



U.S. GPS Civil Service and International GNSS Activities Update

THE 10th CHINA SATELLITE NAVIGATION CONFERENCE



22-25th MAY, 2019

BEIJING • CHINA

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Overview

- **Policy and Service Provision**
 - Constellation Status and Modernization
 - International Cooperation



U.S. National Space Policy

Space-Based PNT Guideline: Maintain leadership in the service, provision, and use of GNSS

- Provide civil GPS services, free of direct user charges
 - Available on a continuous, worldwide basis
 - Maintain constellation consistent with published performance standards and interface specifications
 - Foreign PNT services may be used to augment and strengthen the resiliency of GPS
- Encourage global *compatibility* and *interoperability* with GPS
- Promote *transparency* in civil service provision
- Enable market access to industry
- Support international activities to detect and mitigate harmful interference



GPS Signal in Space Performance

GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM) (VS. JPL, RMS, URE, CM)

BEST WEEK*

BEST DAY*

WORST DAY*

ENDING

URE

ENDING

URE

ENDING

URE

ROLLING YEAR

8 DEC 18

45.7

14 MAR 18

37.5

27 AUG 18

73.2

BEST WEEK EVER

29 NOV 16

44.1

**ROLLING YEAR*





GPS Performance Report Cards

- 2013-2018 performance reports now available on gps.gov
- These reports measure GPS performance against GPS Standard Positioning Service (SPS) Performance Standard commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

Performance Standard Metric		2013	2014	2015	2016	2017	2018
SIS Accuracy	URE Accuracy	✓	✓	✓	✓	✓	✓
	UTC OE Accuracy	N/A	N/A	✓	✓	✓	✓
SIS Integrity	Instantaneous URE Integrity	✓	✓	✓	✓	✓	✓
	Instantaneous UTC OE Integrity	N/A	N/A	✓	✓	✓	✓
SIS Continuity	Unscheduled Failure Interruptions	✓	✓	✓	✓	✓	✓
	Status and Problem Reporting	N/A	x	✓	x	x	✓
SIS Availability	Per-Slot Availability	✓	✓	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓	✓	✓

<https://www.gps.gov/systems/gps/performance/>



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GPS Constellation Status

**36 Satellites / 30 Set Healthy as of 17 May 2019
(Baseline Constellation: 24)**

Four Generations of Operational Satellites

- Block IIA - 1 Operational
 - 7.5 year design life
 - Launched 1990 to 1997
- Block IIR - 11 Operational
 - 7.5 year design life
 - Launched 1997 to 2004
- Block IIR-M - 7 Operational
 - 7.5 year design life
 - Launched 2005 to 2009
 - Added 2nd civil navigation signal (L2C)
- Block IIF - 12 Operational
 - 12 year design life
 - Launched 2010 to 2016
 - Added 3rd civil navigation signal (L5)



Block IIA Satellite – Designed & Built by Rockwell International



Block IIR/IIR-M Satellite – Designed & Built by Lockheed Martin



Block IIF Satellite – Designed & Built by Boeing



GPS III: Newest Block of GPS Satellites

- 4 civil signals: L1 C/A, L1C, L2C, L5
 - First satellites to broadcast common L1C signal
- 3 improved Rubidium atomic clocks
- Better User Range Error than IIF Satellites
- Increased availability
- Increased integrity
- 15 year design life



***GPS III SV01 launched on a Falcon 9 on 23 Dec 2018
On-orbit checkout underway***



GPS Ground Segment

- **Current Operational Control Segment (OCS)**

- Flying GPS constellation using Architecture Evolution Plan (AEP) and Launch and Early Orbit, Anomaly, and Disposal Operations (LADO) software capabilities
- Increasing Cyber security enhancements



Monitor Station

- **Next Generation Operational Control System (OCX)**

- Incremental Development
 - Block 0 Launch and Checkout System (LCS)
 - Block 1/2 Operational Control System
- Current Status
 - LCS supported GPS III SV01 launch on 23 December 2018
 - Continues to function nominally during SV01 on-orbit checkout and testing (OOCT)
 - Preparing to support SV02 launch
 - Block 1/2 ready to transition to operations in 2022
- Enhanced command and control capability
- Modernized, agile architecture



Ground Antenna



Modernized GPS Civil Signals

- Second civil signal "L2C"
 - Designed to meet commercial needs
 - Broadcast since 2005
 - Currently 19 satellites broadcasting L2C



- Third civil signal "L5"
 - Meets transportation safety of life requirements
 - Uses Aeronautical Radio Navigation Service band
 - Enables triple-frequency positioning techniques
 - Currently 12 satellites broadcasting L5

- Fourth civil signal "L1C"
 - Designed for GNSS interoperability
 - Specification developed in cooperation with industry
 - Improved performance in challenged environments
 - Launched with first GPS III in 2018



