



**SPACE-BASED POSITIONING
NAVIGATION & TIMING**
NATIONAL ADVISORY BOARD

NATIONAL SPACE-BASED POSITIONING, NAVIGATION, AND TIMING ADVISORY BOARD

White Paper

Celebrating the GPS 50th Anniversary: Recommitting to U.S. Leadership in PNT

May 4, 2023

This white paper was prepared by the board to support recommendation number PNT27-09-SPG for a celebration of the 50th Anniversary of GPS, which was approved at the PNTAB-27 meeting held on November 16-17, 2022, and formally submitted to the National Space-Based PNT EXCOM co-chairs via Memorandum on January 27, 2023.

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Celebrating GPS 50th Anniversary

Recommitting to U.S. Leadership in Positioning, Navigation, & Timing

Bottom Line Up Front: This year marks the 50th anniversary of the Global Positioning System program. In December 1973 the Defense Systems Acquisition Review Council (DSARC) gave the U.S. Air Force approval to proceed with the development of the Navstar Global Positioning System (GPS).

GPS has provided America and the world innumerable and incalculable benefits. It has also been a symbol of America's strength and global leadership for decades.

Recommitting to U.S. positioning, navigation, and timing (PNT) leadership must be a key public policy objective in an era of great power competition.

A visible celebration of the 50th Anniversary of GPS will remind Americans and the world what GPS has done for humankind and must serve as the catalyst to elevate global PNT leadership to its proper place in our national policy agenda.

Opportunities at GPS 50 celebration to highlight:

- Fighting climate change with GPS
- Women & minorities' historic & ongoing contributions to GPS (ex: Gladys Mae West)
- International cooperation & engagement around GPS & Global Navigation Satellite System issues (GNSS)
 - GPS as the progenitor, inspiring other GNSS & multiple augmentations
 - International cooperation on GNSS at United Nations & peaceful engagement
 - Benefits of GPS for entire planet population regardless of nationality, etc.
- Vice President's leadership of space issues and Space Council
 - Key elements of national security, economic growth, & international cooperation.
 - Leading whole-of-government effort executing national GPS & PNT policy, & ensuring U.S. leadership & competitiveness in key cyber, information technology (IT), infrastructure areas (see attachment 4).
 - Planning for the next 50 years of GPS & U.S. global PNT leadership

Reminding America & the World

GPS has brought innumerable benefits to the nation and the world.

This has made it a pillar of America's global leadership and soft power for 40 years.¹ Other nations have taken note. Some are attempting similar successes and challenging our leadership with their own GNSS and PNT systems.²

¹ In September 1983 President Reagan authorized GPS for civil use after the downing of KLA Flight 007 by the Soviet Union.

² China's BeiDou: New Dimensions of Great Power Competition, Harvard Belfer Center, February 2023

GPS' outstanding record of performance has made it a silent utility that is taken for granted by most users.

The celebration must highlight important contributors to GPS, its many important benefits, and recommit the nation to providing leadership for GPS & American PNT going forward.

More Focused and Agile Governance

GPS is a "dual use" technology key to both national security and economic prosperity. It is an essential utility in IT and cybersecurity, transportation, economic development, and sustainment of day-to-day life in the homeland.

As such, GPS and American PNT requires a whole-of-government approach led by focused, agile day to day leadership and coordination addressing the countless issues impacting its utility, reliability, and security.

The greatly improved awareness generated by the celebration should engender improvements to governance for the next 50 years of GPS and U.S. PNT leadership and competitiveness.

A National Resilient PNT Architecture

American leadership and competitiveness in PNT, and the countless technology and applications it supports, will require a comprehensive system of systems approach.

The nation requires reliable, robust, resilient PNT for the next 50 years so that the "silent utility" remains just that, verses a series of challenges to be overcome.

The celebration should engender coordination of public and private PNT efforts resulting in a resilient national PNT architecture that will ensure military and civilian users have services whenever and wherever needed.

Recommendations

Identify a responsible organization to help and convene a White House summit celebrating U.S. achievements with GPS and launch new era of innovation and prosperity. The summit should:

- Raise awareness of GPS' contributions and importance to America and the world,
- Lead to improvements in the agility of PNT governance by assigning a senior responsible federal official, and
- Lead to implementation of a systems approach to a resilient national PNT architecture to underpin national security and economic prosperity.

