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

China Satellite Navigation Conference 2015
Xi’an, May 12-15

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Policy and Service Provision

- Constellation Status and Modernization
- International Cooperation
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
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
Civil Service Accuracy: Standard Positioning Service Performance Standard

Standard Positioning Service (SPS) Signal-in-Space Performance

User Range Error (URE) in Meters

- 2001 SPS PS 6 m RMS
- 2008 SPS Performance Standard (PS)
  - Worst of Any Healthy Satellite, 7.8 m @ 95%
- Equivalent RMS Value from 2008 SPS PS (4 m)
  - Worst of Any Healthy Satellite (95%)

Across All Healthy Satellites (RMS, 68%)

- 2001: 1.6
- 2002: 1.4
- 2003: 1.2
- 2004: 1.2
- 2005: 1.1
- 2006: 1.1
- 2007: 1.0
- 2008: 1.0
- 2009: 0.9
- 2010: 0.9
- 2011: 0.9
- 2012: 0.8
- 2013: 0.8
- 2014: 0.7

System accuracy better than published standard
Overview

• Policy and Service Provision

◆ Constellation Status and Modernization

• International Cooperation
GPS Constellation Status

31 Operational Satellites
(Baseline Constellation: 24+3)

• Robust operational constellation
  – 3 GPS IIA – L1 C/A, L1 P(Y), L2 P(Y) signals
  – 12 GPS IIR – same signals as IIA
  – 7 GPS IIR-M – adds L2C, L1M, L2M signals
  – 9 GPS IIF – adds L5 signal

• 4 successful GPS IIF launches in 2014!
  – Latest launch: March 25, 2015
  – 3 more GPS IIFs to launch - SVs 10, 11, and 12
  – Two more GPS IIF launches planned 2015

March 25, 2015 IIF-9 Launch
GPS Modernization Status

- GPS III is the newest block of GPS satellites
  - 4 civil signals: L1 C/A, L1C, L2C, L5
  - First U.S. satellites to broadcast international common L1C signal
    - Three improved Rubidium atomic clocks
    - GPS III SV01 available for launch in CY 2017
- Current system Operational Control Segment (OCS)
  - Flying GPS constellation on Architecture Evolution Plan (AEP) and Launch & Early Orbit, Anomaly, and Disposal Operations (LADO) software systems
- Next Generation Operational Control System (OCX)
  - Modernized command & control system with M-Code, modern civil, signal monitoring, information assurance infrastructure & improved PNT performance – Raytheon (Aurora, CO) - Prime
  - Civil Signal Performance Monitoring capability scheduled for OCX Block 2 in 2020
Now on the Air: Modernized Civil Signals

• The U.S. initiated continuous CNAV message broadcast (L2C & L5) on 28 Apr 14

• On December 31, 2014, the Air Force started transmitting CNAV uploads on a daily basis. L2C and L5 should continue to be considered pre-operational and should be employed at the user's own risk
  • Position accuracy not guaranteed during pre-operational deployment
  • L2C message currently set “healthy”
  • L5 message set “unhealthy” until sufficient monitoring capability established
Overview

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➢ 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**
GNSS: A Global Navigation Satellite System of Systems

- 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: China

• First bilateral space-based PNT related meeting to discuss civil cooperation topics held 19 May 2014 in Beijing
  – Topics of discussion included: interoperability, service monitoring, interference detection, spectrum protection, and civil aviation applications
  – Agreement to establish a civil satellite navigation cooperation working group for additional discussions on topics of mutual interest
  – Joint Statement signed
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

ICG Provider Forum

- Members include the U.S., EU, Russia, China, India, and Japan
  - Focused discussions on compatibility and interoperability, encouraging development of complimentary systems
  - Exchange detailed information on systems and service provision plans
- Consensus reached on Principles of compatibility, interoperability and transparency in civil service provision
  - Compatibility definition includes spectral separation between each system’s authorized service signals (e.g. U.S. M-code) and other systems’ signals
- Providers are leading efforts to promote GNSS radio-frequency interference detection and mitigation
- The Next Provider’s Forum (14th) Meeting will take place in June in Vienna, Austria
• Interference Detection and Mitigation (IDM)
  – Nations should evaluate & implement existing/emerging IDM capabilities and work with the telecom industry on standards for crowd sourcing IDM techniques
  – The ICG Secretariat and IDM taskforce will organize UN-sponsored workshops on RNSS spectrum protection and IDM for user community member nations
  – IDM Task Force initiated a discussion on GNSS as critical infrastructure
• International Multi-GNSS monitoring and assessment (IGMA)
  – Existing civil service centers should establish a link to a new ICG web portal allowing users to easily find GNSS monitoring information and products
  – Conduct a workshop in 2015 focused on multi-GNSS open service monitoring, parameters to be monitored, and an organizational approach
• Interoperability Task Force and System Providers should continue to assess industry feedback received at 4 interoperability workshops

