



***U.S. GPS Program Update
and
International Activities to
Protect GNSS Spectrum***

**CSIS/UTokyo/ICG GNSS Training
Programme and Workshop**

*Office of Space Affairs
U.S. Department of State*

14 February 2024



Agenda



- Program Update
- PNT Policy
- GNSS Spectrum Protection, IDM and the ICG



GPS Constellation Status



38 Satellites • 31 Set Healthy
Baseline Constellation: 24 Satellites



Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	7 (3*)	22.1	26.5
GPS IIR-M	7 (1*)	16.3	18.3
GPS IIF	11 (1*)	10.0	13.7
GPS III	6 (1*)	3.3	5.1

*Not set healthy

As of 01 Feb 2024

GPS Signal in Space (SIS) Performance

From 31 Dec 22 to 31 Dec 23

Average URE*	Best Day URE	Worst Day URE
48.7 cm	33.4 cm (22 Jun 23)	165.7 cm (25 Jan 23)

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



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 IIIIF (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

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 IIIIF 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)



GPS III

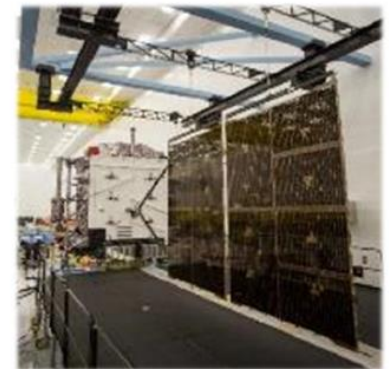


- SV01 Set healthy and available for use on 13 Jan 20
- SV02 Set healthy and available for use on 1 Apr 20
- SV03 Set healthy and available for use on 1 Oct 20
- SV04 Set healthy and available for use on 2 Dec 20
- SV05 Set healthy and available for use on 25 May 22
- SV06 Set healthy and available for use on 16 Feb 23



GPS III SVs in storage

- SV07 in storage –AFL 20 May 21; TLD NET June 2024
- SV08 in storage –AFL 10 Jun 21; TLD FY25
- SV09 in storage –AFL 23 Aug 22; TLD FY25
- SV10 in Storage –AFL 8 Dec 22; TLD FY26



–AFL –Available For Launch; NET –No Earlier Than; TLD
–Target Launch Date



Next Generation Operational Control System (OCX)



- Next-generation command, control and cyber-defense for GPS
 - Enhanced command and control capability
 - Modernized architecture
 - Robust information assurance and cyber security
- Incremental Development
 - OCX Block 0: Launch and Checkout System (LCS) for GPS III
 - OCX Blocks 1 and 2: Controls and manages all GPS spacecraft and signals
 - OCX 3F: Adds support for GPS III F vehicle and new capabilities
- Current Status
 - LCS successfully supported Launch and Checkout for GPS III SVO1-SVO6
 - OCX Block 1 completed factory integration and in Golden Dry Run for factory qualification
 - Delivery/DD250 Mid-2024; Ready for Transition to Ops (RTO) Early 2025



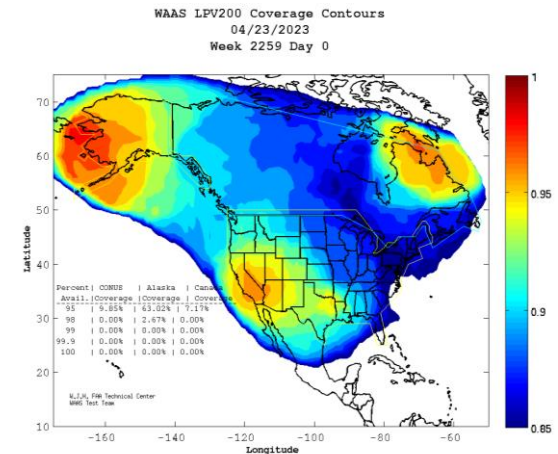
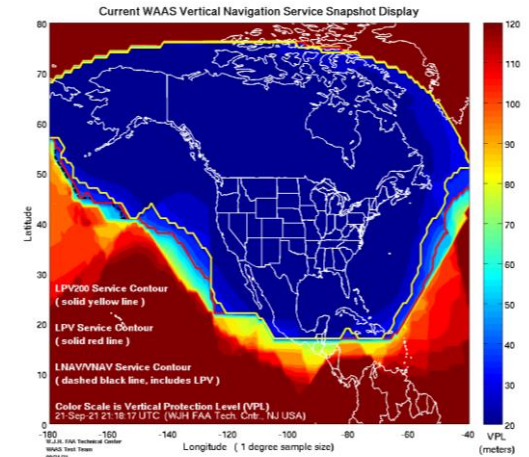
OCX program continues to execute and is nearing completion



