NATIONAL POSITIONING, NAVIGATION AND TIMING ARCHITECTURE TERMS OF REFERENCE

1. Purpose

This Terms of Reference (TOR) documents a planned approach to develop a National Positioning, Navigation and Timing (PNT) Architecture to help guide future PNT system-of-systems investment and implementation decisions. The objective is to provide more effective and efficient PNT capabilities focused on the 2025 timeframe and an evolutionary path for government-provided PNT systems and services. The choice of 2025 is a point far enough in the future to allow flexibility in the development of alternate architectures while permitting sufficient time to address needed, more near term, programmatic and budgeting requirements to achieve this "long term" goal.

This effort will document the current national PNT architecture and evaluate alternative future mixes of global (space and non space-based) and regional PNT solutions, backup systems, PNT augmentations, and autonomous PNT capabilities to address priorities identified in the DoD PNT Joint Capabilities Document (JCD) and civil equivalent documents. It will support future decisions of bodies such as the DoD PNT and Civil Pos/Nav Executive Committees, as well as the National Space-Based PNT Executive Committee (EXCOM).

2. Background

U.S. Space-Based PNT Policy states that the U.S. must continue to improve and maintain the Global Positioning System (GPS), augmentations to GPS, and back-up capabilities to meet growing national, homeland, and economic security requirements. PNT touches almost every aspect of American life today. It is essential for defense and civilian applications ranging from the Department of Defense's Joint network centric and precision operations to the transportation and telecommunications sectors—improving efficiency, increasing safety, and making America more productive. However, the extent of dependence on systems like GPS, or possible alternate systems for PNT, is not explicitly understood. Nor is implementation of PNT services guided by an architecture that enables contributions of component parts of the national PNT enterprise to be evaluated within the context of the overall system for investment decisions related to system sustainment or improvement. Absence of a coordinated PNT architecture may result in operational risks, uncoordinated research efforts, lack of clear developmental paths, potentially wasteful procurements, inefficient deployment of PNT resources, and possible impacts to architectures or other systems depending on PNT.

3. Authority

The National Security Space Office (NSSO) under the DoD Executive Agent for Space was tasked in a 21 Mar 2005 memo from the acting Secretary of the AF and Director of the NRO to develop architectures for national security space (NSS)[1] and to lead the collaborative efforts of the NSS community to:

[1]National Security Space is defined as the combined space activities of the DoD and National Intelligence Community (IC) as well as those of the civil and commercial sectors that impact U.S. national security.

"Develop and coordinate for community consideration using appropriate processes: NSS strategies, concepts, plans, architectures for mid-to-long-term, enterprise engineering activities, transition strategies, and functional area integration efforts."

Request for architecture support came from both the Assistant Secretary of Defense for Networks and Information Integration (ASD(NII)) and the National Space-Based PNT EXCOM.

- ASD(NII) requested the NSSO conduct a PNT architecture study to develop a National PNT Architecture to help guide DoD decisions, as well as national resource allocation in the development of future PNT systems.
- U.S. Space-Based PNT Policy directs the National Space-Based PNT EXCOM to develop a Five-Year National Space-Based PNT Plan. The National Space-Based PNT EXCOM Charter, signed by the Secretaries of Defense and Transportation, indicates that the Five-Year Plan will include architectures. The National Space-Based PNT EXCOM directed the National Space-Based PNT Coordination Office (NPCO) to initiate an effort with the NSSO to develop an overall U.S. space-based PNT architecture as part of this process (Action Item, 26 Jan 06).

The architecture development effort will also support Joint and related Civil PNT efforts.

- Joint Requirements Oversight Council (JROC) Memo 171-05 highlighted USSTRATCOM's PNT JCD as the basis for future PNT to meet warfighter needs. This architecture effort will define the "as is" architecture and provide an analytic basis for a Functional Solution Analysis (FSA) to address gaps identified in the PNT JCD.
- The U.S. Department of Transportation (DOT) Research and Innovative Technology Administration (RITA) was tasked by the Under Secretary (U/S) of Transportation for Policy to lead the National PNT Architecture effort on behalf of the civil community. RITA, which includes the Volpe National Transportation Systems Center, will coordinate Architecture products through the Office of the Secretary of Transportation (OST) Policy staff for policy oversight and guidance.

