United States GPS Program and GNSS International Activities Update

China Satellite Navigation Conference 2014

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Overview

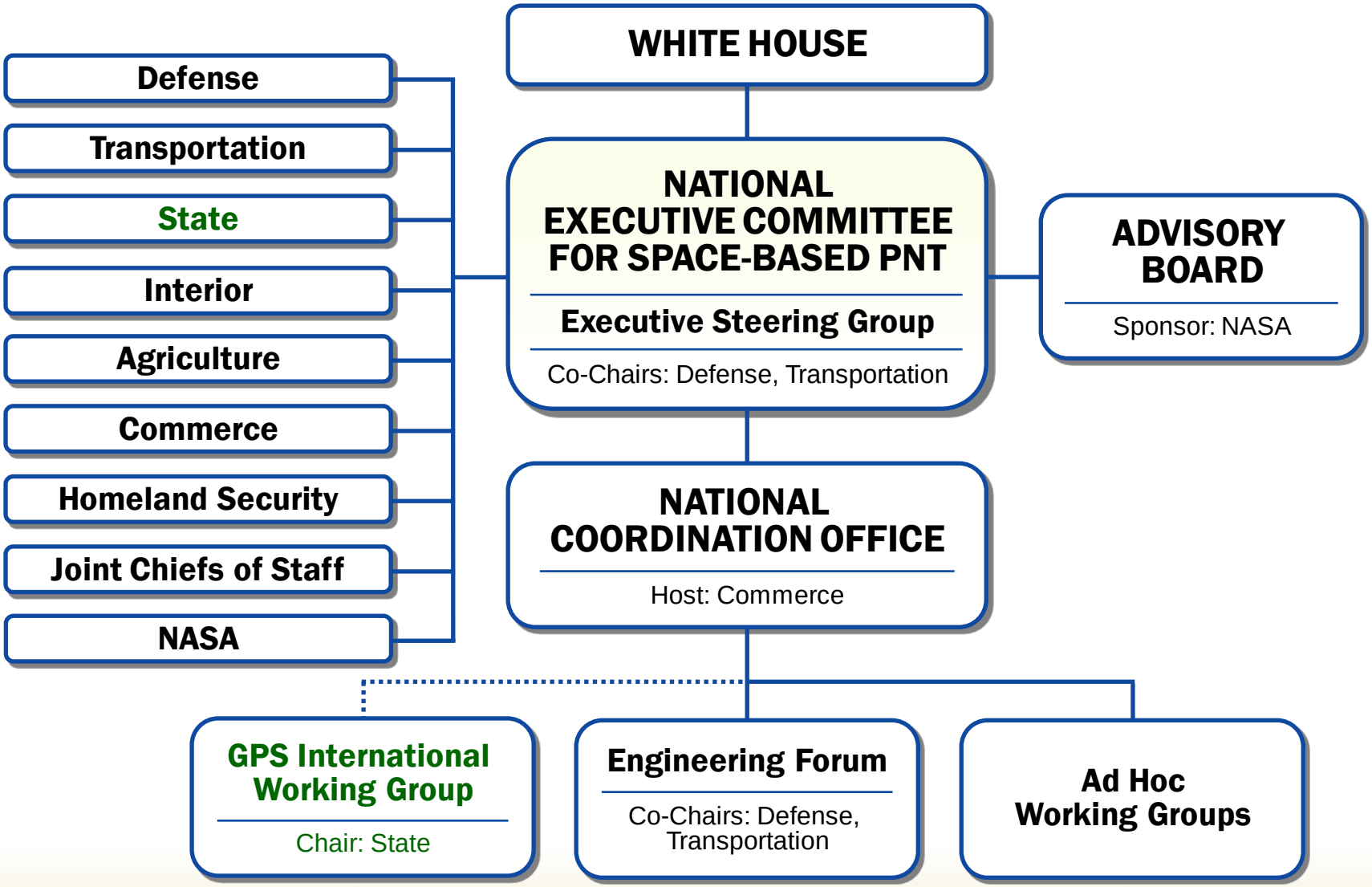
- **U.S. Space-Based PNT Policy**
- GPS Program Status
- International Cooperation Activities
- Summary

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 complement services from 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

