SPACE-BASED POSITIONING
NAVIGATION & TIMING
NATIONAL COORDINATION OFFICE

GPS Update

The Institute of Positioning, Navigation and Timing of Japan (IPNTJ) GPS/GNSS Symposium

27 October 2021

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National Coordination Office

GPS Constellation Status

37 Satellites • 30 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	7 (5*)	19.8	24.2
GPS IIR-M	7 (1*)	14.0	16.1
GPS IIF	12	7.8	11.4
GPS III	4 (1*)	1.5	2.8

*Not set healthy

As of 16 Oct 21

GPS Signal in Space (SIS) Performance

From 16 Oct 20 to16 Oct 21

Average URE*	Best Day URE	Worst Day URE
48.6 cm	31.5 cm (20 Apr 21)	70.4 cm (13 Mar 21)

*All User Range Errors (UREs) are Root Mean Square values

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GPS Modernization

Space Segment

SV families provide L-Band broadcast to User Segment

GPS IIA/IIR
- Basic GPS
- Nuclear Detonation Detection System (NDS)

GPS IIR-M
- 2nd Civil Signal (L2C)
- New Military Signal
- Increased Anti-Jam Power

GPS IIF
- 3rd Civil Signal (L5)
- Longer Life
- Better Clocks

GPS III (SV01-10)
- Accuracy & Power
- Increased Anti-Jam Power
- Inherent Signal Integrity
- 4th Civil Signal (L1C)
- Longer Life
- Better Clocks

GPS IIIF (SV11-32)
- Unified S-Band Telemetry, Tracking & Commanding
- Search & Rescue (SAR) Payload
- Laser Retroreflector Array
- Redesigned NDS Payload

Control Segment

TT&C of Space Segment assets & distribution of data to user interfaces

Legacy (OCS)
- Mainframe System
- Command & Control
- Signal Monitoring

Architecture Evolution Plan (AEP)
- Distributed Architecture
- Increased Signal Monitoring Coverage
- Security
- Accuracy

OCX Block 0
- GPS III Launch & Checkout System

GPS III Contingency Ops (COps)
- GPS III Mission on AEP

M-Code Early Use (MCEU)
- Update OCS to operationalize Core M-Code for MGUE

OCX Block 1/2
- Fly Constellation & GPS III
- Begin New Signal Control
- Upgraded Information Assurance

OCX Block 2+
- Control all signals
- Capability On-Ramps
- GPS IIIF Evolution

User Segment

Applies Space and Control Segment data for PNT applications

Continued support to an ever-growing number of applications
- Annual Public Interface Control Working Group (ICWG)
- Standard Positioning Service (SPS) Performance Standard Updates
- Precise Positioning Service (PPS) Enhancements
- Sustained commitment to transparency
- Visit GPS.gov for more info

Modernized Civil Signals
- L2C (Various commercial applications)
- L5 (Safety-of-life, frequency band protected)
- L1C (Multi-GNSS interoperability)

