



SPACE-BASED POSITIONING
NAVIGATION & TIMING

NATIONAL COORDINATION OFFICE

Program and Policy Update

*15th Meeting
of the
International Committee on GNSS
Vienna, Austria*

28 September 2021

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Director
National Coordination Office



GPS Constellation Status



37 Satellites • 30 Set Healthy
Baseline Constellation: 24 Satellites



Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	8 (4*)	19.6	24.1
GPS IIR-M	7 (1*)	13.9	15.9
GPS IIF	12	7.6	11.3
GPS III	4 (1*)	1.4	2.7

*Not set healthy

As of 1 Sep 21

GPS Signal in Space (SIS) Performance

From 7 Aug 20 to 7 Aug 21

Average URE*	Best Day URE	Worst Day URE
50.0 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>GPS IIA/IIR</p> <ul style="list-style-type: none"> • Basic GPS • Nuclear Detonation Detection System (NDS) | <p>GPS IIR-M</p> <ul style="list-style-type: none"> • 2nd Civil Signal (L2C) • New Military Signal • Increased Anti-Jam Power | <p>GPS IIF</p> <ul style="list-style-type: none"> • 3rd Civil Signal (L5) • Longer Life • Better Clocks | <p>GPS III (SV01-10)</p> <ul style="list-style-type: none"> • Accuracy & Power • Increased Anti-Jam Power • Inherent Signal Integrity • 4th Civil Signal (L1C) • Longer Life • Better Clocks | <p>GPS IIIF (SV11-32)</p> <ul style="list-style-type: none"> • 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

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

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"> • 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 | <p>Modernized Civil Signals</p> <ul style="list-style-type: none"> • L2C (Various commercial applications) • L5 (Safety-of-life, frequency band protected) • L1C (Multi-GNSS interoperability) |
|--|--|



Wide Area Augmentation System

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

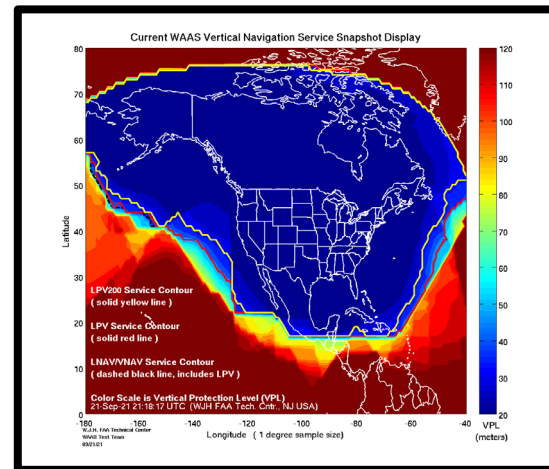
GEO Sustainability

- 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

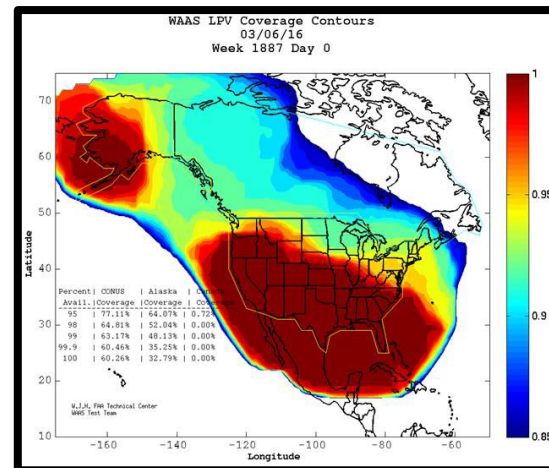
WAAS Modernization Efforts

- 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)

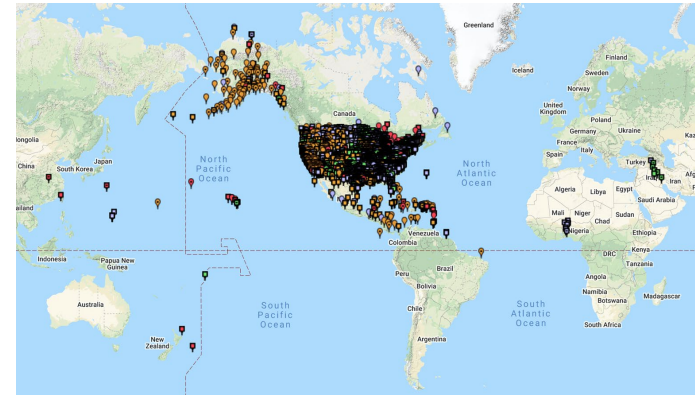




NOAA CORS Network (NCN)



- **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



The Multi-GNSS Space Service Volume: Earth's Next Navigation Utility



- 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



- 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



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



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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 Global Positioning System (GPS) and related topics

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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?

FOR GPS PROFESSIONALS

What's **HOT** for Pros

- **CGSIC St. Louis, Sep 20-21**
- **Technical documentation**
 - ICD updates for 2021
 - Public ICWG meeting, Sep 29
 - PRN assignments, Jun 2021
- **Ligado Networks and GPS**
 - Secretary of Commerce letter to Senator Inhofe (PDF)
 - FCC order denying motion for stay
- **U.S. Space-Based PNT Policy of 2021**
- **Recent presentations**
- **Funding & legislation**
 - FY22 GPS funding & NDAA

News Items ➔

- *Aug 18:* Innovation is the game, GPS III-5 is the name
- *Jul 1:* GPS III SV05 receives operational acceptance