Wide Area Augmentation System (WAAS)



- WAAS provides high availability service to aviation users in North America
- Developing Dual Frequency WAAS
 - Will enable high availability of WAAS vertical service during ionospheric disturbances
- GEO Sustainability
 - Currently maintaining 3 GEO constellation
- WAAS Modernization Efforts
 - Dual Frequency Multi-Constellation (DFMC)
 - Advanced Receiver Integrity Monitoring (ARAIM)
 - Authentication/Resiliency
 - Transition to IP based communications network
 - Security Upgrades

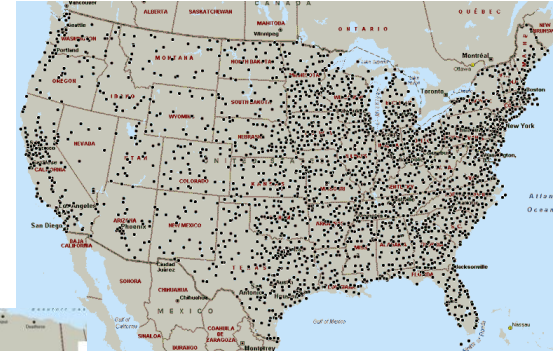




WAAS Procedures and Avionics Equipage



- Procedures:
 - 4,127 Localizer Performance with Vertical Guidance (LPV) approaches in the NAS
 - 1,116 provide CAT I (200') equivalent performance
- Equipage
 - General Aviation:
 - Over 131,000 equipped aircraft in the NAS
 - All classes of aircraft are served in all phases of flight
 - Airlines
 - Airline integration through MMRs
 - Main aircraft with SBAS capability in the US - A220
- Enabling technology for NextGen Programs
 - Automatic Dependent Surveillance Broadcast (ADS-B)
 - Performance Based Navigation (PBN)





U.S. Space-based PNT Policy (2020 NSP & SPD-7)

