail.

Should the government agree with and fully adopt our tenets, the next important questions for government and industry alike are:

- What requirements must be established for such service contracts? And
- How should various proposals be evaluated?

We have tried to capture those issues of greatest importance to a successful acquisition and implementation. We do not propose the following as complete and authoritative answers. The below are offered for consideration by all who might be concerned with such questions**.**

I. Re-Validation of Need, Approach, and Urgency

Before addressing the primary focus of this paper, we note that there may still be questions in some quarters about the necessity of establishing a resilient national timing architecture. This, despite experts within the field having called for it for more than twenty years, and still calling for such a capability today.

In 1997 a Presidential commission on critical infrastructure protection recommended the problem of over dependence on the Global Positioning System (GPS) be examined in depth.[2] This resulted in an August 2001 report by the Department of Transportation's Volpe Center that called for a GPS complementary and backup capability.[3]

Numerous other groups and studies have since echoed that, including several recommendations by the National Space-based Positioning, Navigation, and Timing (PNT) Advisory Board.[4]

Since publication of our "A Resilient National Timing Architecture" white paper in October 2020, the calls for a national timing system have continued, especially from the telecommunications and electrical utility industries.

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[1] P.L. 115-282-Dec 2, 2018 https://www.congress.gov/115/plaws/publ282/PLAW-115publ282.pdf#page=86

[2] "Critical Foundations, Protecting America's Critical Infrastructures. - The report of the President's Commission on Critical infrastructure Protection" October 1997 https://fas.org/sgp/library/pccip.pdf

[3] Vulnerability of the Transportation Infrastructure Relying on the Global Positioning System, Final Report, August 29, 2001

[4] See for example "Topic Papers" September 2018, page 3

In May the National Security Telecommunications Advisory Committee (NSTAC) recommended federal funding for such an effort to President Biden.[5] Members of NSTAC are CEOs and senior executives of major telecommunications firms.

The NSTAC report noted that GPS is vulnerable to a host of significant threats and minor disruptions are common. To address this, the group recommended an approach

> "… similar to that reflected in the Resilient Navigation and Timing Foundation's paper entitled "A Resilient National Timing Architecture." Further, to enhance the ability of commercial entities to afford leveraging this architecture, the Administration should appropriate sufficient funds to lay the foundation for creating this timing architecture, with the Federal Government being the first customer for what will ultimately become a resilient, interconnected network for PNT delivery."

Federal funding support is necessary, according to NSTAC, because free GPS services greatly suppress market demand for alternatives.

The telecommunications industry standards group Alliance for Telecommunications Industry Solutions (ATIS) also vigorously supports federal funding. In May letters to leaders in both houses of Congress[6] ATIS cited

> "… the urgent need for funding the deployment and adoption of Alternative Positioning, Navigation, and Timing (PNT) Systems in U.S. critical infrastructure, including the U.S. telecom industry."

The need for federal support for timing and positioning backups for GPS was also documented in a two-year old study released by RAND Corporation in May of this year.[7]

And in August of this year, media featured numerous reports from Space Force about existential Chinese and Russian threats to U.S. space-based assets. These include "kamikaze," "nesting doll," and "kidnapper" satellites, other electronic anti-satellite weapons, and terrestrial lasers.

Concerns have also been periodically expressed about strategic national security issues arising from America's lack of widespread alternatives to GPS, while adversaries like China, Russia, and Iran are able to rely on terrestrial systems in the absence of space-based signals.

In "The Russia Trap" author George Beebe cites this as a "technology resilience gap." If GPS is seriously interfered with, he says, this gap could result in an escalating series of responses that could lead to armed conflict or all-out war.

At a George Washington University webinar in May, Dr. Scott Pace, former Executive Secretary for the National Space Council, echoed Beebe's concerns. He said that when the U.S. has an alternative in place

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[5] NSTAC Report to the President on Communications Resiliency, May 6, 2021

[6] See letters dated May 7, 2021 at https://www.atis.org/policy/public-policy-filings/

[7] Unfortunately, the major thrust of the RAND paper was to loudly proclaim that a complete duplication of GPS capabilities for a backup would not be worth the cost. In our view this hid the study's messages about the need for timing and federal support for positioning systems to support E9-1-1. We find it curious that RAND proclaimed loudly what is so obviously not needed and whispered so softly about what is needed.

it will “lower the pressure on us to escalate and respond” should GPS satellites be damaged, or services disrupted.

At the same event former Department of Transportation Assistant Secretary Greg Winfree said that having an alternative would also make America’s GPS system safer by making it a less attractive target. He said we need to implement at least one alternative as soon as possible to “Get the bullseye off GPS.”

These and other public statements convince us the need for a resilient national timing architecture continues to exist, and may demonstrate an increasing level of urgency.

