National Positioning, Navigation, and Timing Architecture Study

Final Report

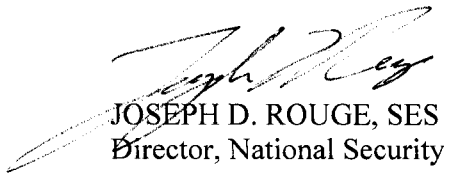
September 2008

This Document Is Cleared For Public Release

Note: This file only contains the Executive Summary of the PNT Architecture Study Final Report.

FOREWORD

This document summarizes the results of the National Positioning, Navigation, and Timing Architecture Study conducted from May 2006 to August 2007.



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1 EXECUTIVE SUMMARY

1.1 Background

The Assistant Secretary of Defense for Networks and Information Integration (ASD/NII) and the Under Secretary of Transportation for Policy (UST/P) sponsored a National Positioning, Navigation, and Timing (PNT) Architecture Study to "provide more effective and efficient PNT capabilities focused on the 2025 timeframe and an evolutionary path for government-provided systems and services." ASD/NII and UST/P co-sponsored the study in response to multiple Department of Defense (DoD) and Civil Agency recommendations to develop a comprehensive National PNT Architecture as a framework for developing future PNT capabilities and supporting infrastructure.

1.2 Scope

The PNT architecture is national in scope and includes DoD, the intelligence community, as well as civil, commercial, and international users and systems supporting global U.S. interests. This includes terrestrial- and space-based PNT data providers, autonomous sources of PNT data, complementary communications and data networks as sources of PNT data, terrestrial- and space-based users, research and development efforts, and US Government organizations involved with providing, coordinating, or implementing PNT data.

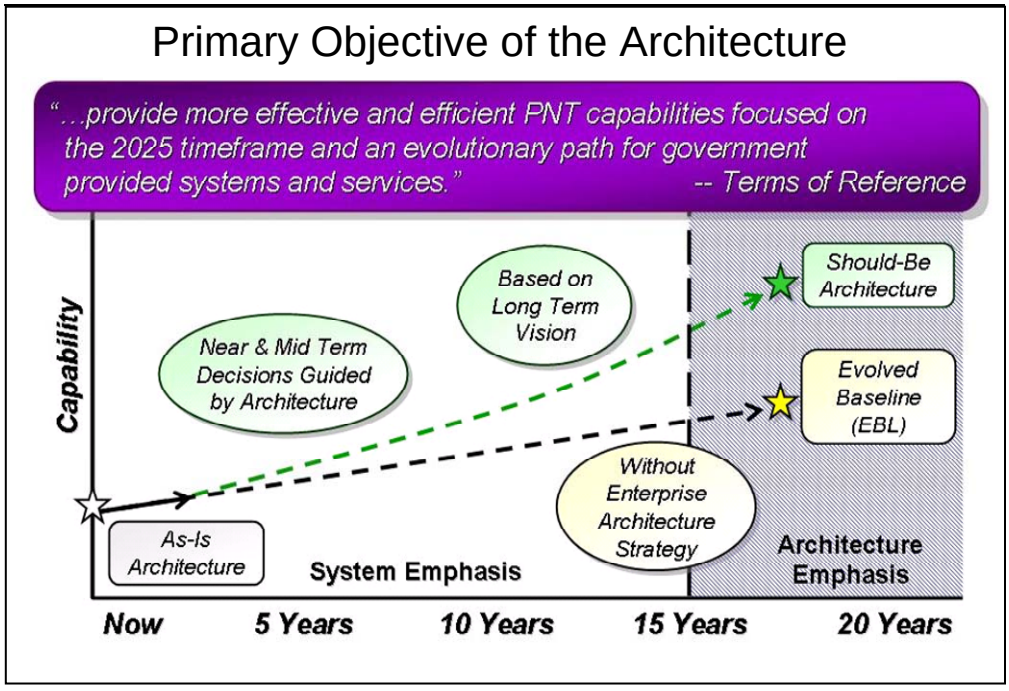

Figure 1-1 "As-Is", Evolved Baseline, and "Should-Be" Architectures

1.3 Process

Many DoD and Civil Agencies provided manpower for the Architecture Development Team (ADT) that executed a structured process to identify and describe three PNT architectures (Figure 1-1):

- an “As-Is” Architecture describing the current mostly *ad hoc* mix of capabilities
- an Evolved Baseline (EBL) depicting future capabilities based on current planning and programming documents, and on expected supporting technological advances. The ADT determined that the EBL would not meet all future PNT capability needs.
- The ADT constructed the “Should-Be” Architecture to address the projected capability gaps representing future capabilities based on a long-term vision that more completely satisfies future needs.