Attachments:

- 1) Potential agenda items for GPS 50th Anniversary Summit
- 2) GPS, an Essential but Silent Utility
- 3) GPS, PNT and Great Power Competition
- 4) Some necessary steps for global PNT leadership
- 5) Brief GPS & PNT Policy History
- 6) "What's the economic impact of GEO services?" - Oxera for Google, 2013 (excerpt)
- 7) "Putting the U.S. Geospatial Services Industry on the Map" Boston Consulting Group, 2012 (excerpt)
- 8) "White House Summit – Future GPS & PNT for National Security & Economic Growth (50 years on) – PNT Advisory Board Recommendation, November 2022

Attachment 1

Potential agenda items for GPS 50th Anniversary Summit

- Introductory Video – “GPS, America’s Gift to the World” (TB Developed, NASA & Space Force)
- GPS & PNT: National Security Essentials and Economic Drivers
- Protecting, Toughening, & Augmenting GPS
- Resilient PNT for Autonomy & the Future – the “Humphreys Principle” of layered systems
- Dual use (military/civil) technologies – balancing benefits and disadvantages
- PNT governance for success - agile & focused whole-of-government efforts
- US GPS & PNT Leadership, a Force for Good in the World – American PNT as the gold standard & counter balancing China efforts.
- Bipartisan Congressional Resolution presented by leaders of GPS Caucus in Senate and House
- Awards Ceremony Recognizing GPS Leaders and Hidden Figures
 - Presented by the Vice President of the United States

Attachment 2

GPS, an Essential but Silent Utility

Look around you. Almost everything you see is enabled or improved by America's gift to the world, the Global Positioning System (GPS). It has transformed industries and economies and has improved the lives of billions. GPS has become a must-have that supports critical infrastructure and virtually every technology.

Are you indoors?

The electricity for your lights and computer is delivered by electrical grids that use GPS timing in ten different ways.³ Your furniture was efficiently transported using GPS-based navigation. Your cell phone works because wireless networks are synchronized using GPS. Your cash came from a bank or ATM that timestamps transactions using GPS time. The food in your kitchen or in the snack machine down the hall was produced at much lower cost with GPS-based precision agriculture.

Are you outside?

GPS is a critical tool for fighting climate change and preserving the environment. Efficient navigation saves billions of gallons of fuel each year. GPS is an essential tool for scientists studying the atmosphere and detecting changes in the oceans and on land. GPS lets farmers use tiny amounts of fertilizer for each seed, and precisely target pesticides minimizing the environmental impacts of both.

The airplanes you see overhead, the cars and trucks down the street, the train you hear in the distance, all use and are far more efficient and safer because of GPS.

Are you hungry? Do you need a ride home? Do you need the route to the nearest pharmacy? Do you need help from a first responder? GPS is essential to quickly getting you what you need and want. It has been instrumental in saving tens of thousands of lives that would have otherwise been lost.

The positioning, navigation, and timing (PNT) services GPS provides have increased productivity, reduced costs, and enabled entirely new industries. The benefits of GPS are measured in hundreds of thousands of jobs and trillions of dollars in global benefits each year.⁴

GPS has transformed U.S. and allied military operation with its ability to precisely locate friendly forces, surveil and track enemy forces and actions, and execute combat operations with precise and lethal effects.

³ MITRE, "GPS Resiliency for Critical Infrastructure: Energy Sector Baseline Report (FINAL)," Version 1.1, November 24, 2013

⁴ See for example "What is the impact of Geo Services?" Oxera for Google, January 2012, Attachment 6 & "Putting the U.S. Geospatial Services Industry on the Map," Boston Consulting Group, December 2012, Attachment 7.

And GPS is critical to fighting climate change.

- Efficient navigation saves an estimated 7 billion gallons of fossil fuel each year.⁵
- Precision agriculture means fertilizers and pesticides are used at only a fraction of the rate they were before GPS.
- Scientists study GPS signal propagation to better understand the atmosphere, and GPS enables their precise measurement of changes in the sea and earth.

GPS supports and has revolutionized all critical infrastructures including ground, air and maritime transportation, power grids, energy pipelines, telecom's, banking and finance, disaster response to name a few.

GPS has transformed America's economy and society.⁶

In the process it has become an essential silent utility. Vastly underappreciated, yet one we cannot afford to be without, Over-dependence on GPS has caused it to become, in the words of Deputy Homeland Security Advisor Durkovich, "A single point of failure" for America.⁷

⁵ Est 1.1B/yr for automobiles & trucks per Oxera. Est 5% savings for maritime 4.3B/yr, and aviation 1.6B/yr

⁶ "Pinpoint: How GPS is Changing Technology, Culture, and Our Minds," Greg Milner, Norton, 2016

⁷ NSC Director: GPS 'Still a single point of failure' GPS World, 4 January 2022

Attachment 3

GPS, PNT and Great Power Competition

GPS' contributions to America's global leadership and economic prosperity have not gone unnoticed by our allies and adversaries.