4. Objectives

The PNT Architecture will:

- Define a future PNT system-of-systems architecture achievable through evolution and investment by the 2025 timeframe to include a definition of critical interrelationships between component systems as well as backup systems.
- Serve as the DoD PNT architecture to guide DoD decisions on future PNT system-of-systems for providing worldwide PNT capability.
- Serve as key input to future Five-Year National Space-Based PNT Plans and provide a basis for future Federal Radionavigation Plan (FRP) development.
- Provide an analytic basis for a FSA in response to gaps identified in USSTRATCOM's PNT JCD. To address gaps identified by the PNT JCD, while concurrently meeting civil requirements for reliable PNT services, it is important for the architecture to address capabilities that are cost-effective, even in physically and electromagnetically challenged environments.
- Guide development of the DoD PNT Science & Technology (S&T) Roadmap to balance needs of known requirements (demand pull) with the need to maintain a

capabilities- and effects-based S&T program that satisfies anticipated or unforeseen long-term PNT user needs (technology push).

- Serve as a basis for making informed recommendations on DoD, civil, commercial, and international PNT program plans, requirements, budgets, schedules, international partnerships, S&T investments, and policies.
- Serve as a framework against which new requirements or capabilities can be systematically evaluated.
- Inform follow-on efforts to transition from the existing ad hoc architecture, through the funded extended baseline architecture, to an envisioned 2025 architecture.
- Be refined and evolved by a repeatable process that in turn will support inputs to the annual budget process. This process will enable integration of changes to evolving threats, requirements, technologies, and resources into future planning activities and the evolving PNT architecture.

5. Scope

This effort will document the current national PNT architecture and evaluate alternative future mixes of global (space and non space-based) and regional PNT solutions, backup systems, PNT augmentations and autonomous PNT capabilities to address priorities identified in the PNT Joint Capabilities Document, and to inform future decisions of the DoD and National Space-Based PNT EXCOM regarding National PNT Services.

The architecture will be national in scope, and will include DoD, intelligence community (IC), civil, commercial, and international users and systems supporting global U.S. interests. The effort will address the value users obtain from the systems, and how those users are supported by the systems. In order to evaluate end-to-end capabilities, the architecture must also take into account integration of PNT hardware and software into specific end user devices and applications.

Sovereign PNT legal responsibilities and liabilities will be considered in development of any proposed global U.S. services. The effort must accommodate relevant U.S. commitments in international agreements[2].

The U.S. PNT system-of-systems should provide uninterrupted service anywhere in the world and in space to at least geosynchronous altitude and provide robust protection against interference. It is therefore important that architecture development be influenced by Navigation Warfare (Navwar)[3] electronic protection, electronic support, infrastructure protection, and information assurance requirements, and to a lesser degree, by electronic attack (EA) and EA associated electronic support needs (EA will be considered in greater detail by an NSSO Space Control Architecture). The architecture should also be cognizant of safety-of-life navigation, homeland security, and commercial needs for protection of PNT capability and reduction of

[2] An example is the commitment in Article 11 of the 2004 Agreement on GPS-Galileo Cooperation that the "Parties agree to use [a] common baseline modulation for the Galileo Open Service and the future GPS III civil signal …"

[3] **Navwar Terms** – *Electronic Protection*: the ability of our forces to effectively use GPS information in the conduct of military operations, this is accomplished by overcoming the effects of hostile jamming on GPS receivers; *Electronic Support*: involves several tasks—detecting hostile jamming targeting our forces, characterizing and locating the interference source, and negating or destroying if required; *Electronic Attack*: the ability to effectively deny adversary forces access to and use of satellite navigation information against our forces.

vulnerability to intentional and unintentional disruption. Current use and alternatives for future use of foreign operated PNT services will be examined for means to protect U.S. interests.

While the PNT architecture effort can consider concepts that are neither in existence nor planned, emphasis should be on initiatives that will improve one or more areas of the evolved baseline. While GPS is one of many PNT systems within the scope of the study, the focus of the PNT Architecture is not on developing new, alternate GPS architectures.

The architecture concepts must be fiscally informed and cost estimates should be produced to support comparing architecture alternatives and programming for recommended architecture components. To ensure the most cost effective solutions for the USG, support affordability determinations, and to inform cost allocation decisions, cost must always be considered during the evaluation and selection of concepts.

The architecture effort will describe projected long term resources and efforts required to transition and sustain the selected architecture into the future. Included in the architecture are S&T efforts, supporting infrastructure, key models and standards.

To keep the effort manageable and within available resources, the effort will leverage existing studies and analysis tools (in particular those with a quantitative basis), and select only those areas for intensive study that show promise for improvement and efficiency enhancements, and are most likely to close capability gaps.

It is understood that certain pre-decisional budget data and cost estimates, data which are not normally shared between Departments, will need to be provided to NSSO and the ADT to document and evaluate alternative architectures. The NSSO has processes in place to protect the security and proprietary nature of such data.