The path to achieving the “Should-Be” Architecture is described by the National PNT Architecture’s Guiding Principles (Figure 1-2), representing an overarching Vision of the US role in PNT, an architectural Strategy to fulfill that Vision, and four Vectors which support the Strategy. The ADT recommended nineteen specific initiatives to support executing the Strategy to implement the Architecture’s Vectors.

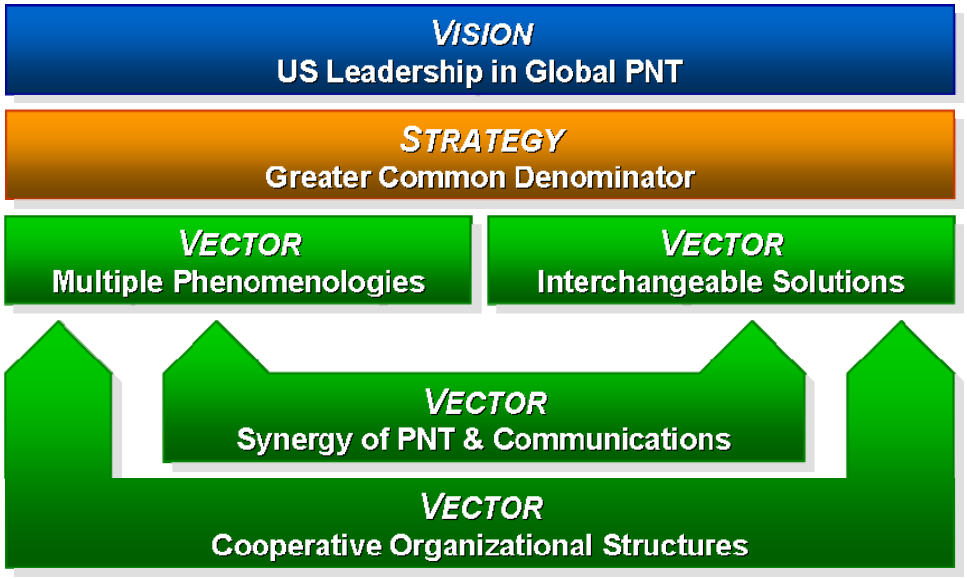

Figure 1-2 PNT Architecture Guiding Principles

1.4 Vision

The National PNT Architecture’s vision is for the United States to maintain leadership in global PNT by efficiently developing and fielding effective PNT capabilities that are available worldwide. The US can achieve this vision by implementing the following practices:

- Developing and adhering to stable policies, building credibility both domestically and internationally, thus enabling the commercial sector to innovate and advance PNT through competitive practices
- Providing PNT capabilities in a coordinated manner, sharing information, and presenting a unified view of National objectives by promoting inter-agency cooperation across the full scope of PNT activities

- Maximizing the practical use of military, civil, commercial and foreign systems and technologies, and leading the effort to integrate all available signals to achieve assured higher-performing PNT solutions
- Judiciously developing and applying comprehensive standards and best practices, while encouraging others to adopt or align with US capabilities

1.5 Strategy

The National PNT Architecture seeks to fulfill its vision using a Greater Common Denominator strategy to effectively provide standard solutions that meet the majority of users' needs. The study found that a large number of PNT users have a set of needs in **common** with each other that can be more efficiently satisfied by standard solutions than by numerous customized systems without losing effectiveness. External sources of PNT information such as the Global Positioning System (GPS) make a broad range of capabilities globally available to meet the needs of the **greatest** number of users. Therefore, a vital element of the strategy is to leverage US Global Navigation Satellite System (GNSS) modernization, which provides significantly more capability on a global scale to an unlimited number of users. The strategy also focuses the architecture on wide adoption of low-burden (*e.g.* size, weight, power, and cost) autonomous features to overcome physical and electromagnetic interference. In addition, the strategy accommodates specialized solutions where it is either inefficient or inappropriate to provide the required capability using a standard solution. Lastly, the US must continue to balance the need for a national security advantage with the advantages inherent in providing greater common capabilities, in accordance with National policies.

1.6 Architectural Vectors

1.6.1 Multiple Phenomenologies

The National PNT Architecture promotes the use of multiple phenomenologies to ensure robust availability and to address gaps in the ability to operate in physically and electromagnetically impeded environments. Multiple phenomenologies refer to diverse physical phenomena such as multiple radiofrequencies and inertial sensors as well as diverse sources and data paths using those physical phenomena (*e.g.* multiple radio frequencies) to provide interchangeable solutions to the user. The Multiple Phenomenology Vector includes issues related to standards, criteria of use (especially when incorporating foreign data sources), and mixing ground-, air-, space-based and internal data sources for a single solution.

