



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



China Satellite Navigation Conference 2018

Harbin, China May, 2018

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**May 23, 2018**



# *Overview*

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



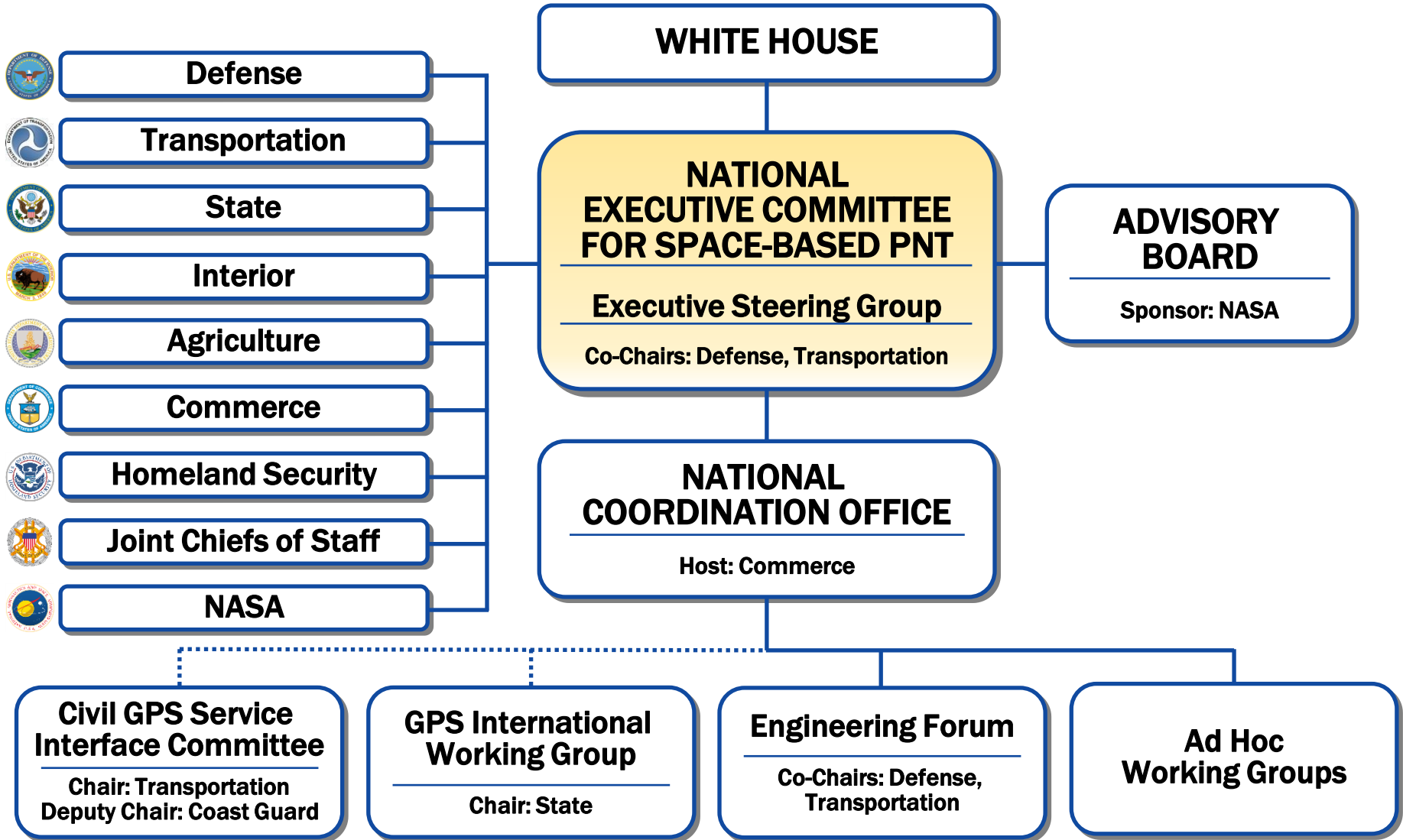
# ***U.S. National Space Policy***

## ***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



# National Space-Based PNT Organization





# *GPS Civil Service Provision*

- Global GPS civil service performance commitment continuously met/exceeded since 1993
- Open, public signal structures with public domain documentation necessary to develop receivers
  - Promotes open competition and market growth for commercial GNSS
- A critical component of the global information infrastructure
  - **Compatible** with other satellite navigation systems and **interoperable** at the user level
  - Guided at a national level as multi-use asset
  - Acquired and operated by Air Force on behalf of the USG

