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

International GNSS 2020

Sydney, Australia

Office of Space and Advanced Technology
U.S. Department of State

05 February 2020

Overview

➢Policy and Service Provision

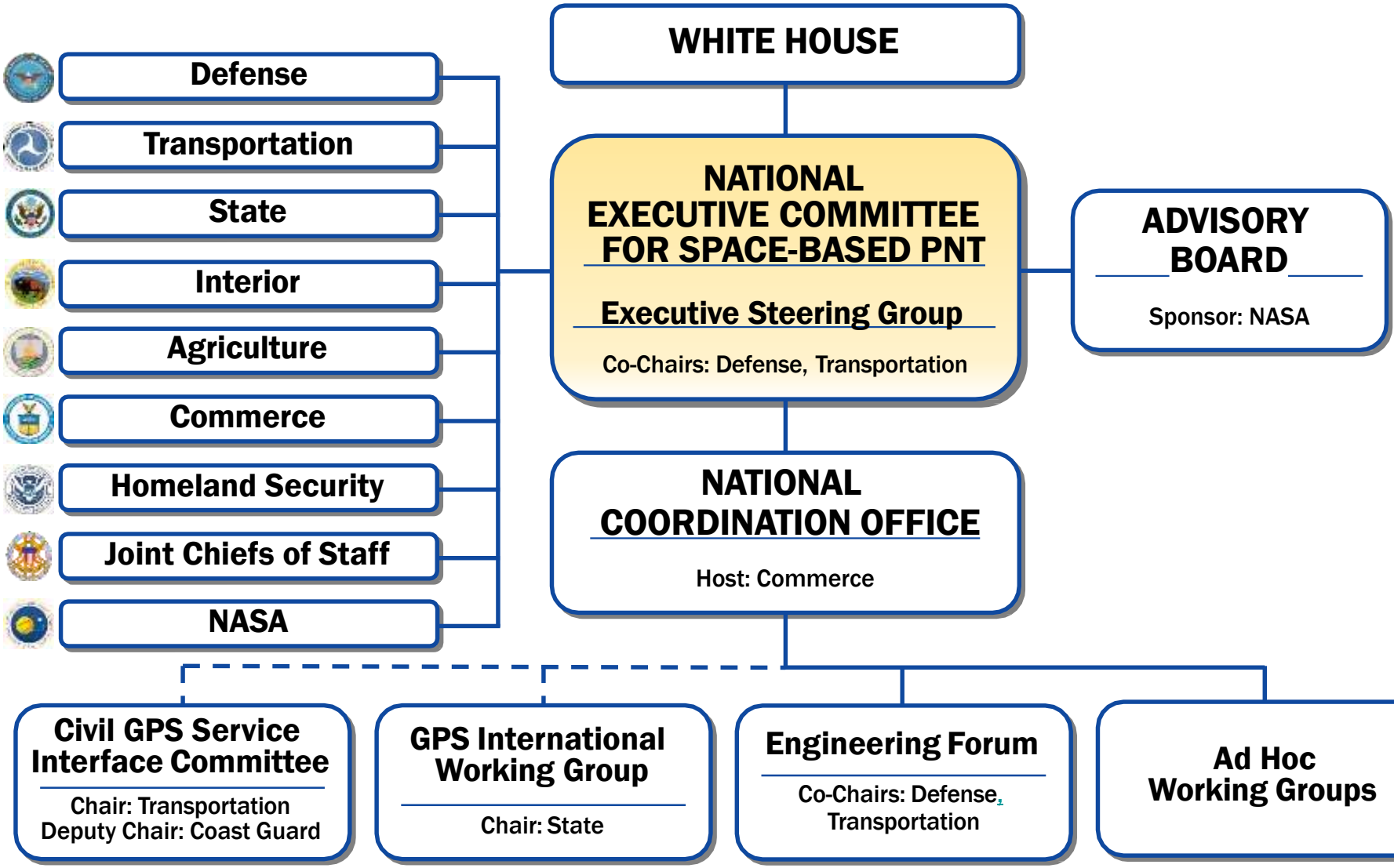
- Constellation Status and Modernization
- International Cooperation