1.6.2 Interchangeable Solutions

The National PNT Architecture promotes the flexibility to provide timely, accurate, and reliable PNT solutions that meet user needs regardless of the data sources available. This includes the ability to combine signals from multiple data sources into a single solution, as well as the ability to provide a solution from System B when System A is not available. This vector includes the US taking a leadership role in international forums as part of the effort to establish clear, reasonable standards to enable efficient, effective exploitation of diverse PNT data sources.

1.6.3 Synergy of PNT with Communications

Data communications networks currently support PNT capabilities by carrying PNT aiding and augmentation data, GIS data, etc. The National PNT Architecture leverages users' increasing connectivity to more capable communications networks to use those networks as sources of PNT, not merely as data channels for PNT aiding and augmentation data. This vector promotes the fusion of PNT features with new and evolving communications capabilities (*e.g.*, cellular telephones), which will enable increased PNT robustness by offering services outside of traditional radionavigation spectrum. Further detailed assessments regarding specific solutions are needed to provide recommended implementation guidance.

1.6.4 Cooperative Organizational Structures

The National PNT Architecture requires interagency coordination and cooperation to ensure the necessary levels of information sharing across the PNT Enterprise. This vector includes establishing coordination processes to ensure effective operations, efficient acquisition (for both data source equipment and user equipment), and relevant science and technology application development. This vector also incorporates an enterprise-level PNT modeling and simulation capability to benefit, for example, mission planning and user equipage decisions. In addition, this capability would support subsequent architecture development efforts.

1.7 Architecture Recommendations

The Architecture Development Team identified a set of nineteen recommended actions to support implementing the strategy and vectors leading to the "Should-Be" Architecture as documented in Architecture Guidance Memo dated 16 June 2008:

GREATER COMMON DENOMINATOR STRATEGY

1. Maintain GPS as a cornerstone of the National PNT Architecture
2. Monitor PNT signals to verify service levels, observe environmental effects, detect anomalies, and identify signal interference for near real-time dissemination
3. As GPS modernization or other methods demonstrate new operational capabilities, agencies should transition or divest US GNSS augmentation assets that are unnecessarily redundant to their requirements
4. Continue to investigate methods to provide high-accuracy-with-integrity solutions for safety-of-life applications
5. Develop a National approach to protect the military PNT advantage

MULTIPLE PHENOMENOLOGY VECTOR

6. Encourage appropriate development and employment of equipment that integrates information from diverse sources and information paths
7. Assess the potential for the use of foreign PNT systems for safety-of-life applications and critical infrastructure users and, as appropriate, develop clear standards and criteria for their use

8. Continue military PNT Exclusive Use Policy while studying development of capabilities to enable military use of other signals
9. Promote standards for PNT pseudolites and beacons to facilitate interchangeability and avoid interference
10. Study evolution of space-based and terrestrial PNT capabilities to support diversity in PNT sources and information paths
11. Ensure critical infrastructure precise time and time interval users have access to and take advantage of multiple available sources

INTERCHANGEABLE SOLUTIONS VECTOR

12. Use participation in international PNT-related activities to promote the interchangeability of PNT sources while assuring compatibility
13. Evolve standards, calibration techniques, and reference frames to support future accuracy and integrity needs
14. Identify and develop common standards that meet users' needs for PNT information exchange, assurance, and protection
15. Establish common standards that meet users' needs for the depiction of position information for local and regional operations

SYNERGY OF PNT AND COMMUNICATIONS VECTOR

16. Identify and evaluate methods, standards, and potential capabilities for fusion of PNT with communications

COOPERATIVE ORGANIZATIONAL STRUCTURES VECTOR

17. Develop a National PNT coordination process
18. Identify and leverage Centers of Excellence for PNT phenomenology and applications
19. Define, develop, sustain, and manage a PNT modeling and simulation core analytical framework

1.8 Conclusion

The National PNT Architecture encompasses ground-, air-, space-based and internal PNT data sources to efficiently provide effective PNT solutions to DoD and US Civil users around the world and in space. It also identifies the importance of supporting infrastructure necessary to implement and maintain future PNT services for US users world-wide. The architecture addresses capability gaps projected to exist in the 2025 timeframe, and articulates recommended initiatives to close those gaps (or mitigate their effects). Implementing the National PNT Architecture recommendations and transition to the Should-Be Architecture will maximize PNT services to DoD and US Civil users.