Continuous Broadcast of the new civil navigation "CNAV" message on L2C and L5 began April 28, 2014



Wide Area Augmentation System (WAAS)

- Satellite Based Augmentation System (SBAS)
- Designed for aviation use, but available and used by many GPS users today
- Localizer Performance with Vertical Guidance (LPV)-200 approach is comparable to ILS Category I
- Provides the capability for increased availability and accuracy in position reporting, allowing more time for uniform and high quality air traffic management.
- Provides service for all classes of aircraft in all phases of flight

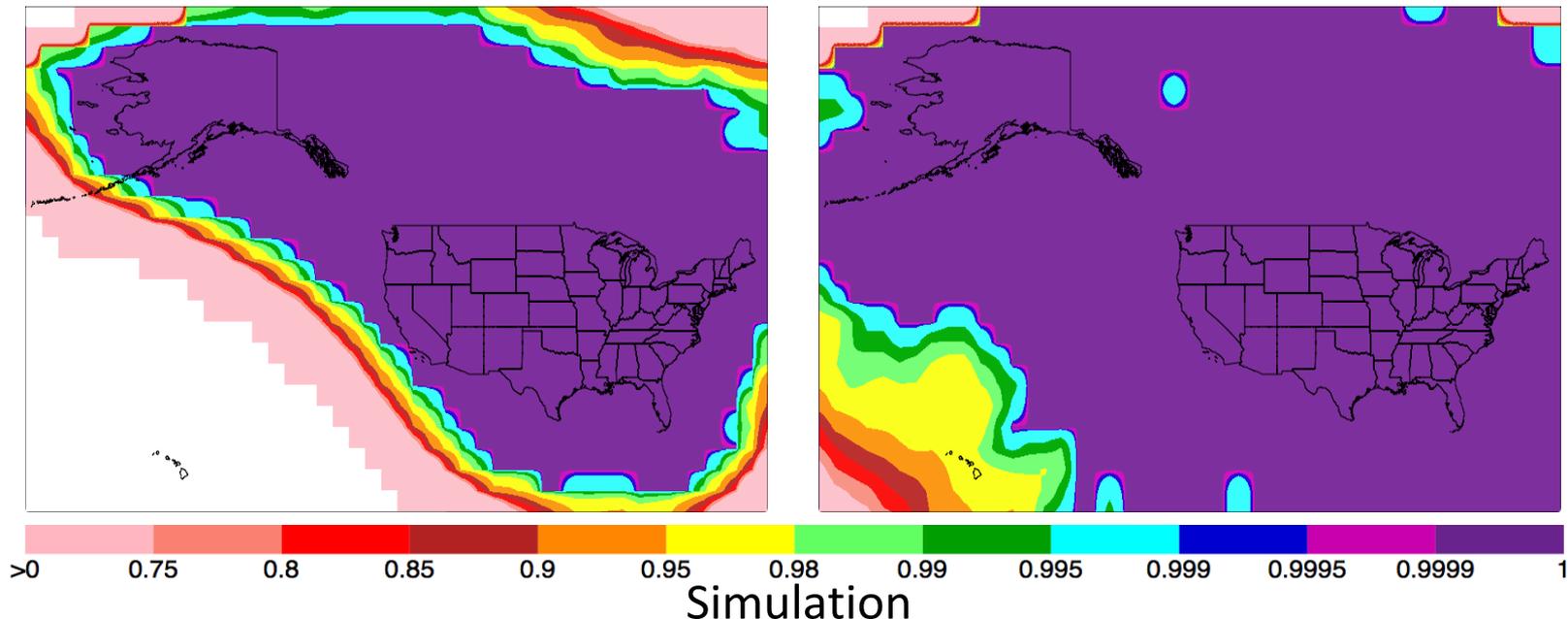


WAAS Dual Frequency Service

- WAAS system changes initiated to enable L1/L5 service
- Minimum Operational Performance Standards (MOPS) and Standards And Recommended Practices (SARPS) requirements development is underway
- Significant additional work needed to implement a dual frequency WAAS Service - Preparing for FAA investment decision in 2019
- Dual frequency L1/L5 service improves availability and continuity

L1

L1, L5





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U.S. Objectives in Working with Other GNSS Service Providers

- 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
 - Radio frequency compatibility
 - Spectral separation between M-code and other signals
- Achieve **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 or signal
- Promote fair competition in the global marketplace

Pursue through Bilateral and Multilateral Cooperation



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 (2)
- **Australia SBAS (2)**



Bilateral Cooperation

China

- GNSS Plenary meeting held May 2018 in Harbin, China
- Three Working Groups Established
 - Meet as needed
- Public Joint Statement on Civil Signal Compatibility and Interoperability signed in November 2017