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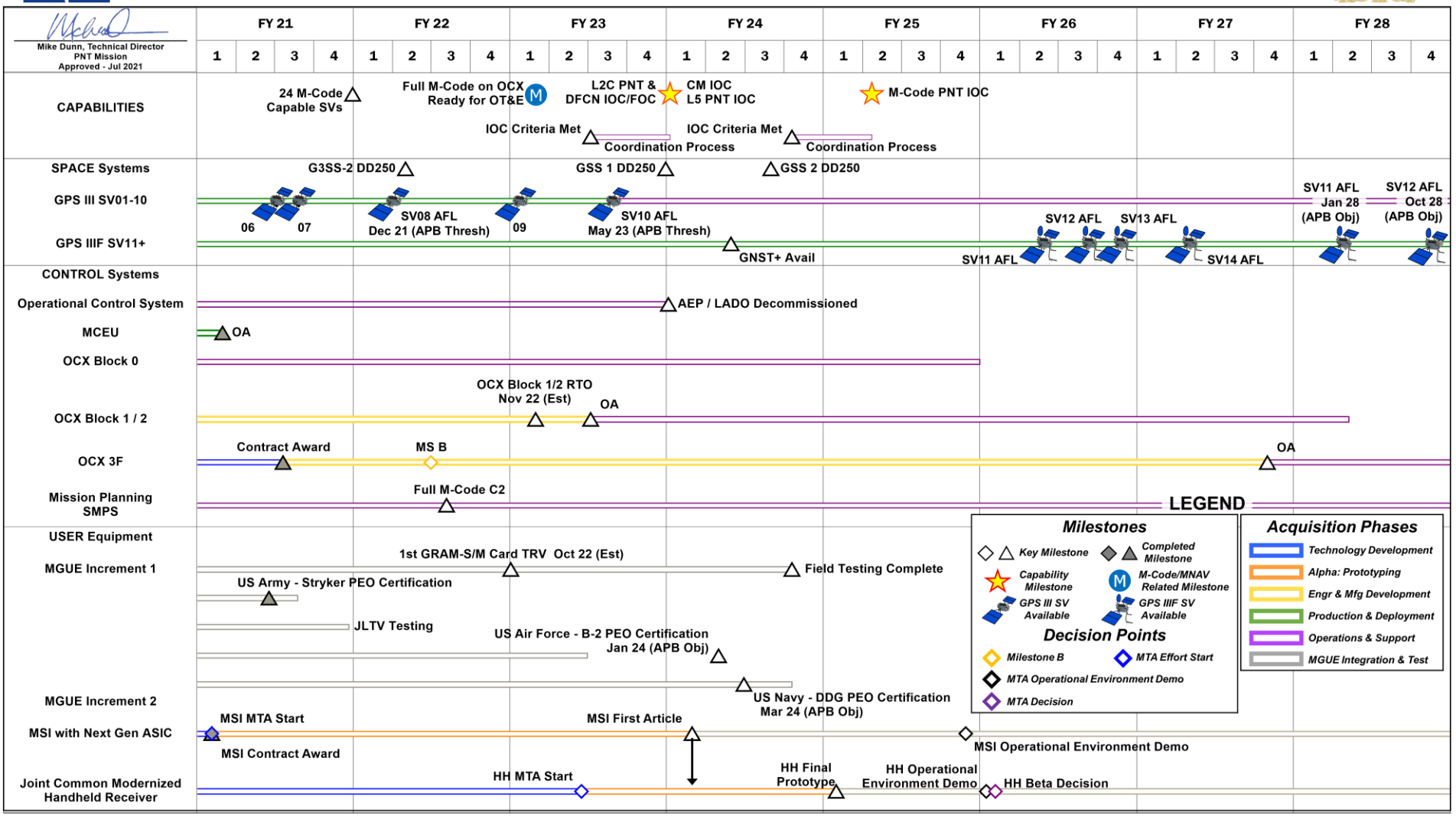
GPS Enterprise Roadmap



AEP	Architecture Evolution Plan	DFCN	Dual-Frequency Civil Navigation	GSS	GPS Satellite Simulator	MNAV	Military Navigation	OT&E	Operational Test and Evaluation
AFL	Available for Launch	Est	Forecast Estimate	HH	Handheld	MS	Milestone	PEO	Program Executive Officer
APB	Acquisition Program Baseline	FOC	Full Operational Capability	IOC	Initial Operating Capability	MSI	Miniature Serial Interface	PNT	Positioning, Navigation & Timing
ASIC	Application-Specific Integrated Circuit	GRAM-S/M	GPS Receiver Application Module – Standard Elec Module/Modernized	JLTV	Joint Light Tactical Vehicle	MTA	Middle Tier Acquisition	RTO	Ready for Transition to Ops
C2	Command & Control			LADO	Launch, Anomaly, and Disposal Operations	OA	Operational Acceptance	SMPS	SAASM Mission Planning System
CM	Constellation Management	G3SS	GPS III Satellite Simulator	MCEU	M-Code Early Use	Obj	Objective Date	SV	Space Vehicle
DDG	Arleigh Burke Guided Missile Destroyer	GNST+	GPS IIIF Non-Flight Satellite Testbed	MGUE	Military GPS User Equipment	OCX	Next Gen Operational Control System	TRV	Technical Requirements Verification