U.S. Space-Based PNT Organization Structure



U.S. Policy Promotes Global Use of GPS Technology

- No direct user fees for civil GPS services
  - Provided on a continuous, worldwide basis
- Open, public signal structures for all civil services
  - Promotes equal access for user equipment manufacturing, applications development, and value-added services
  - Encourages open, market-driven competition
- Global compatibility and interoperability with GPS
- Service improvements for civil, commercial, and scientific users worldwide
- Protection of radionavigation spectrum from disruption and interference

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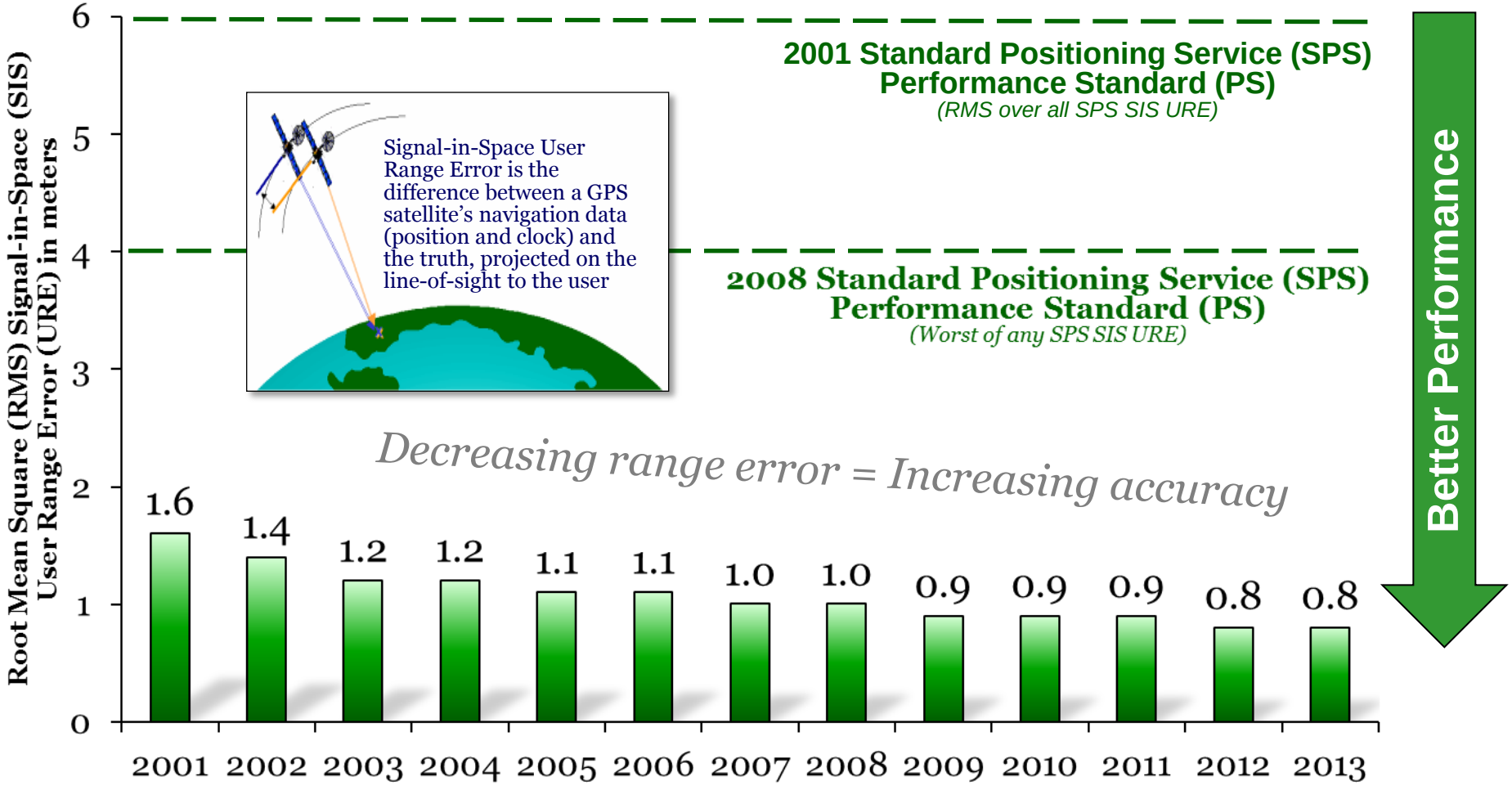
GPS Constellation Status