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



Overview

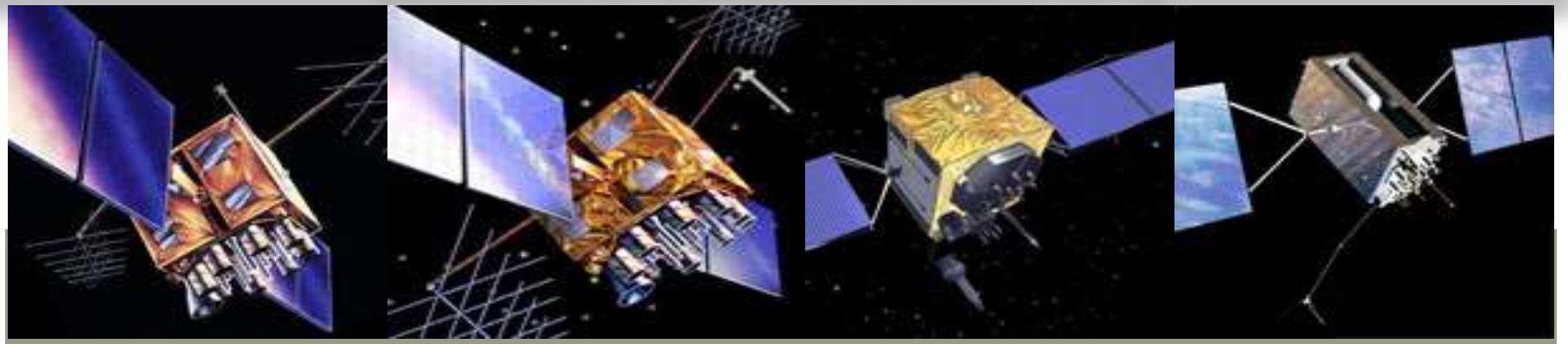
- Policy and Service Provision

- **Constellation Status and Modernization**

- International Cooperation

GPS Constellation Status

31 Set Healthy as of 29 January 2020
(Baseline Constellation: 24)



BLOCK IIR	BLOCK IIR-M	BLOCK IIF	GPS III/IIIF
11 operational	**7 operational**	**12 operational**	**1 operational**
• C/A code on L1 • P(Y) code on L1 & L2 • On-board clock monitoring • 7.5-year design lifespan • Launched in 1997-2004	• All legacy signals • 2nd civil signal on L2 (L2C) • New military M code signals for enhanced jam resistance • Flexible power levels for military signals • 7.5-year design lifespan • Launched in 2005-2009	• All Block IIR-M signals • 3rd civil signal on L5 frequency (L5) • Advanced atomic clocks • Improved accuracy, signal strength, and quality • 12-year design lifespan • Launched in 2010-2016	• All Block IIF signals • 4th civil signal on L1 (L1C) Enhanced signal reliability, accuracy, and integrity • No Selective Availability •15-year design lifespan • IIIF: laser reflectors; search & rescue payload • First launch in 2018

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 IIIF (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

M-Code Early Use (MCEU)
- Update OCS to operationalize Core M-Code

OCX Block 1
- Fly Constellation & GPS III
- Begin New Signal Control
- Upgraded Information Assurance

OCX Block 2+
- Control all signals
- Capability On-Ramps
- GPS IIIF 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
- 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)

Modernized GPS Civil Signals

- Second civil signal "L2C"
  - Designed to meet commercial needs
  - Broadcast since 2005
  - Currently 20 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 13 satellites broadcasting L5
- Fourth civil signal "L1C"
  - Designed for GNSS interoperability
  - Improved performance in challenged environments
  - Launched with first GPS III in 2018
  - Currently 1 satellite broadcasting L1C

- ***Continuous Broadcast of civil navigation "CNAV" message on L2C and L5 began April 28, 2014***
- ***Signals considered "pre-operational" – To be used at the user's own risk until declared operational***

GPS Performance Report Cards

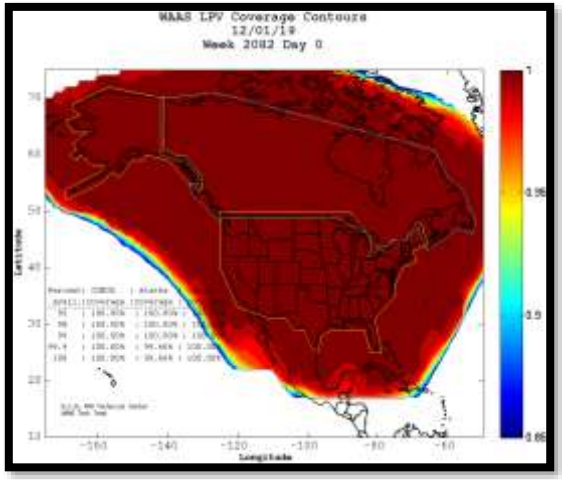
- 2013-2018 performance reports now available on gps.gov
- These reports measure GPS performance against GPS Standard Positioning Service (SPS) Performance Standard commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