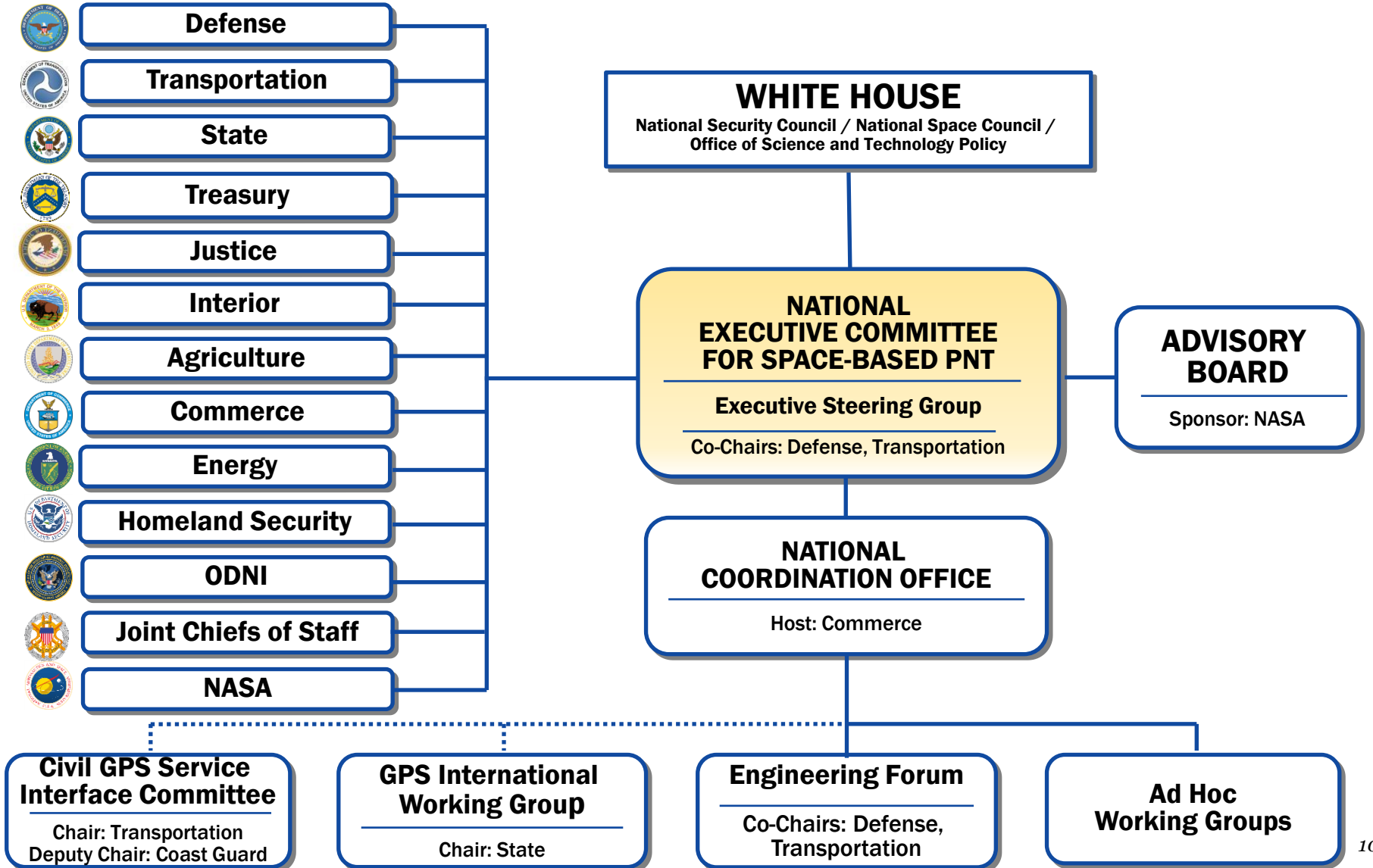


Maintain U.S. leadership in the service provision, and responsible use of GNSS, including GPS and foreign systems

- Ensure **compatibility** – ability of U.S. and non-U.S. space-based PNT services to be used separately or together without interfering with each individual service or signal
- Encourage **interoperability** – ability of civil U.S. and non-U.S. space-based PNT services to be used together to provide the user better capabilities than would be achieved by relying solely on one service
- Promote **transparency** in civil service provision and enable **market access** for U.S. industry
- Promote and support the **responsible use of GPS** as the pre-eminent space-based PNT service
- Foreign space-based PNT services may be used to complement civil GPS service
 - Receiver manufacturers should continue to improve security, integrity, and resilience in the face of growing cyber threats
- Encourage foreign development of PNT services and systems based on GPS
- Support international activities to **detect, mitigate, and increase resilience** to harmful disruption or manipulation of GPS



National Space-Based PNT Organizations





Global Perspective



- Global Constellations

- **GPS (24+3)**
- GLONASS (24+)
- GALILEO (24+3)
- BDS/BEIDOU (27+3 IGSO + 5 GEO)

- Regional Constellations

- QZSS (4+3)
- IRNSS/NAVIC (7)
- Korea – KPS (7)

- Satellite-Based Augmentations

- **WAAS (3)**
- MSAS (2)
- EGNOS (3)
- GAGAN (3)
- SDCM (3)
- BDSBAS (3)
- KASS - Korea (2)
- SPAN – Australia/NZ (2)





International Committee on GNSS (ICG)



- Pursuing a Global Navigation Satellite System-of-Systems to provide civil GNSS services that benefit users worldwide
 - Promote the use of GNSS and its integration into infrastructures, particularly in developing countries
 - Encourage compatibility and interoperability among global and regional systems
- U.S. priorities include spectrum protection, system interoperability and information dissemination
- 17th Meeting held in Madrid, Spain in October 2023
- New Zealand will host the 18th Meeting in October 2024



What is Spectrum Protection?



- "Protection" is about keeping the spectrum 'clean'
- Clean spectrum means keeping the frequencies near to GNSS free from licenced, unlicensed and illegal transmissions that interfere with GNSS reception, e.g.
 - GNSS jammers
 - Uncontrolled GNSS repeater installations
 - Spurious emissions from radio equipment, e.g. motors
 - Other radio services, e.g. TV broadcasts
 - Malfunctioning electronic equipment



Clean Spectrum



- Clean spectrum for GNSS minimizes signal errors and maximizes the performance for GNSS receivers
 - Better and more reliable positioning and timing
 - Faster time to first fix
 - Better tracking performance in challenging environments
- Keeping spectrum clean requires technical means to detect when such interference occurs
- National regulators usually have the capacity to detect **strong** interferers
 - Direction finding equipment or geolocation techniques
 - The ITU can also help coordinate such activities when cross border interference occurs



GNSS Interference



- Strong interferers are relatively easy to detect
- However, if weak interferers are far away from the detectors, they will not be seen
- The weak interfering signals are still stronger than GNSS and will have widespread impact on GNSS reception
- To find weak interferers (e.g. 'personal' GNSS jammers) requires more specialised local equipment or a dense detector network
- The ICG has been considering this challenge