II. Attributes of the RFP

In this paper we discuss two essential components of a government Request for Proposal (RFP) to begin implementing and integrating systems required within the national timing architecture.

While there are several important process-related components of an RFP, we concern ourselves here with describing the procurement’s goals, performance requirements that proposals must address, and how proposals will be evaluated.

As much as possible, we phrase these in the sections that follow as they might be phrased in a government RFP.

Procurement Goals and Information

The purpose of the RFP is to procure foundational precise timing services which can support a wide variety of public and private applications across the nation. These services, which may be provided by one or more systems, will, along with signals from GPS, form the basis of the U.S. National Timing Architecture.[8]

The federally funded portions of this architecture are expected to form a “backbone” upon which others can build. In addition to the services offered to the government in responses to this request, offerors may plan, if they are successful in being awarded this contract, to subsequently offer the government and other customers enhanced timing and/or location services for additional fees. These plans may be included in proposals, but are not necessary.

This project is not intended to meet the timing needs for all applications and users. It is designed to provide a resilient and reliable basic technology infrastructure for timing delivery that will better support current applications and provide a solid and resilient foundation for private and commercial development of new applications and technologies.

Because the services are intended to protect users against interruptions to GPS, capabilities that are entirely independent from and have minimal or no common failure modes with GPS and other Global Navigation Satellite Systems (GNSS) are sought.

[8] See “A Resilient National Timing Architecture, RNT Foundation, October 2020

Proposals offering services combining fiber and radio frequency-based systems for delivery of time signals are expected, though not required. Proposals need not include one or either of these methods if they meet the performance requirements stated herein.

Offerors are encouraged to propose a phased implementation and build out approach. Such a methodology can provide better opportunities for beta testing, cost and complexity control, and incorporation of lessons learned in later phases. Proposed solutions should provide some level of service to users in the early phases vice waiting until the entire system is built out.

Proposals should be based upon providing services continually for 20 years once performance has begun. Proposals should include full life-cycle costs for the fielded solution over its entire 20-year life expectancy.

Performance Requirements – Proposed services and systems must meet the following minimum requirements to be considered responsive:

> **Areas Served** – The land mass, Exclusive Economic Zone, and airspace from the surface to 10,000 ft MSL of the United States of America. Additional included services, such as to indoor, underwater, and underground users are desired, but not required, and will be considered in the evaluation process.
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> **Users Served** – Both fixed and mobile users must be able to access at least one non-space-based service so as to avoid, as much as possible, common failure modes with GPS and other GNSS. Servicing mobile users will require the proposed system or combination of systems to provide location information at a basic level.
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> **Accuracy** –The time accessed by users in all locations within the service area must conform within 500ns to coordinated universal time (UTC) as maintained by the U.S. Naval Observatory (USNO) or the National Institute of Standards and Technology (NIST). Note that an agreement between NIST and USNO states that UTC is equivalent between them at accuracies of 20 ns or less. The time accessed by users within the 50 largest US Major Metropolitan Statistical Areas must conform within 100ns to UTC(USNO) or UTC(NIST). Note that UTC(lab) is the standard way of referring to UTC from a specific laboratory.
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> **Integrity** - The service must provide confidence in its ability to provide accurate services as defined above, including issuing alerts and warnings when required accuracy is not maintained.
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> Examples of how this may be achieved include delivery of the service by multiple, diversly routed methods with diverse, orthogonal failure modes, and regular comparison and reporting of service conformance as referenced to UTC.
>
> **Continuity & Availability** – Services must function without interruption and meet the above-mentioned performance standards 99.9999% of each year by providing at least one non-space-based method of time delivery. Each method of delivery must function without interruption for 99.9% of each year.
>
> **System Monitoring and Control –** Proposals must include a performance monitoring and control system to assure its performance across the coverage area.

Evaluation Criteria & Process - The following will be used to evaluate proposals for systems that meet all the above criteria.

Annual Cost of Service – While cost is not the only consideration in this acquisition, the government has a fiduciary responsibility to taxpayers to minimize costs. Proposals offering constant annual subscription costs, adjusted for inflation, over the life of the contract are preferred. Proposals may also include alternate pricing schemes in which the government makes a single payment upon contract award or at another point before services begin, if such a payment would speed establishment of the service and reduce future annual cost to the government.

Infrastructure Required Per Unit of Coverage Area – Less infrastructure is generally preferred as it allows fewer points of failure, eases implementation and maintenance, and can minimize the difficulty of integrating systems into communities.

Need or desire for government furnished facilities and/or equipment – Proposals that include use of idle and potentially available government-owned facilities and equipment will not be penalized. Such proposals must, however, describe how they would proceed should those facilities and/or equipment not be available.

Spectrum – Proposals for wireless/ radio frequency systems should describe availability of and access to needed spectrum, and associated costs (if any). Spectrum band reservations, licenses, pre-allocated bands, other bands, and adjacent band uses will all be given consideration.

