



SPACE-BASED POSITIONING  
NAVIGATION & TIMING

NATIONAL COORDINATION OFFICE

# *U.S. Space-Based Positioning, Navigation and Timing (PNT) Policy Update*

*Munich Satellite Navigation Summit  
March 2022*

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# Overview



- **GPS Status Update**
- **National Space-Based PNT Organization**
- **U.S. Policy**
  - SPD-7
  - National Space Policy
  - E0-13905
  - SPD-5



# GPS Constellation Status



**37 Satellites • 30 Set Healthy**  
**Baseline Constellation: 24 Satellites**



Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	7 (5*)	19.9	24.3
GPS IIR-M	7 (1*)	14.1	16.2
GPS IIF	12	7.8	11.5
GPS III	4 (1*)	1.6	2.9

\*Not set healthy

As of 20 Nov 21

## GPS Signal in Space (SIS) Performance

From 20 Nov 20 to 20 Nov 21

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

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



# GPS Modernization



## Space Segment

*SV families provide L-Band broadcast to User Segment*

- |  |  |  |  |   |
|--|--|--|--|---|
| <p><b>GPS IIA/IIR</b></p> <ul style="list-style-type: none"> <li>• Basic GPS</li> <li>• Nuclear Detonation Detection System (NDS)</li> </ul> | <p><b>GPS IIR-M</b></p> <ul style="list-style-type: none"> <li>• 2<sup>nd</sup> Civil Signal (L2C)</li> <li>• New Military Signal</li> <li>• Increased Anti-Jam Power</li> </ul> | <p><b>GPS IIF</b></p> <ul style="list-style-type: none"> <li>• 3<sup>rd</sup> Civil Signal (L5)</li> <li>• Longer Life</li> <li>• Better Clocks</li> </ul> | <p><b>GPS III (SV01-10)</b></p> <ul style="list-style-type: none"> <li>• Accuracy &amp; Power</li> <li>• Increased Anti-Jam Power</li> <li>• Inherent Signal Integrity</li> <li>• 4<sup>th</sup> Civil Signal (L1C)</li> <li>• Longer Life</li> <li>• Better Clocks</li> </ul> | <p><b>GPS IIIF (SV11-32)</b></p> <ul style="list-style-type: none"> <li>• Unified S-Band Telemetry, Tracking &amp; Commanding</li> <li>• Search &amp; Rescue (SAR) Payload</li> <li>• Laser Retroreflector Array</li> <li>• Redesigned NDS Payload</li> </ul> |
|--|--|--|--|---|

## Control Segment

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

- |   |  |  |   |   |
|---|--|--|---|---|
| <p><b>Legacy (OCS)</b></p> <ul style="list-style-type: none"> <li>• Mainframe System</li> <li>• Command &amp; Control</li> <li>• Signal Monitoring</li> </ul> | <p><b>Architecture Evolution Plan (AEP)</b></p> <ul style="list-style-type: none"> <li>• Distributed Architecture</li> <li>• Increased Signal Monitoring Coverage</li> <li>• Security</li> <li>• Accuracy</li> </ul> | <p><b>OCX Block 0</b></p> <ul style="list-style-type: none"> <li>• GPS III Launch &amp; Checkout System</li> </ul> <p><b>GPS III Contingency Ops (COps)</b></p> <ul style="list-style-type: none"> <li>• GPS III Mission on AEP</li> </ul> <p><b>M-Code Early Use (MCEU)</b></p> <ul style="list-style-type: none"> <li>• Update OCS to operationalize Core M-Code for MGUE</li> </ul> | <p><b>OCX Block 1/2</b></p> <ul style="list-style-type: none"> <li>• Fly Constellation &amp; GPS III</li> <li>• Begin New Signal Control</li> <li>• Upgraded Information Assurance</li> </ul> | <p><b>OCX Block 2+</b></p> <ul style="list-style-type: none"> <li>• Control all signals</li> <li>• Capability On-Ramps</li> <li>• GPS IIIF Evolution</li> </ul> |
|---|--|--|---|---|