30 Operational Satellites as of May 16, 2014

- "Expandable 24" configuration (27 slots)
- 6 Block IIA
- 12 Block IIR
- 7 Block IIR-M
- 5 Block IIF
- Additional residuals on orbit
- Continuously assessing constellation health to determine launch need

GPS IIF-6 Just Launched

GPS SPS Signal in Space Performance



Global GPS service performance commitment met continuously since December 1993

GPS Modernization Program

Legacy GPS IIA/IIR
- Single Frequency (L1)
- Coarse acquisition (C/A) code
- Y-Code (L1Y & L2Y)

GPS IIR-M
- 2nd Civil Signal (L2C)
- M-Code (L1M & L2M)

GPS IIF
- 3rd civil signal (L5)
- 2 Rb + 1 Cs Clocks
- 12 year design life

GPS III
- 4th civil signal (L1C)
- 4x better User Range Error than IIF
- Increased availability
- Increased integrity
- 15 year design life

Legacy OCS
- Mainframe system
- Command & Control
- Signal monitoring

AEP
- Distributed architecture
- Increased signal monitoring
- Security
- Accuracy
- Launch and disposal ops

OCX Block 0
- Launch & On-Orbit Checkout of GPS III
- Fly legacy constellation

OCX Block 1
- Transition from OCS to OCX for all GPS command and control operations

INCREASING SYSTEM CAPABILITIES - INCREASING USER BENEFIT

GPS III Space and Ground Segments

- GPS Block III, Satellites 1-8
  - SV01 initial power turn-on 27 Feb 13
  - Final elements of Navigation Payload are in acceptance test
  - SV07/08 contract awarded 31 Mar 14
- GPS Block III, Satellites 9+
  - Committed to add search and rescue payload (SAR-GPS) and satellite laser retro-reflectors
  - Studying options for dual launch and other cost savings
- Next Generation Operational Control System (OCX)
  - Modernized command & control system with M-Code and modern civil signal monitoring
  - OCX Block 0 supports launch & checkout for GPS III and is in integration & test
  - OCX Block 1 will support transition from OCS in 2017

Monitor Station

Ground Antenna

Modernized Civil GPS Signals

- Second civil signal "L2C"
  - Designed to meet commercial needs
  - Broadcast since 2005
  - Currently 12 satellites broadcasting L2C

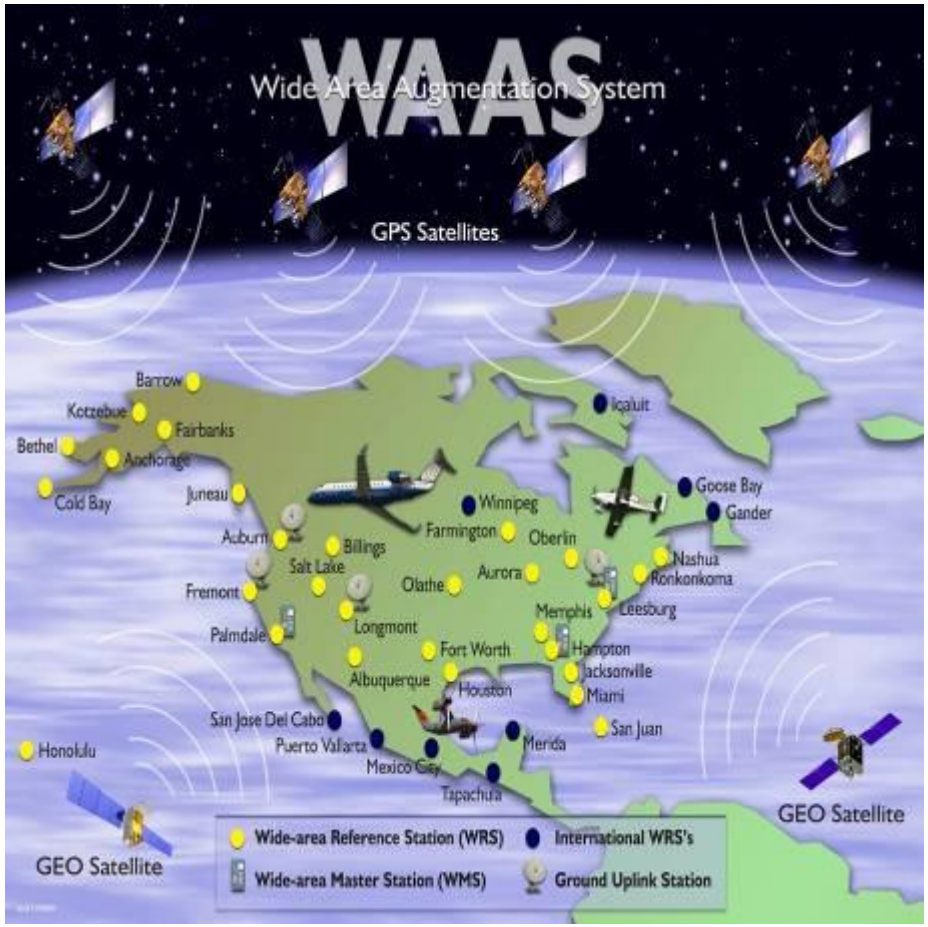
- Third civil signal "L5"
  - Meets transportation safety of life requirements
  - Uses Aeronautical Radio Navigation Service band
  - Enables triple-frequency positioning techniques
  - Currently 5 satellites broadcasting L5