- In succession, Russia, Europe, and China built their own global navigation satellite systems.
- In parallel, adversaries have demonstrated capabilities to disrupt, deny and destroy U.S. PNT capabilities in crises and conflicts, as well as use their PNT capabilities to threaten U.S. forces and operations
- Both Europe and China are aggressively promoting their newer systems, which have many desirable features GPS does not, as alternatives. Both see adoption of their systems as a way to broaden their global influence.
- China is particularly aggressive using its satnav system (BeiDou) as a tool to increase its national power and international influence.⁸
- China has also established an integrated and resilient PNT architecture that includes several space-based systems, fiber, and terrestrial eLoran. It has justified its terrestrial systems as ensuring it is not dependent on space for essential PNT services.^{9,10}
- In the run up to its invasion of Ukraine, Russia recognized the importance and power of GPS by threatening to destroy the satellites and "blind NATO" should the West intervene.¹¹

Russia's invasion of Ukraine in February 2022 and the growing assertiveness of China has demonstrated the rise great power competition and that PNT and specifically GPS, is becoming an increasingly important sphere of that competition. At the same time, threats to GPS are coming from lesser adversaries, non-state actors and unintentional causes (as witnessed in recent domestic disruptions of GPS services).

China's activities are especially concerning. China overtly interferes with GPS signals and has demonstrated the ability to disable satellites. More subtly, China is aggressively using BeiDou as an instrument for soft power influence and to gain tangible leverage over the critical infrastructure of other nations.¹²

⁸ China's BeiDou: New Dimensions of Great Power Competition, Harvard Belfer Center, February 2023

⁹ China leads world with plan for 'comprehensive' PNT, GPS World 15 Nov 2019

¹⁰ U.S. is concerned about rivals' space threats, leaked documents show, Washington Post 25 April 2023

¹¹ Russia issues threats to GPS satellites, GPS World 29 November 2021

¹² OpCit Harvard Belfer Center

While Chinese and Russian anti-space efforts are the most advanced, Iran, and North Korea also have cyber and kinetic programs of concern, and non-state actors have acted against space with cyberattacks.¹³

Protecting GPS satellites, services, and users is essential to America's national and economic security and U.S. global leadership in PNT.

It is vital to make governance of GPS and PNT more agile, providing the day-to-day leadership and coordination needed to maintain and advance America's GPS/PNT enterprise. Otherwise, unmet goals of NSPD-39 and SPD-7 and additional initiatives needed for American global leadership, such as those discussed in Attachment 4, will remain only good ideas.

¹³ [Space Threat Assessment 2023](#), CSIS April 2023

Attachment 4

Some necessary steps for global PNT leadership

American PNT leadership is key to ensuring our national and economic security, and our position on the world stage.

The following are some of the actions needed.

From NSPD-39 and SPD-7:

- Monitor civil GPS signals to ensure adherence to agreed-upon international standards and report results,
- Monitor and detect GPS/GNSS interference,
- Protect GPS/GNSS spectrum, and
- Establish appropriate alternative source(s) for signals to complement and backup GPS.

Recent PNT Advisory Board Recommendations:

- Establishment of a wireless, internet-based high accuracy and authentication service. This will greatly increase accuracy and security, while improving GPS' comparability to newer systems.
- Increased adoption and use of receivers resistant to interference, including modifying export controls on adaptive antennas,
- Process and procedures to warn the public during major GPS disruption events,
- Deploy a National GNSS Interference Detection and Reporting system based on mobile wireless technology,
- Make PNT security a prominent part of the National Cyber Director's, departments, and agencies cyber portfolios,
- Ensure a trained and educated workforce to meet the nation's PNT needs. The field of geodesy is particularly in crisis.

Attachment 5

Brief GPS & PNT Policy History

- December 1973: Defense Systems Acquisition Review Council (DSARC) gave Col. Brad Parkinson approval to proceed with the development of the Navstar Global Positioning System (GPS)
- September 1983: President Reagan approves GPS for civilian use after downing of Korean Air Line flight 007.
- December 1993: 24 satellites in space, constellation becomes fully operational
- July 1995: GPS declared fully operational.
- March 1996: Interagency GPS Executive Board established by Presidential Directive NSTC-6
- May 2000: Selective Availability (SA) discontinued.
- July 2003: U.S. FAA Wide Area Augmentation System (WAAS) operational
- December 2004: National Security Presidential Directive NSPD-39, “National Space-based PNT Policy,” establishes National PNT Executive Committee (PNT Excom), to be led by DOD and DOT, and assigns tasks to departments.
- February 2008: DHS announces decision (endorsed by PNT Excom) to upgrade Loran-C to eLoran for GPS backup in fulfillment of NSPD-39 mandate.
- February 2010: U.S. Loran de-funded and terminated.
- December 2015: Deputy Secretaries of Defense and Transportation letter to Chair of House Transportation committee chair and others pledging to establish eLoran as a backup for GPS.
- December 2018: President signs the National Timing Resilience and Security Act requiring establishment of a terrestrial timing backup for GPS.
- February 2020: EO 13905 “Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Timing Services”
- January 2021: Space Policy Directive 7 “National Space-based PNT Policy