## User Segment

*Applies Space and Control Segment data for PNT applications*

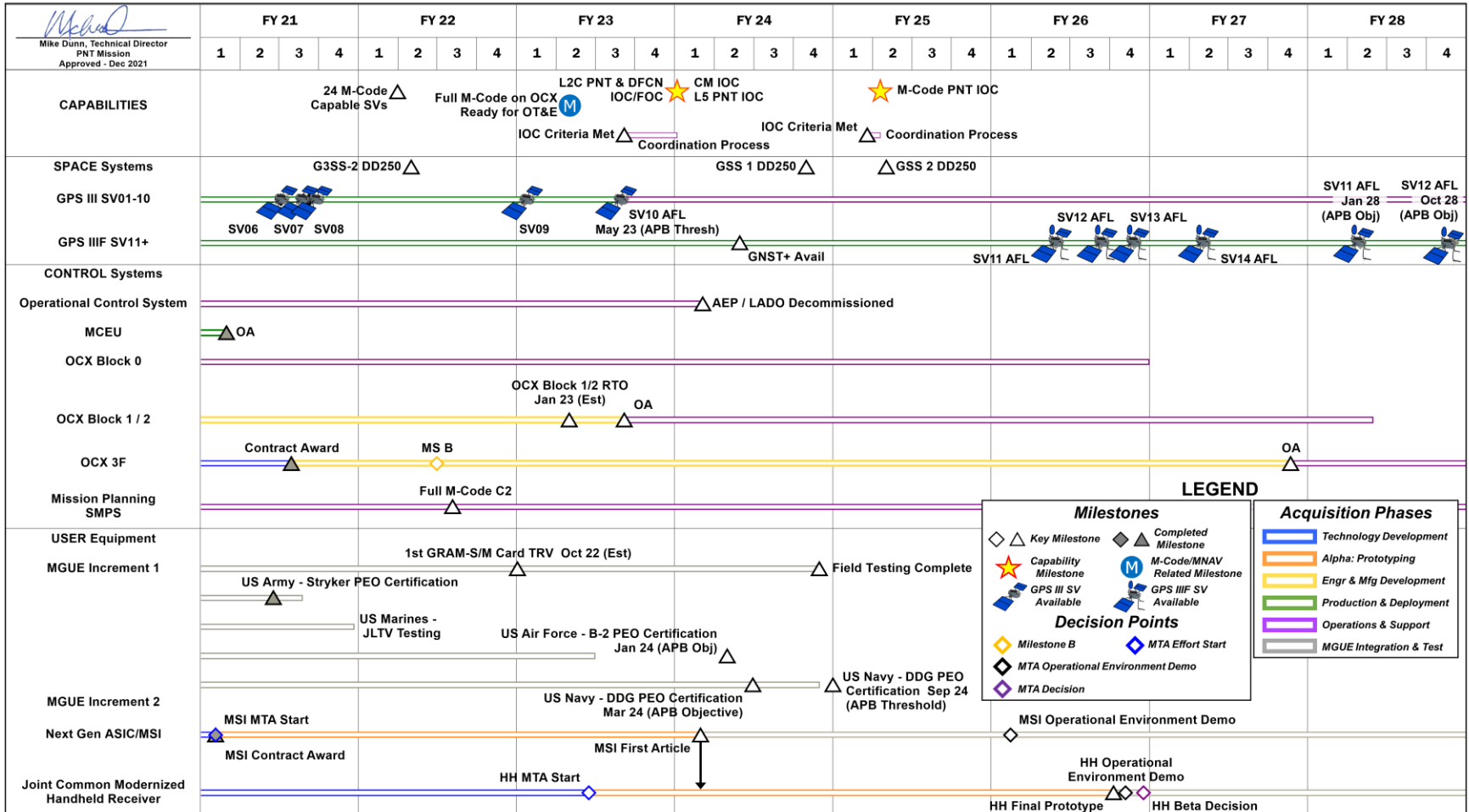
- |  |  |
|--|--|
| <p>Continued support to an ever-growing number of applications</p> <ul style="list-style-type: none"> <li>• Annual Public Interface Control Working Group (ICWG)</li> <li>• Standard Positioning Service (SPS) Performance Standard Updates</li> <li>• Precise Positioning Service (PPS) Enhancements</li> <li>• Sustained commitment to transparency</li> <li>• Visit <a href="http://GPS.gov">GPS.gov</a> for more info</li> </ul> | <p><b>Modernized Civil Signals</b></p> <ul style="list-style-type: none"> <li>• L2C (Various commercial applications)</li> <li>• L5 (Safety-of-life, frequency band protected)</li> <li>• L1C (Multi-GNSS interoperability)</li> </ul> |
|--|--|