WAAS Current Status

Current WAAS provides high availability service to aviation user in North America

- 4,086 Localizer Performance with Vertical Guidance (LPV) approaches in the NAS
  - Over 1050 LPVs are LPV-200's which provides CAT I equivalent instrument approach performance

Preparing WAAS to take advantage of Dual Frequency service that will be provided by GPS

- To continue high availability of WAAS vertical service during ionospheric disturbances

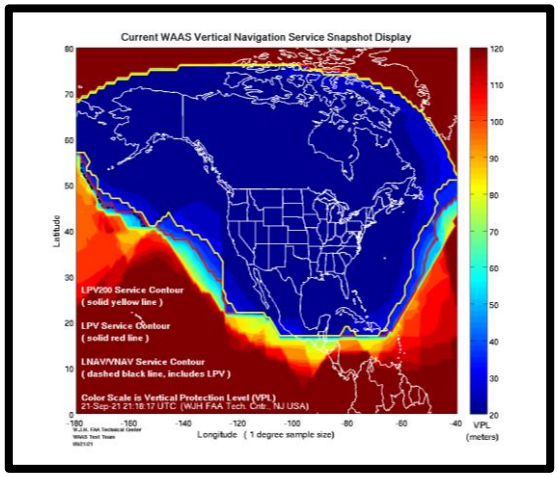
GEO Sustainability

- Currently maintaining 3 GEO's (Anik F1R [CRE], Eutelsat 117 WB [GEO 5], SES-15 [GEO 6])
- Intelsat Galaxy 30 (GEO 7), launched August 2020, currently being integrated, expect operational in 2022

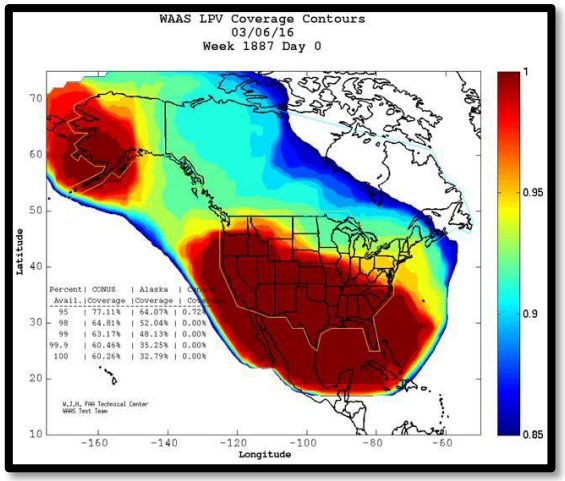
WAAS Modernization Efforts

- Dual Frequency Multi-Constellation (DFMC)
- Advanced Receiver Integrity Monitoring (ARAIM)