Europe

- GPS-Galileo Cooperation Agreement signed in 2004
- Working Group on Next Generation GPS/Galileo Civil Services meets twice per year
- EU waiver of FCC Part 25 rules discussed by Working Group on Trade & Civil Applications
- On-going PRS access negotiations



Bilateral Cooperation (continued)

Japan

- Comprehensive Dialogue held in Tokyo, July 2018
- Civil Space Dialogue held in Washington, May 2017
- Technical Working Group (TWG) discusses GPS and QZSS compatibility and interoperability
 - ITU coordination is ongoing

India

- U.S.–India Joint statement signed in 2007
- U.S.-India Civil Space Joint Working Group (CSJWG) met October 2017 in Washington
 - Agenda included GNSS discussions
- Next meeting scheduled to occur before the end of 2019



International Committee on Global Navigation Satellite Systems (ICG)

- Emerged from 3rd UN Conference on the Exploration and Peaceful Uses of Outer Space July 1999
 - Promote the use of GNSS and its integration into infrastructures, particularly in developing countries
 - Encourage compatibility and interoperability among global and regional systems
- Members include:
 - **GNSS Providers:** (U.S., EU, Russia, China, India, Japan)
 - Other Member States of the United Nations
 - International organizations/associations



<http://www.unoosa.org/oosa/en/ourwork/icg/icg.html>



13th Meeting of the International Committee on GNSS (ICG)



Xi'an, China: 4-9 November 2018

- More than 200 participants
 - Representatives from 27 countries/organizations
 - Representation from all 6 GNSS Providers
- Agenda included:
 - Meeting of the Providers' Forum
 - System Provider Updates
 - Applications and Experts Session
 - Meeting of all four Working Groups
- New Membership approval: Australia





ICG Important Activities

GNSS Interference and Spectrum Protection

- Core Area of Focus of the ICG
- IDM Workshops have been held since 2012 – organized by the ICG
 - 8th IDM Workshop took place May 2018 as part of Baska GNSS Conference in Croatia
- Spectrum Protection Educational Seminars organized by ICG Experts – Focused on the importance of protecting GNSS spectrum
 - 3rd Seminar held March 2018 in Argentina

Interoperability and Service Standards

- Interoperable Time
 - Timing Workshop held in 2018 focused on GNSS Time Offsets
- Performance Standard Template
 - “Guidelines” document being developed as a template for Providers
- International GNSS Monitoring and Assessment (IGMA)
 - Trial Project with IGS is in progress



Other Important ICG Activities

Space Service Volume

- **United Nations booklet “The Interoperable GNSS SSV” – prepared by GNSS Providers through WG-B – published in early 2018 and highlighted at ICG-13**

http://www.unoosa.org/res/oosadoc/data/documents/2018/stspace/stspace75_0.html/stspace75E.pdf

- Outreach efforts continue on benefits of an interoperable space service volume and development of space-based user equipment

Search and Rescue

- Discussion about compatibility and interoperability of MEOSAR systems

Precise Point Positioning (PPP)

- Workshop proposed by WG-D focused on multi-GNSS PPP based on plans by regional and global service providers



Summary

- U.S. policy encourages the worldwide use of civil GPS services and cooperation with other GNSS providers
 - **Compatibility, interoperability, and transparency in civil service provision** are priorities
 - Pursued through bilateral and multilateral dialogues
- GPS performance exceeds commitments while modernization efforts continue
 - First GPS III satellite launched in 2018
 - Progress on modernized ground segment to meet future needs
- The ICG, with strong U.S. participation, continues to pursue a **Global Navigation Satellite System-of-Systems** to provide civil GNSS services that benefit users worldwide



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**

Home » Support » GPS Service Outages & Status Reports

SUPPORT:

Frequently Asked Questions

Address, Route, & Map Problems

Service Outages & Status Reports

Civil GPS Service Interface Committee (CGSIC)

Technical Documentation

External Links

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GPS Service Outages & Status Reports

Users experiencing GPS service problems can get support from one of three federal agencies, depending on their application: civil non-aviation, civil aviation, or military. The responsibilities of the support agencies are documented in an interagency agreement. [VIEW AGREEMENT](#) →

Civilian User Support – Non-Aviation

The U.S. Coast Guard Navigation Center (NAVCEN) is the primary point of contact in the government for providing operational GPS user support to the civilian community. The following links lead to pages on the NAVCEN website.



- [Check the operational status of the GPS satellites](#) →
- [Look up planned GPS service disruptions due to interference testing](#) →
- [Report a GPS service outage or anomaly \(non-aviation\)](#) →
- [Receive GPS status messages & user advisories via email](#) →

If you suspect a GPS disruption due to illegal signal jamming ([LEARN MORE](#) →), please call the FCC Jammer Tip Line immediately at 1-855-55-NOJAM, then submit an outage report to NAVCEN.



谢谢

THANK YOU!

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