***GPS provides continuously improving, predictable, and dependable Global Public Service***





# GPS Signal in Space Performance Scoreboard

## GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM)

**BEST WEEK \***

**BEST DAY \***

**WORST DAY \***

**ENDING**

**SIS**

**ENDING**

**SIS**

**ENDING**

**SIS**

**ROLLING YEAR**

**20 SEP 17**

**48.9**

**26 JAN 17**

**35.0**

**1 DEC 17**

**77.7**



**BEST WEEK EVER**

**29 NOV 16**

**44.1**

*\*ROLLING YEAR*





# GPS Performance Report Cards

**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 - Systems - GPS - Performance

**SYSTEMS:**  
 GPS Overview  
 Space Segment  
 Control Segment  
 Ground Segment  
 Accuracy  
 Modernization  
 Augmentation Systems  
 Other GNSS  
 Technical Documentation

**GPS Performance**

The U.S. government is committed to providing GPS to the civilian community at the performance levels specified in the GPS Standard Positioning Service (SPS) Performance Standard (PS). [VIEW DOCUMENT](#)

The following study, commissioned by the Air Force, concludes that, "All the SPS PS metrics examined in the report were met in 2016 with one exception. The exception was the report notification requirement for scheduled interruptions. This was met in 27 of 28 cases (96%). The assertions evaluated include those of accuracy, integrity, continuity, and availability of the GPS signal in space (SIS) and the position performance standards.

**UTC Offset Anomaly**  
 On January 25-26, 2016, GPS users experienced a rare anomaly in operations. For several hours, multiple satellites broadcast information regarding the offset between GPS time and UTC in a manner that did not conform to the GPS signal interface specification. Nevertheless, there was no violation of the UTC offset error assertions in the SPS PS for receivers that honor the UTC offset data set fit interval.

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**2016 GPS SPS Performance Analysis**  
 Download 3.9 MB

[LEARN MORE \(700 KB PDF\)](#)

- 2013-2016 performance reports now available on gps.gov
- 2017 performance report in coordination
- These reports measure GPS performance against GPS SPS PS commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

Performance Standard Metric		2013	2014	2015	2016
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
SIS Availability	Per-Slot Availability	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓



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# GPS Constellation Status

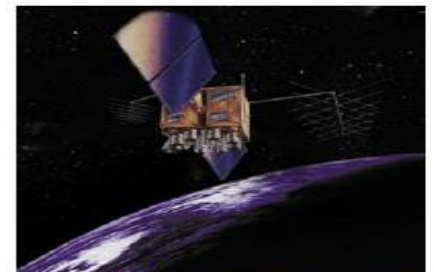
**34 Satellites / 31 Set Healthy  
(Baseline Constellation: 24)**

## Four Generations of Operational Satellites

- Block IIA - 1 Operational
  - 7.5 year design life (24.4 years old)
  - Launched 1990 to 1997
- Block IIR - 11 Operational
  - 7.5 year design life (Average = 16.2; Oldest = 20.7)
  - Launched 1997 to 2004
- Block IIR-M - 7 Operational
  - 7.5 year design life (Average = 10.7; Oldest = 12.5)
  - Launched 2005 to 2009
  - Added 2nd civil navigation signal (L2C)
- Block IIF - 12 Operational
  - 12 year design life (Average = 4.2; Oldest = 7.8)
  - 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



***First GPS III Satellite to be Launched in 2018***



# *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)**

- Modernized command and control system - replaces legacy system and adds modern features
- Worldwide, 24 hr/day, all weather, position, velocity and time source for military & civilian users
- Modern civil signal monitoring and improved PNT performance
- Robust cyber security infrastructure
- New capabilities including civil signal performance monitoring capability



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
  - Launches with GPS III in 2018