**The United States will Host ICG-10 in Boulder, Colorado, November 1-6, 2015**
Summary

• U.S. policy encourages worldwide civil GPS/GNSS use
  – International cooperation to ensure **compatibility, interoperability, and transparency** is a priority

• GPS and augmentations continue to provide enhanced capabilities while maintaining backward compatibility for all users

• Assured service, policy stability, transparency, and continuous improvement are the keys to successfully providing a **Global Public Service** like GPS civil service

• The ICG, with strong U.S. participation, is pursuing a **Global Navigation Satellite System-of-Systems** to provide civil GNSS services that benefit users worldwide
For Additional Information...

[Image of a web page: GPS.GOV - Official U.S. Government information about the Global Positioning System (GPS) and related topics.]

**Multilingual Content**

To improve global understanding about GPS, we are pleased to offer key portions of this website in multiple languages. Please note that some pages link back to English content.

- **Español**
  - Página Principal
  - El Sistema de Posicionamiento Global
  - Ampliaciones al GPS
  - Aplicaciones del GPS

- **中文**
  - 首页
  - 全球定位系统
  - GPS的增强系统
  - GPS的应用

www.gps.gov
Bilateral GNSS Cooperation

- Europe: GPS-Galileo Cooperation Agreement signed 2004
  - ITU coordination agreement between GPS and Galileo: 2014
  - Current issues include pseudolite interference, spectrum
- China: First civil GNSS bilateral held May 2014
  - Issues include spectrum protection, civil aviation applications
  - U.S.-China Strategic and Economic Dialogue agreed to regular meetings on outer space activities – GNSS meeting planned
- Japan: Regular plenary and technical WG meetings
  - U.S. hosts QZSS monitoring stations in Hawaii and Guam
- India: Discussion on emerging IRNSS and spectrum use
  - ITU compatibility coordination completed
- Russia: No current bilateral GNSS related discussions
  - Engagement in multilateral fora such as ICG continues
Current International Signal Plans

- **GPS** (US)
- **GLONASS** (Russia)
- **Galileo** (Europe)
- **COMPASS** (China)
- **IRNSS/GINS** (India)
- **QZSS** (Japan)
- **SBAS** (US, Europe, India, Japan)

**Future CDMA signal**

**Note:** GINS modulations TBD

**Compass & IRNSS in S-band**
ICG WG-A Interoperability Workshops

- First Workshop held April 2013, hosted by the U.S. in Honolulu - @ Pacific PNT 2013
- Three other workshops held in 2014
  - Russia hosted Workshop in April
  - China hosted Workshop in May
  - Japan hosted Workshop in August
- Europe just hosted their workshop in March 2015
- Workshops are focused on receiving industry/user feedback on Interoperability and multi-GNSS use
- The interoperability task force will be meeting this week on the margins of Pacific PNT 2015
• U.S. will host in Boulder, Colorado
  ➢ 45 km from Denver

• Meeting Venue: University Corporation for Atmospheric Research (UCAR)
  ➢ Consortium of more than 100 member colleges and universities focused on atmospheric research and Earth system sciences
  ➢ UCAR manages the National Center for Atmospheric Research (NCAR) on behalf of the National Science Foundation

• Tour Sites confirmed
  ➢ National Oceanic and Atmospheric Administration, National Space Weather Prediction Center
  ➢ UNAVCO: University-governed consortium, which facilitates geoscience research and education using geodesy
  ➢ National Institute of Standards and Technology, Time and Frequency Laboratory

UCAR Center Green Facility
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
Complementary PNT

• The EXCOM is assessing the need for a complementary service to GPS
  – Assessment driven by many factors: from policy to technology
  – U.S. coverage for GPS outage from natural or man-made events

• Current Activity: Identify and assess alternatives
  – Assessed a broad mix of terrestrial RF and autonomous PNT technologies

• Decision timeline: No earlier than summer 2015
  – Supports FY17 investment decisions

• Federal Register Notice published to solicit public stakeholder engagement