ICG and GNSS Spectrum Protection



- ITU is responsible for international spectrum framework, including the protection of radio services
- Actual implementation of this framework is accomplished by national telecommunication administrations
- National telecommunication administrations work with relevant industries and stake holders
- ICG provides a forum that can facilitate and encourage the protection of GNSS spectrum by its members and participants in a voluntary, non-binding way



ICG Working Groups



- **Systems, Signals and Services (Co-Chairs: U.S. & Russia)**
 - Focus on compatibility and interoperability, encouraging development of complimentary systems
 - Exchange information on systems and service provision plans
 - Includes **spectrum protection** and **IDM**
- **Enhancement of GNSS Performance, New Services and Capabilities (Co-Chairs: India, European Space Agency, China)**
 - Focus on system enhancements (multipath, integrity, interference, etc.) to meet future needs
- **Capacity Building, Education and Outreach (Chair: UN Office for Outer Space Affairs)**
 - Focus on training/workshops, promoting scientific applications, space weather
- **Reference Frames, Timing and Applications (Co-Chairs: IAG, IGS & FIG)**
 - Focus on timing, monitoring and reference station networks



Addressing Spectrum Protection and IDM within ICG



- Establishment of Compatibility Subgroup in 2011
 - Focused on compatibility issues to include spectrum protection and IDM
- Establishment of Interference Detection and Mitigation Task Force in 2013
 - Objectives include:
 - 1) Develop a common set of information to be reported to GNSS civil service centers
 - 2) Establish routine communications among the (provider service) centers
 - 3) Develop guidelines for common capabilities to be considered in the development of future national IDM networks
 - Ten (10) IDM Workshops held since 2012



10th ICG Workshop on IDM



- Workshop held on 06 December 2022
- Agenda included:
 - Use of GPS by U.S. Coast Guard Navigation Center – Coast Guard Navigation Center, United States
 - Sharing and Crowdsourcing GNSS Data to Monitor and Protect RF Environment – Virginia Polytechnic Institute and State University
 - DOT Strategic Plan for GPS/GNSS Interference Detection – Department of Transportation, United States
 - Critical Infrastructure Dependency on PNT – Department of Homeland Security, United States
 - Use of ADS-B for Interference Detection - EUROCONTROL
 - Characterization of ADS-B Performance under GNSS Interference – Stanford University
 - Detecting GNSS Spoofing of ADS-B Equipped Aircraft Using INS – Illinois Institute of Technology



ICG Recommendations Related to IDM and Spectrum Protection



Recent Recommendations Adopted by the ICG

2014/2017	Crowdsourcing capabilities analysis for IDM
2015/2016/2017	UN regional workshops on GNSS spectrum protection and IDM
2015/2016	Campaign of Protection of RNSS operations – GNSS providers and GNSS user community member states promote spectrum protection
2015/2016	UN COPUOS multi-year agenda item focused on National Efforts to protect RNSS Spectrum, and develop IDM capability
2017	Encourage national regulators to use the protection criteria in relevant ITU-R Recommendations
2019	Produce a draft booklet on GNSS/RNSS spectrum Protection based on material used for the ongoing spectrum seminars
2022	Incorporating Resilience into GNSS Interference Detection and Mitigation



Other Related Topics Discussed within the ICG



- Adjacent Band Compatibility
- Unintentional Interference
 - Electromagnetic emissions limits from non-licensed transmitters
- Interference Detection and Geo-Location Capabilities
- Critical Infrastructure



For Additional Information...



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?
- How do I report GPS service outages?
- Can GPS help me find my lost phone?
- How does GPS work?
- How accurate is GPS?
- How vulnerable is GPS to malicious jamming?

FOR GPS PROFESSIONALS

What's **HOT** for Pros

- PNT advisory board, Dec 2023
- CGSIC Denver 2023
- Technical documentation
 - Public ICWG, Sep 2023
 - PRN assignments, Apr 2023
 - GPS III antenna patterns (USCG.gov)
 - ICD uprevisions, Aug 2022

News Items →

- Nov 20: PNT Advisory Board to convene December 6-7 in Houston, TX
- Sep 19: DHS Invites Critical Infrastructure Owners and Operators to GPS Spoofing Test Event
- Apr 12: PNT Advisory Board to convene May 3-4 in Annapolis, MD
- Mar 20: Joint announcement on GPS-KPS technical working group meeting

New Additions to GPS.gov →