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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	Standard Elec Module/Modernized	JLTV	Joint Light Tactical Vehicle	MTA	Middle Tier Acquisition	RTO	Ready for Transition to Ops
C2	Command & Control	GRAM-S/M	Standard Elec Module/Modernized	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 IIF Non-Flight Satellite Testbed	MGUE	Military GPS User Equipment	OCX	Next Gen Operational Control System	TRV	Technical Requirements Verification

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# WAAS Current Status



**Current WAAS provides high availability service to aviation users 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**

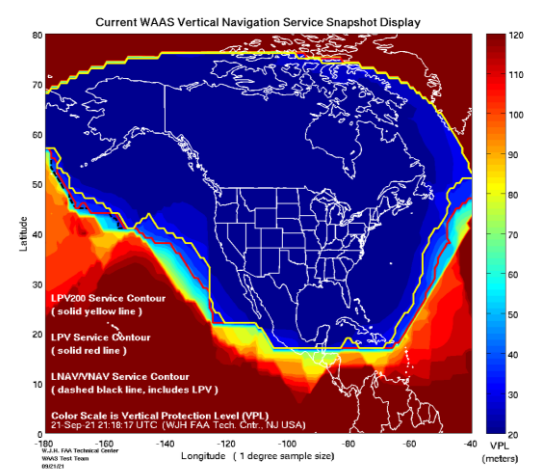
## GEO Sustainability

- 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

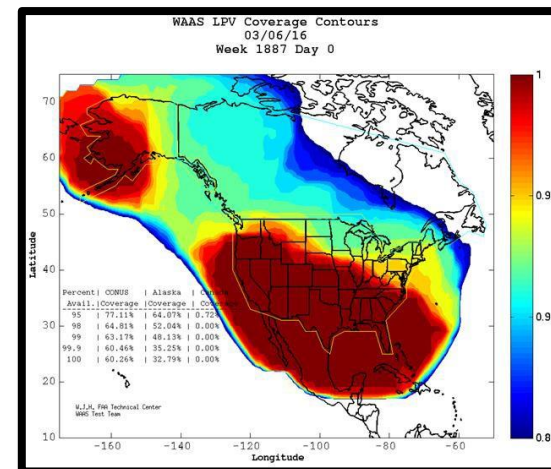
## WAAS Modernization Efforts

- 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)