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



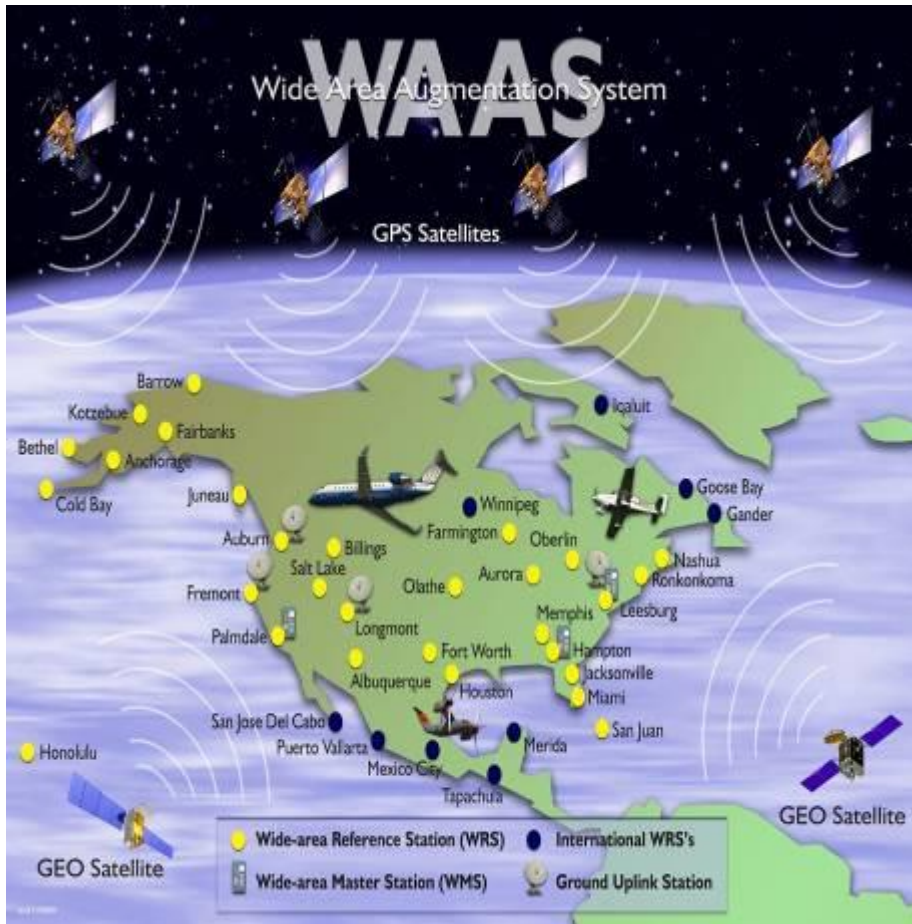
# *Wide Area Augmentation System (WAAS)*