- Fourth civil signal "L1C"
  - Designed for GNSS interoperability
  - Specification developed in cooperation with industry
  - Improved performance in challenged environments
  - Launches with GPS III in 2016

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

Wide Area Augmentation System (WAAS) Architecture

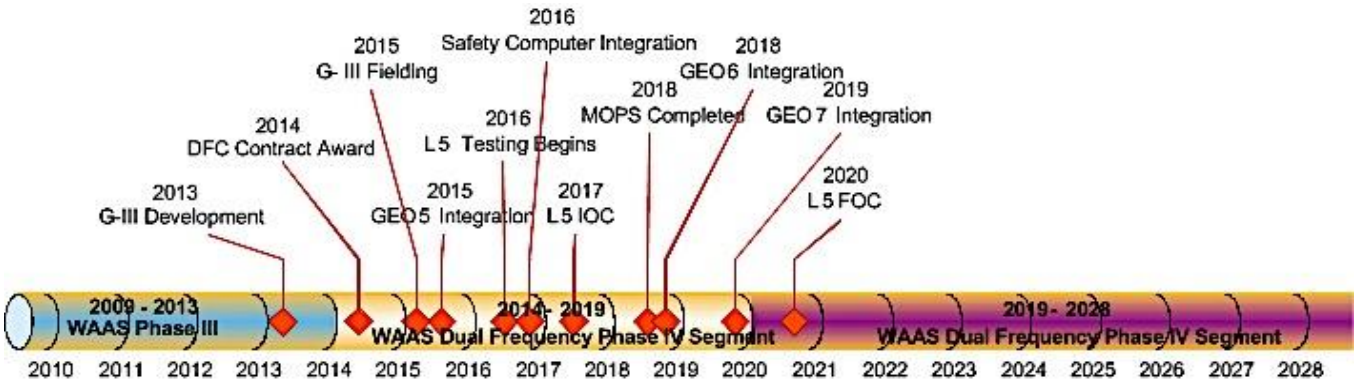
- A combination of ground-based and space-based systems that augment the GPS Standard Positioning Service (SPS)
- Provides the capability for increased availability and accuracy in position reporting, allowing more time for uniform and high quality air traffic management.
- Provides service for all classes of aircraft in all phases of flight - including en route navigation, airport departures, and airport arrival