Current WAAS LPV Coverage



WAAS LPV Coverage March 6, 2016 Iono event

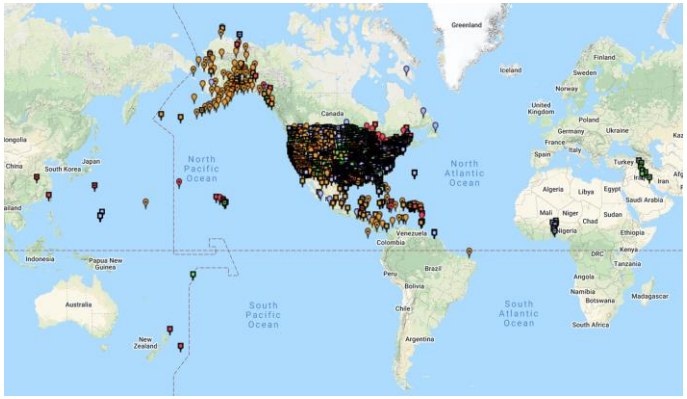


WAAS Avionics Equipage Status

- Over 144,000 WAAS equipped aircraft in the NAS
  - WAAS receivers provided by companies such as: Garmin, Universal, Rockwell Collins, Honeywell, Avidyne, Innovative Solutions & Support (IS&S), Thales and Genesys Aerosystem (Chelton)
- Since 2006, aircraft equipage rates have increased each year
- All classes of aircraft are served in all phases of Flight
  - Recent STC for Boeing 737-600/700/800 avionics
- Enabling technology for NextGen programs
  - Automatic Dependent Surveillance Broadcast (ADS-B)
  - Performance Based Navigation (PBN)

NOAA CORS Network (NCN)

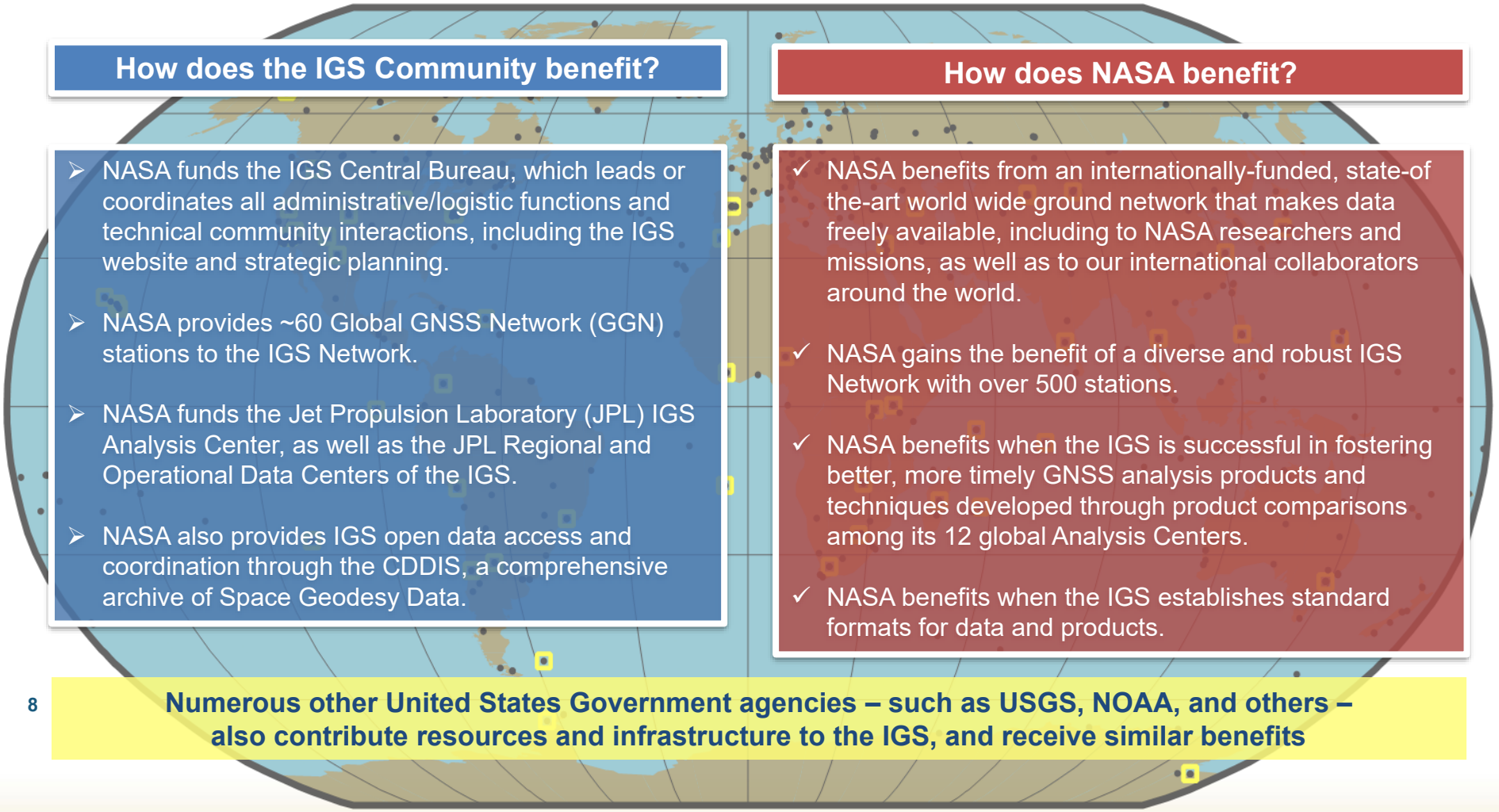
- 1,887 Continuously Operating GNSS Reference Stations
  - 239 government, academic & private partners
  - Managed by National Geodetic Survey
  - Provides GNSS data supporting National Spatial Reference System, high precision 3D positioning, meteorology, space weather, other geophysical applications