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

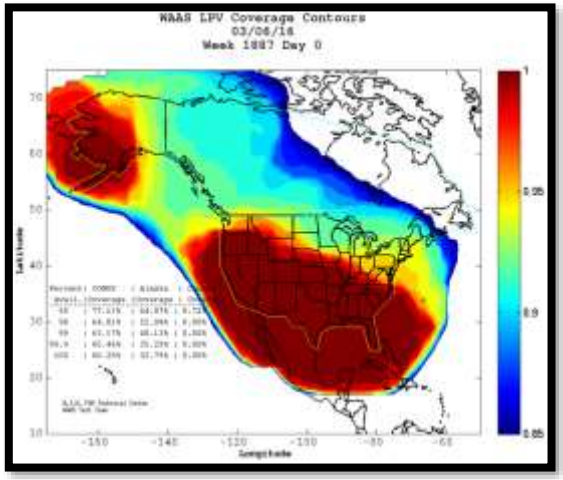
https://www.gps.gov/systems/gps/performance/

WAAS Current Status

- **Current WAAS provides high availability service to aviation user in North America**
  - 4031 Localizer Performance with Vertical Guidance (LPV) approaches in the NAS
    - Over 1000 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])
  - Developing future GEO's 7/8/9 to replace legacy GEO's upon lease expiration
    - GEO 7 is Intelsat at 125 West
- **WAAS Modernization Efforts**
  - Dual Frequency Multi-Constellation (DFMC)
  - Advanced Receiver Integrity Monitoring (ARAIM)