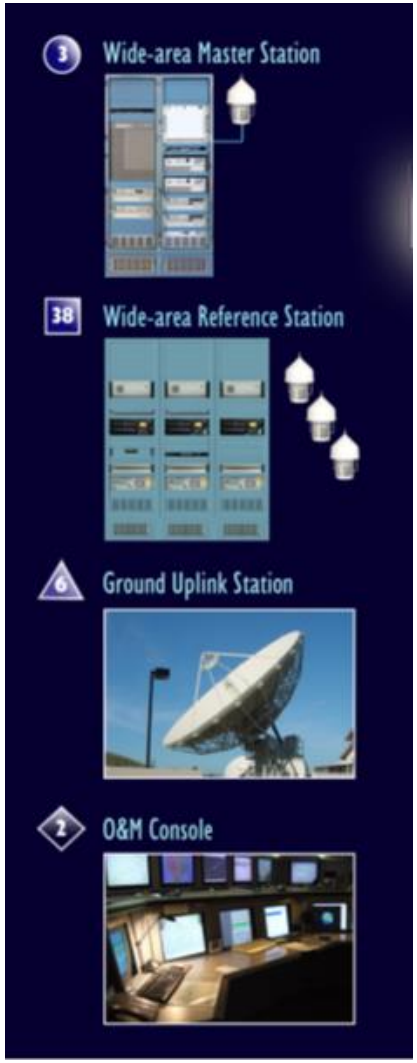


Sponsor: Federal Aviation Administration

WAAS Status

- Phase III: Full LPV-200 Performance, 2009-2013
- **Phase IV: Dual Frequency (L1, L5) Operations (2014 – 2028)**
  - Improved availability/continuity during severe solar activity
  - Transition from use of L2 to L5 in WAAS reference stations
  - Support sustainment of WAAS GEOs
  - Infrastructure modifications to support L1/L5 users
  - Continue to support single frequency users
  - Evaluate Multi-Constellation utility





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Planned GNSS

Global Constellations

- **GPS (24+)**
- GLONASS (30)
- Galileo (27+3)
- 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)

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

Bilateral Cooperation

- **Japan**: Joint statement signed in 1998; cooperation focuses on compatibility and interoperability between GPS and Japan's Quasi-Zenith Satellite System (QZSS)
- **European Union**: GPS-Galileo Agreement signed in 2004, ratified by EU in December 2011; working groups formed under the agreement continue to meet
- **India**: Joint statement on GNSS cooperation signed 2007; continuing discussions under the Joint Civil Space Cooperation Working Group
- **Russia**: GPS-GLONASS discussions ongoing since 1996; Joint Statement issued Dec. 2004; May 2012 request to consider hosting SDCM sites within U.S. territory to monitor GLONASS civil signals is still under review within the U.S. government

U.S. Cooperation with China

- Operator-to-operator coordination under ITU auspices for GPS & Beidou was completed in September 2010
- Following CSNC 2011:
  - Workshop on GNSS conducted by the Chinese Academy of Engineering and U.S. National Academy of Engineering
  - Meeting between the CAAC (中国民用航空局) and U.S. FAA focused on aviation satellite navigation issues
- On going cooperation with China Satellite Navigation Office (CSNO) and China National Administration of GNSS and Applications (CNAGA), on the margins of the International Committee on GNSS (ICG)
- Delegations from both nations just met on May 19 in Beijing to discuss civil cooperation topics such as interoperability, service monitoring, interference detection, spectrum protection, and civil aviation applications

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.oosa.unvienna.org/oosa/en/SAP/gnss/icg.html

ICG-8 Meeting in Dubai: Nov 10-14, 2013

- Interference detection and mitigation (IDM) Task Force established
  - Focus on developing a common set of information to be reported to GNSS civil service centers
  - Third IDM Workshop to be held in 2014 (China likely host)
- Interoperability Task Force established
  - Focus on analyzing the results of the April 2013 U.S. hosted Interoperability Workshop
  - Additional Interoperability Workshops to be held in 2014 (hosted by different GNSS Providers)
- Multi-GNSS monitoring: International GNSS Monitoring and Assessment (IGMA) Task Force to focus on:
  - Identifying what service parameters should be monitored
  - Defining the level and methods for carrying out the monitoring
- Consensus that achieving a fully interoperable GNSS space service volume would provide significant performance benefits that no single system could provide on its own

ICG-9 will be hosted by the EU in Prague, November 2014

Progress at ICG in GNSS Civil Service Provision

- ✓ Providers Forum
  - ✓ Providers Forum System Report
    - ✓ Principles of Compatibility, Interoperability, and Transparency
      - ➢ Template for Performance Standards (and ICDs)
        - ➢ *Postulated Performance Standards for future services*
          - Service Assurances or Commitments
            - *Monitoring of service performance*
              - *Interference monitoring*

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- U.S. policy encourages worldwide GPS use
  - International cooperation to ensure compatibility, interoperability, and transparency is a priority
- GPS and augmentations continue to provide improved service and modernized capabilities while maintaining backward compatibility for all users
- Policy stability, service transparency, and continuous improvement are the keys to success in GNSS Programs

For Additional Information…

www.gps.gov

谢谢

THANK YOU!

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