Penetration – Service to underwater, underground, and indoor locations is desirable.

Resilience – Resilience is defined as the ability of a system, combination of systems, or service to resist disruption (e.g.: jamming, spoofing, physical damage negatively impacting service) and, once disrupted, to quickly return to normal operation/conditions.

Operational resilience – The difficulty of intentionally or accidentally disrupting a service. Considerations will include factors such as the amount of energy required to interfere with the service, the ease with which the service could be interfered with intentionally or accidentally, the possibility of interference from other users of the service's spectrum or adjacent spectrum users, and whether the used spectrum is licensed and/or reserved.

Recovery resilience: The speed and ease with which a service can return to normal operation after disruption.

Cybersecurity – Protection against the criminal or unauthorized use of systems and services.

Network security – The degree to which a system is connected to outside networks and can resist intrusions.

Signal security – The degree to which system signals can be successfully infiltrated and/or imitated.

Challenge Testing

The government may elect to conduct challenge testing on equipment and/or services included in an offer as part of the evaluation process. This will be done in a GNSS-denied environment and using a “red team” approach. In the event this is done, testing conditions will be as similar for each offeror as possible. Testing will be against performance requirements defined above.

Technological Maturity - Proposed solution(s) must have been proven under real-world conditions, i.e. Technology Readiness Level 9.

Implementation Schedule – A phased approach to implementation that meets all requirements is desired. Within these constraints, a quicker implementation will generally be viewed more favorably than a longer one.

III. The Importance of Partnering

As a final note, we observe that in developing an RFP the government will want to leverage the expertise of advisory panels and knowledgeable industry groups, as well as provide the opportunity for public input and comment to the process. Some of the groups to consider are:

The National Space-based Positioning, Navigation, and Timing Advisory Board is chartered under the Federal Advisory Committee Act (FACA). Despite its name, this group has also dealt with terrestrial timing systems. Members have diverse expertise in areas ranging from telecommunications networks to autonomous vehicles.[9]

The National Security Telecommunications Advisory Committee is another FACA group and should be consulted. Composed of CEOs and other senior executives of major telecommunications companies, this group has extensive access to engineering and technical talent that could inform the government’s efforts.

The Alliance for Telecommunications Industry Solutions (ATIS) is a telecoms industry technical standards body. Its Synchronization Committee has authored several papers about timing needs and GPS vulnerability. ATIS will be an invaluable resource.[10]

The Institute of Electrical and Electronics Engineering (IEEE) is a standards development organization. It has recently undertaken efforts in coordination with the Department of Homeland Security to define and set standards for “resilience” in navigation and timing equipment. A working group is meeting regularly as of this writing.

[9] Full disclosure, two of the authors are members of the PNT Advisory Board.
[10] Full disclosure, two of the authors are members of the ATIS Synchronization Committee

About the Authors

Marc Weiss, PhD

Dr. Weiss worked at the NIST Time and Frequency Division from 1979 through 2013. He has since been a consultant on precision timing systems for NIST and for various companies. He received several awards during his tenure at NIST. He led the NIST program to support the GPS program office in developing their clocks and timing systems. In 1992, Dr. Weiss founded and has continued to lead the Workshop on Synchronization and Timing Systems (WSTS), now the premier conference on timing and synchronization in industry. In April, 2019, Dr. Weiss was awarded the Marcel Ecabert Lifetime Achievement Award "For his key contributions to remote clock comparisons, to time scale algorithm development and to accurate synchronization for science and industry."

Patrick Diamond, PhD

Dr. Diamond has 40+ years in development and design of network technologies. His tenure in the network technology, design and implementation marketplace has been, specifically in the commercial marketplace. He has and is a participant in Standards body development organizations, IEEE, IETF, ITU. He has helped develop numerous Wide Area Network technologies such as SONET/SDH, TCP/IP, IEEE 1588, IEEE 802.1AS, 3GPP and numerous others specifically dedicated to precision timing in networks and end user systems. He developed and managed organizations that created highly complex System on a Chip technologies in semiconductors for these end implementations. He now serves and a member of the US National Space-Based Positioning, Navigation and Timing Advisory Board.

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Mr. Dana A. Goward is President of the Resilient Navigation and Timing Foundation, a scientific and educational charity dedicated to protecting GPS/GNSS signals and users.

He is a lifelong practical navigator orienteering ashore, serving as a ship's navigator at sea, and in the air as a career Coast Guard helicopter pilot.

He retired in 2013 from the Senior Executive Service as the maritime navigation authority for the United States and now serves as a member of the US National Space-Based Positioning, Navigation, and Timing Advisory Board. He is also a senior advisor to Space Command's Purposeful Interference Response Team, is an emeritus Chairman of the Board for the Association for Rescue at Sea, and is the proprietor at Maritime Governance, LLC.