WAAS LPV Coverage March 6, 2016 Iono event

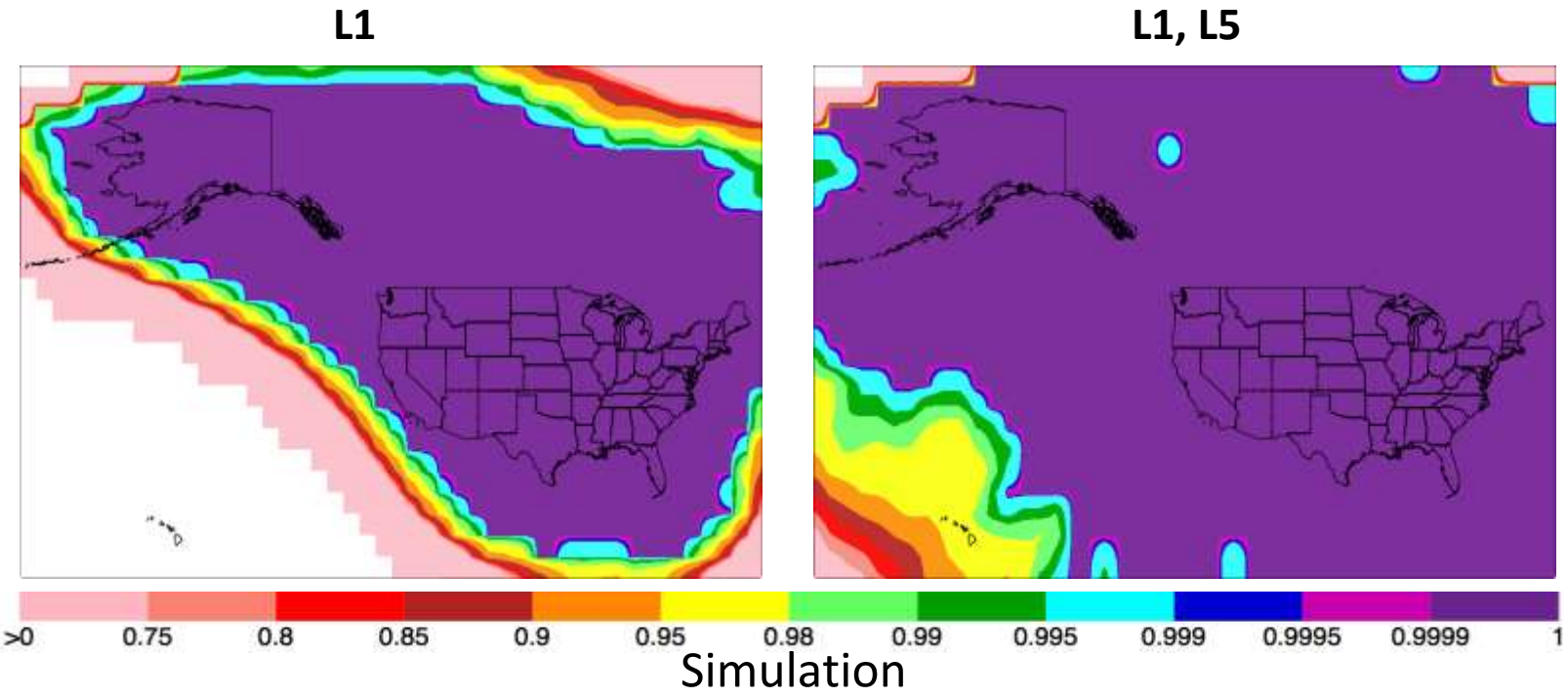


WAAS Avionics Equipage Status

- **Over 130,000 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**
- **Enabling technology for NextGen programs**
  - Automatic Dependent Surveillance Broadcast (ADS-B)
  - Performance Based Navigation (PBN)

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
- Significant additional work needed to implement a dual frequency WAAS Service
- Dual frequency L1/L5 service improves availability and continuity



Overview

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

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)
  - Australian 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
- U.S.-EU Space Dialogue held June 2019 in Prague
- Working Group on Next Generation GPS/Galileo Civil Services meets twice per year
- Working Groups on Compatibility and Interoperability, and Trade & Civil Applications meet as needed

Bilateral Cooperation (continued)

India

- U.S.–India Joint statement signed in 2007
- U.S.-India Civil Space Joint Working Group (CSJWG) met November 2019 in Bangalore
  - Agenda included GNSS discussions
- Technical Working Group established in 2019 to discuss compatibility and interoperability issues and coordination

Japan

- Comprehensive Dialogue held in Washington, DC, July 2019
- Technical Working Group (TWG) discusses GPS and QZSS compatibility and interoperability
  - ITU coordination is ongoing

Additional Bilateral Dialogues

- ***Australia:*** Joint Delegation Statement on Cooperation in the Civil Use of GPS in 2007
  - Regular discussions about Australia's plans for SBAS
  - U.S.-Australia Civil Space Dialogue held in November 2018
  - Australia became a member of the ICG at the 13th mtg (2018)
- ***Canada:*** Civil GNSS meeting held in Washington, D.C. – March 2019
- ***Republic of Korea:*** Discussion about Korea's development of their SBAS and KPS
- ***Indonesia:*** *U.S. hosted* 1st Civil Space Dialogue in April 2019 – GNSS applications discussed
- ***Thailand:*** 2nd Civil Space Dialogue, August 2019 in Bangkok – Agenda item on GNSS collaboration

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

14h Meeting of the International Committee on GNSS (ICG)

Bangalore, India: 8-13 December 2019

- More than 250 participants
  - Representatives from 19 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: New Zealand

ICG International Committee on Global Navigation Satellite Systems

ICG Important Activities

GNSS Interference and Spectrum Protection

- Core Area of Focus of the ICG
- Closely monitoring ITU/WRC proposals and regulations related to RNSS spectrum
- IDM Workshops have been held since 2012 – organized by the ICG
- Spectrum Protection Educational Seminars organized by ICG Experts – Focused on the importance of protecting GNSS spectrum
  - Recommendation adopted at ICG-14 to develop a booklet

Interoperability and Service Standards

- Interoperable Time
  - Timing Workshops focused on GNSS Time Offsets
- Performance Standard Template
  - "Guidelines" document 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

- UN booklet "The Interoperable GNSS SSV" – prepared by GNSS Providers through WG-B – published in early 2018
- Technical discussions and outreach efforts continue – focused on benefits of an interoperable space service volume and development of space-based user equipment

Orbital Debris and Orbital De-confliction

- ICG working with IADC to review debris guidelines for MEO/IGSO satellites

Precise Point Positioning (PPP)

- ICG-14 recommendation adopted to form a Task Force on PPP interoperability – co-chaired by Australia, Japan and EU
- PPP Workshop proposed for 2020

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 made available for use 13 January 2020
  - 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…

www.gps.gov

THANK YOU!

Office of Space and Advanced Technology
U.S. Department of State