- Installing multiple GNSS stations and InSAR corner reflectors at each NRAO VLBA radio telescope
  - In collaboration with National Geospatial-Intelligence Agency
  - Will greatly improve ties between space geodetic techniques
  - Critical for defining terrestrial reference frame and tracking Earth's center of mass

Example of United States contributions to the International GNSS Service (IGS):

NASA Investment in the Continued Success of the IGS for the Benefit of the International Geodesy Community



How does the IGS Community benefit?

- NASA funds the IGS Central Bureau, which leads or coordinates all administrative/logistic functions and technical community interactions, including the IGS website and strategic planning.
- NASA provides ~60 Global GNSS Network (GGN) stations to the IGS Network.
- NASA funds the Jet Propulsion Laboratory (JPL) IGS Analysis Center, as well as the JPL Regional and Operational Data Centers of the IGS.
- NASA also provides IGS open data access and coordination through the CDDIS, a comprehensive archive of Space Geodesy Data.

How does NASA benefit?

- ✓ NASA benefits from an internationally-funded, state-of the-art world wide ground network that makes data freely available, including to NASA researchers and missions, as well as to our international collaborators around the world.
- ✓ NASA gains the benefit of a diverse and robust IGS Network with over 500 stations.
- ✓ NASA benefits when the IGS is successful in fostering better, more timely GNSS analysis products and techniques developed through product comparisons among its 12 global Analysis Centers.
- ✓ NASA benefits when the IGS establishes standard formats for data and products.