- 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 Architecture



38 Reference Stations



3 Master Stations



6 Ground Earth Stations



3 Geostationary Satellite Links



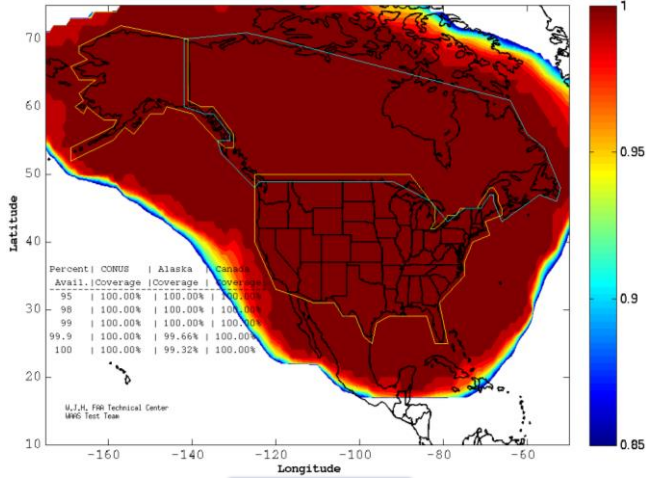
2 Operational Control Centers



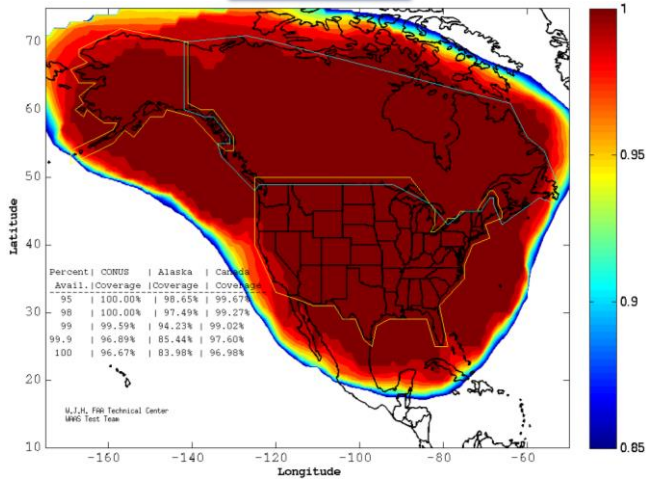


# Current WAAS Performance

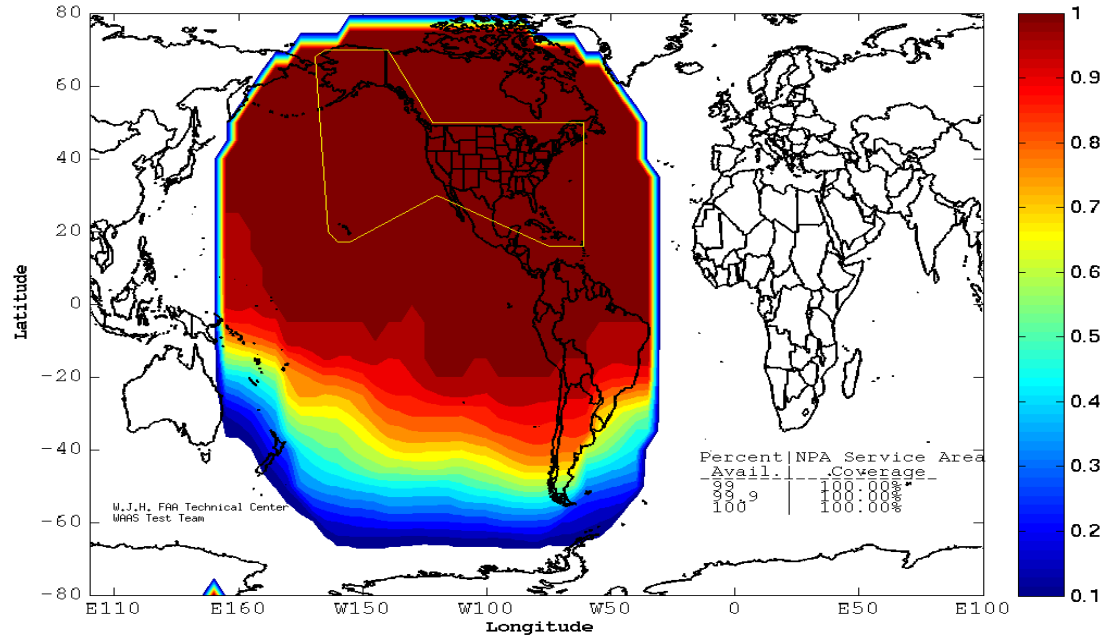
## LPV



## LPV - 200



## RNP 0.3



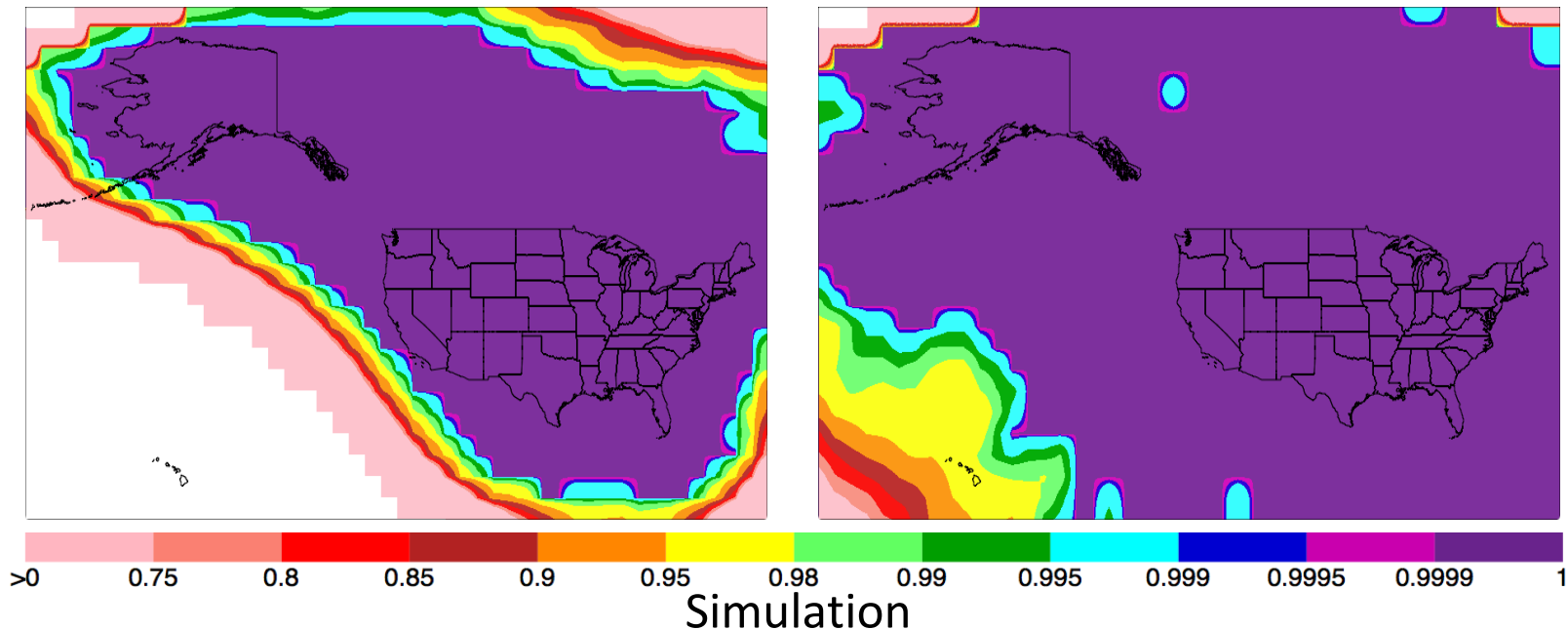


# WAAS Dual Frequency Service

- 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***



# ***GNSS: A Global Navigation Satellite System of Systems for Civil Use***

- Global Constellations

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

- Regional Constellations

- QZSS (4+3)
- IRNSS (7)

- Satellite-Based Augmentations

- **WAAS (3)**
- MSAS (2)
- EGNOS (3)
- GAGAN (2)
- SDCM (3)





# *Bilateral GNSS Cooperation*

- *Europe:* GPS-Galileo Cooperation Agreement signed 2004
  - Working Group on Next Generation GPS/Galileo Civil Services meets twice per year – most recent meeting April 2018
  - Working Group on Trade & Civil Applications meets as needed
  - PRS access negotiations are under way
- *China:* Civil GNSS Plenary Dialogue – Tomorrow
  - Sub-groups met yesterday
  - Joint Statement on Civil Signal Compatibility and Interoperability signed in November 2017
- *Japan:* Civil GNSS Dialogue hosted by U.S. – May 2017
  - Technical Working Group discusses compatibility between GPS & QZSS
- *India:* Civil Space Joint Working Group Meeting in Washington – October 2017
  - ITU compatibility coordination completed





# *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





# 12<sup>th</sup> Meeting of the International Committee on GNSS (ICG-12)



- More than 200 participants