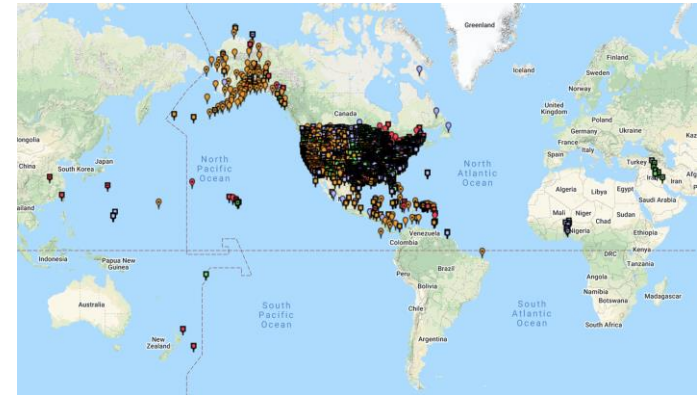




# NOAA CORS Network (NCN)



- **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**

# National Space-Based PNT Organization



- Defense
- Transportation
- State
- Treasury
- Justice
- Interior
- Agriculture
- Commerce
- Energy
- Homeland Security
- ODNI
- Joint Chiefs of Staff
- NASA

**WHITE HOUSE**  
National Security Council / National Space Council /  
Office of Science and Technology Policy

**NATIONAL EXECUTIVE COMMITTEE FOR SPACE-BASED PNT**  
Executive Steering Group  
Co-Chairs: Defense, Transportation

**ADVISORY BOARD**  
Sponsor: NASA

**NATIONAL COORDINATION OFFICE**  
Host: Commerce

**Civil GPS Service Interface Committee**  
Chair: Transportation  
Deputy Chair: Coast Guard

**GPS International Working Group**  
Chair: State

**Engineering Forum**  
Co-Chairs: Defense, Transportation

**Ad Hoc Working Groups**

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



**Updates and replaces U.S. Space-Based PNT Policy of  
2004**

- **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

# National Space Policy

## 9 December 2020



**The U.S. must maintain its leadership in the service, provision, and responsible use of global navigation satellite systems (GNSS)**

- **Provide continuous worldwide access for peaceful civil uses free of direct user fees;**
- **Engage with international GNSS providers to ensure compatibility, encourage interoperability with like-minded nations, promote transparency in civil service provision, and enable market access for United States industry;**
- **Operate and maintain the GPS constellation to satisfy civil and national security needs,**
- **Improve the cybersecurity of GPS, its augmentations, and federally-owned GPS enabled devices,**
- **Allow for the continued use of allied and other trusted international PNT services in conjunction with GPS**



# National Space Policy (cont.)



- **Invest in domestic capabilities and support international activities to detect, analyze, mitigate, and increase resilience to harmful interference to GNSS;**
- **Identify and promote, as appropriate, multiple and diverse complementary PNT systems or approaches for critical infrastructure and mission-essential functions; and**
- **Promote the responsible use of United States space-based PNT services and capabilities in civil and commercial sectors at the Federal, State, and local levels, including the utilization of multiple and diverse complementary PNT systems or approaches for national critical functions.**



# 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.”**



# Thank You



English | español | français | 中文 | عربي  
For Legislative Staff | For Students & Teachers

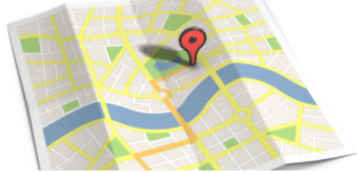
**GPS.gov** Official U.S. government information about the Global Positioning System (GPS) and related topics

Home | What's New | Systems | Applications | Governance | Multimedia | Support

**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?

FOR GPS PROFESSIONALS

**What's **HOT** for Pros**

- Recent presentations**
  - Nepal GNSS training, Jan 11-14
  - PNT advisory board, Dec 9-10
  - Japan GPS/GNSS symposium, Oct 27
- Technical documentation**
  - Dec 2021 proposed change notices (comments due Jan 13, 2022)
  - ICD updates for 2021
  - PRN assignments, Jun 2021
- Ligado Networks and GPS
- U.S. Space-Based PNT Policy of 2021
- Funding & legislation**
  - FY22 GPS funding & NDAA

**News Items** →

- Dec 6: December 2021 PNT advisory board meeting agenda

Stay in touch:

[www.gps.gov](http://www.gps.gov)

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**GPS: Accessible, Accurate, Interoperable**