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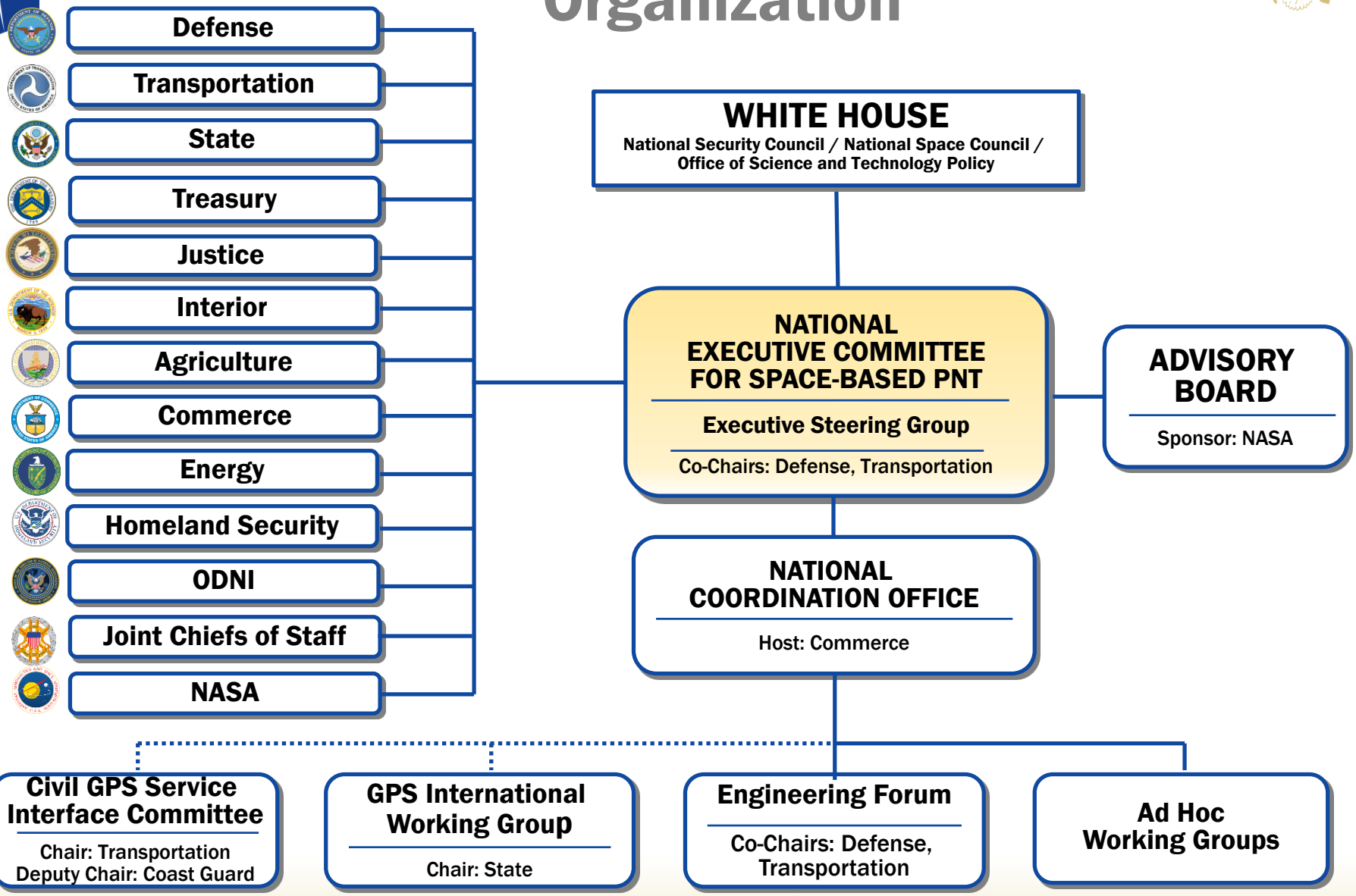
Numerous other United States Government agencies – such as USGS, NOAA, and others – also contribute resources and infrastructure to the IGS, and receive similar benefits

SSV Video

- WG-B Space Use SubGroup (SUSG) will present finalized SSV Video in the ICG Plenary
- Video conveys benefits of a Multi-GNSS SSV and its transformative impact to humanity—in space and on Earth
- Co-sponsors: NASA and **National Coordination Office for Positioning, Navigation and Timing**

National Space-Based PNT Organization



Space Policy Directive 7 (SPD-7)
of 15 January 2021

The goal of [SPD-7] is to maintain United States leadership in the service provision, and responsible use of, global navigation satellite systems (GNSS), including GPS and foreign systems.

- Increased focus on protecting GPS and denying hostile use
- Incorporated principles of Responsible Use of GPS
- New direction on adding cybersecurity protections for GPS and federal user equipment
- Expanded EXCOM Membership
  - Added Departments of Treasury, Justice, and Energy
- New direction to protect the GPS spectrum environment

U.S. Policy

The goal of [SPD-7] is to maintain United States leadership in the service provision, and responsible use of, global navigation satellite systems (GNSS), including GPS and foreign systems.