What is the economic impact of GEO SERVICES

Oxera for Google
January 2013

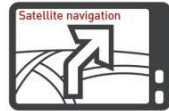
Geo services are:



Satellite receivers and manufacturing



Satellite imagery

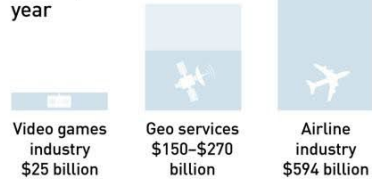


Satellite navigation



Location-based search

Geo services global revenues are \$150-\$270 billion per year



Geo services global added value is around \$100 billion per year



Geo services save:



Geo services save 3.5 billion litres of gasoline per year—approximately 0.1% of the total world production of 5 trillion litres of liquid oil products

Geo services facilitate competition, leading to savings from reduced prices among infrequently bought goods and services of up to:



Geo services can improve agricultural irrigation, helping to achieve global cost savings per year of:



Geo services aid faster emergency response; for example, in England Geo services may have helped to save at least 152 lives per year



Students educated using Geo services can expect

3%

higher average wages five years after graduation than those who weren't

Source: Oxera (2013), analysis.

Does not include value of essential GPS timing & synchronization for tech infrastructure.

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Putting the U.S. Geospatial Services Industry On the Map

December 2012

Main study findings: The impact of geospatial services on the U.S. economy is 15x-20x the size of the geospatial industry

The U.S. geospatial industry generated approximately \$73B in revenues in 2011 and comprises at least 500,000 high-wage jobs

- The industry is composed of geo-data providers, location-enabled device manufacturers, geo-app developers, and a growing network of geospatial experts and educators
- By employees, this is roughly equivalent to the airline industry; by revenues it is approximately \$10B more than the U.S. paper industry

More importantly, geospatial services deliver efficiency gains in the rest of the U.S. economy that are valued at many times the size of the sector itself, creating a lasting source of competitive advantage for the U.S.

- Geospatial services drive \$1.6T in revenue and \$1.4T of cost savings, representing 15 to 20 times the size of the geospatial services industry itself
- Geospatial services are used on a daily basis by roughly 5.3M U.S. workers today (over 4% of the U.S. workforce)

In addition, U.S. consumers place a direct value on geospatial services at \$37B annually—a recognition of the many ways geo-applications and location-enabled devices are central to our daily lives

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Note: Does not include timing and synchronization services essential to critical tech infrastructure.

Attachment 8

National PNT Advisory Board – November 2022 Recommendation – **White House Summit: Future GPS & PNT Infrastructure for National Security & Economic Growth (50 years on)**

- **Finding:**
 - GPS is America's gift to the world – first approved 1973.
 - The PNT services it provides are fundamentally embedded in our national security and the successful functioning of our economy.
 - China's BeiDou system and the EU's Galileo surpass US PNT in both resilience and capability.
 - Adversaries are able to deny GPS service to America.
 - GPS & PNT modernization requires holistic systems approach, including protecting signals, toughening receivers, and augmenting services.
 - Needed technologies are mature and readily available.
 - U.S. Government efforts appear disparate and unfocused. Industry cannot fill gaps without clearer government leadership and support.
 - PNT decision-making authority is diffuse and lacks a clear locus of leadership.
- **Recommendation:**
 - Convene a White House summit celebrating U.S. achievements with GPS and launch new era of innovation and prosperity.
 - Goal: Sharpen, improve agility of PNT governance
 - Goal: Facilitate, enable, direct implementation of systems approach to resilient National PNT Architecture
- **Reason for Recommendation:**
 - GPS & PNT services are essential yet face significant threats.
 - Enormous economic benefits (services, device manufacture, R&D, new applications, ex: autonomy, spectrum efficiency)
- **Consequences of No Action on the Recommendation:**
 - U.S. competitiveness suffers; U.S. leadership in PNT technology will be unsustainable.
 - U.S. becomes increasingly vulnerable to GPS and/or PNT disruption impacting infrastructure, economic activity including supply chains.

Recommendation:

- Convene a White House summit celebrating US achievements with GPS and launch a new era of innovation and prosperity.
 - Goal: Sharpen, improve, agility of PNT governance
 - Goal: Facilitate, enable, direct implementation of system approach to resilient National PNT Architecture