  - Representatives from 20 countries/organizations
  - Representation from 5 GNSS Providers
- Agenda included:
  - Meeting of the Providers' Forum
  - System Provider Updates
  - Applications and Experts Session
  - Meeting of all four Working Groups





# ***ICG-12 Significant Accomplishments***

- 7th ICG **Interference Detection and Mitigation Workshop** held on May 8, 2018 as part of Baska GNSS Conference
- ICG **International Multi-GNSS monitoring (IGMA) workshop** held May 14-15, 2018 at the Noordwijk Galileo Reference Center (GRC) to discuss the multi-GNSS monitoring trial project established in 2016 between the ICG and IGS
- ICG workshop focused on promoting common terminology and definitions for individual **GNSS Open Service Performance Standards** also held May 14-15 at the Noordwijk GRC
- 2<sup>nd</sup> ICG expert level workshop on **Time and Interoperability** to be held in Vienna, June 20, 2018 to further discuss GNSS system time offsets among the systems
- GNSS Providers Booklet on **Space Service Volume** published in 2018 - continued outreach effort on benefits of an interoperable space service volume
- Discussion and exchange of information on **Orbital Debris Mitigation** plans by GNSS 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
- GPS performance continues to improve beyond published commitments
- Ongoing GPS modernization is adding new capabilities for user benefits
- 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

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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.

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



谢谢

***THANK YOU!***

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