- Continuous, worldwide, free of direct user fees
- Encourage compatibility and interoperability with like-minded nations, promote transparency in civil service provisioning and enable market access for United States industry
- Operate and maintain constellation to satisfy civil and national security needs and equip and train for the responsible use of GPS
  - Foreign PNT services may augment and strengthen the resiliency of GPS; however, the US Government does not assure the reliability or authenticity of foreign PNT services
- Invest in domestic capabilities and support international activities to detect, mitigate and increase resiliency to harmful interference
- Improve the cybersecurity of GPS, its augmentations, and United States Government-owned GPS-enabled devices, and foster private sector adoption of cyber-secure GPS enabled systems

SPD-7 Changes to Agency Responsibilities

- *State*
  - New mention of cooperation with DoD in relations with Allies
- *Defense*
  - Direction to work with DOT to maintain "safety-of-life backwards compatibility commitments"
  - Direction to provide cost estimates to the GPS program based on DOT's strategy and future requirements to implement GPS data and signal authentication.
  - New mention of existing role as lead for International Spectrum Coordination
- *Commerce*
  - Direction to Invest in R&D for enhancing commercial services
  - Direction to develop cybersecurity resilience guidelines

SPD-7 Changes to Agency Responsibilities

- *Transportation*
  - Direction to ensure the earliest availability of modernized civil signals
  - New direction to implement Federal and facilitate State, local and commercial capabilities to monitor, identify, locate, and attribute space-based PNT service disruption and manipulations within the U.S.
  - Direction to develop international signal monitoring standards
  - New caution on the use of foreign GNSS
  - New direction to pursue data and signal authentication
- *Homeland Security*
  - Added reference to EO13905 on Responsible Use of PNT
  - Direction to develop procedures for notification of disrupted and/or unreliable PNT
  - Direction to assist DOT in implementing data and signal authentication

Executive Order 13905
of 12 February 2020

Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Timing Services

"Responsible use of PNT services" –
Means the deliberate, risk-informed use of PNT services, including their acquisition, integration, and deployment, such that disruption or manipulation of PNT services minimally affects national security, the economy, public health, and the critical functions of the Federal Government.

Space Policy Directive 5 (SPD-5)
of 4 September 2020

Establishing space cybersecurity policy, standards, and risk management practices

"...the United States considers unfettered freedom to operate in space vital to advancing the security, economic prosperity, and scientific knowledge of the Nation...Therefore, it is essential to protect space systems from cyber incidents in order to prevent disruptions to their ability to provide reliable and efficient contributions to the operations of the Nation's critical infrastructure."

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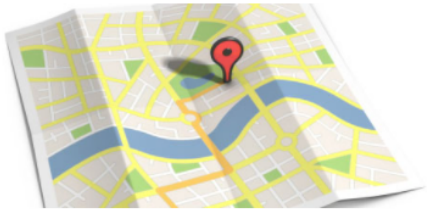
GPS: The Global Positioning System

A global public service brought to you by the U.S. government

INFORMATION FOR THE GENERAL PUBLIC

How to Correct Your Address in GPS Devices, Apps, & Online Maps



Do GPS devices show your home or business in the wrong place? **The problem is not GPS!** It's the mapping software.

Report your issue to the software providers

Common Questions

- How do I add or correct my address in GPS devices, apps, and maps?
- What can I do about trucks driving through my neighborhood?
- How do I report GPS service outages?
- Can GPS help me find my lost phone?

FOR GPS PROFESSIONALS

What's HOT for Pros

- Recent presentations
  - Public ICWG meeting, Sep 29
  - ICG-15 Vienna, Sep 27-Oct 1
  - ICG-15 Video: Multi-GNSS space service volume
  - CGSIC St. Louis, Sep 20-21
- Technical documentation
  - ICD updates for 2021
  - PRN assignments, Jun 2021
- Ligado Networks and GPS
  - Secretary of Commerce letter to Senator Inhofe (PDF)
- U.S. Space-Based PNT Policy of 2021
- Funding & legislation
  - FY22 GPS funding & NDAA

News Items

- *Aug 18:* Innovation is the game, GPS III-5 is the name