6. Roles and Responsibilities

A PNT Architecture **Decision Coordination Group (DCG)** will guide the architecture development and act as sponsors. The DCG will be hosted by NSSO with membership at the senior officer/executive level (O-7/8/SES) from OASD(NII), RITA, Joint Staff, Services, NPCO, FAA, USSTRATCOM, and other stakeholder Departments and Agencies as appropriate. The DCG will periodically review architecture efforts and will forward the final coordinated Architecture Development Team (ADT) products to the OASD(NII), U/S of Transportation for Policy, and Joint Requirements Oversight Council (JROC) for review and approval. After acceptance by ASD(NII) and U/S of Transportation for Policy the final product will be forwarded to the National Space-Based PNT EXCOM for consideration. Any changes in scope or content of the products will be authorized by the D/NSSO after discussion with the DCG or the undersigned, as appropriate. Dissenting views within the DCG will be addressed to resolution or acknowledged in the final report where and when appropriate. Understanding that timing of findings may be critical in Departmental and U.S. government-wide decision making, the DCG may provide coordinated interim findings (e.g., assisting the NPCO in developing the National PNT Five-Year Plan).

A **Review and Validation (R&V) Team** will periodically review ADT status, findings, and direction. The R&V Team will be composed of O-6/GS-15 level representatives from organizations participating on the ADT. Meetings will be hosted by the NSSO/PNT Division Chief.

A **PNT Architecture Development Team** will assist in gathering data, conduct analyses, and coordinate analyses and recommendations. The NSSO PNT Division Chief will lead the team with action officer level participation from organizations across the PNT community within the Federal Government. Participants will need to provide a reach-back capability for data, analyses, and impact descriptions as the effort proceeds. To maximize efficiency, subject matter experts will draft portions of architecture work at their respective work locations and their products will be submitted to the ADT for integration. ADT sub-groups may be formed as needed to investigate specific systems within the architecture, PNT technologies that complement space-based PNT systems, or specific user communities with unique PNT requirements or approaches necessary to achieving its requirements.

Members of the **NSSO PNT Division**, augmented as appropriate by designated representatives from various stakeholder organizations, will coordinate development, consolidate data, conduct or oversee analysis, develop and evaluate concepts and recommendations, and document the overall effort. The PNT Division Chief will lead this group. At the conclusion of the architecture development activity, NSSO PNT will lead a smaller team consisting of representatives from each organization to implement the recommended architecture, construct the final presentation and document the plan to implement the recommendations. Although not intended to participate as members of aforementioned working groups, industry input will be solicited on an "as-needed basis" to provide insight into technologies and opportunities to meet user needs.

Participant organizations will provide support as needed, per respective Department, Agency or DCG direction.

- The NSSO will supply personnel, facilities, and resources to lead and integrate the effort, and will make up the core of the ADT.
- All Departments represented on the National Space-Based PNT EXCOM will provide representatives designated by agency DCG members to participate in the R&V Team, on the ADT, or to provide assistance to the ADT.
- Significant participation and coordination efforts will be required from DOT to represent the civil community in development of a PNT Architecture that meets civil and commercial requirements. RITA has been designated by the Under Secretary of Transportation for Policy to lead the national PNT Architecture effort for the civil community. RITA will provide assistance and expertise as part of the ADT.
- Significant participation and coordination from the NPCO will be required for this national effort to ensure inputs from and participation by all agencies of the U.S. government with PNT missions and responsibilities.
- To respond to the PNT JCD, and for the architecture to serve as an analytic basis for a corresponding FSA, active consultation will be maintained with the FSA sponsor, OASD(NII), USSTRATCOM and Joint Staff J-8 personnel.
- Assistance of the Services, National Geospatial-Intelligence Agency (NGA), and the GPS Joint Program Office (JPO) will be required to obtain GPS-related data, and possibly in conducting limited performance analysis related to variations in alternate GPS architectures. This same assistance will be required from program offices of each GPS augmentation systems.

- Similarly, data and analysis support from non-space based PNT providers and developers will be required to ensure appropriate alternatives and augmentations are considered.
- Combatant Commander and Service Component input will be solicited through the R&V Team and ADT to ensure the architecture is acceptable from a warfighter's perspective.
- Participant organizations will provide data from previous PNT associated analyses to support anticipated assessments required to complete the architecture. Examples of data required include threat and technology assessments, cost estimates, and analyses of alternatives. NSSO will limit the scope and frequency of such data/study requests wherever possible and will keep the Decision Coordination Group (DCG) apprised of the status of all data requests.

7. Security and Classification

The architecture effort will operate at multiple security levels. Activities and meetings will normally be held at the Secret level, but will be conducted with the understanding that National level architecture documentation, roadmap, and final report will be produced at the unclassified level, and cleared for unlimited public distribution. Some subset of the participants, and a small portion of discussion and analysis, will take place at the TS/SCI level to account for user needs protected at that level. The need for a TS/SCI appendix to the final report is yet to be determined. All members of the PNT ADT will need at least a Secret clearance; however, occasional access to personnel without security clearances may be needed to address select issues.

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