International Developments in Global Navigation Satellite Systems (GNSS)

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7 November 2014
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. 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
Planned Space-Based Positioning, Navigation and Timing (PNT) Systems

- **Global Constellations**
  - GPS (24+3)
  - GLONASS (24+)
  - Galileo (24+3)
  - Compass (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)
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
Bilateral 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

• China-U.S. Strategic and Economic Dialogue (S&ED)
  – Agreement on two items related to “satellite collision avoidance” and “establishing bilateral government-to-government consultation mechanisms and holding regular meetings on outer space activities.”
Bilateral Cooperation: Europe

• GPS-Galileo Cooperation Agreement signed in 2004, ratified by EU in December 2011
  – Four working groups established under the Agreement
  – Working groups continue to meet regularly

• Third bilateral Plenary meeting held June 2014 in Torrejon, Spain

• ITU coordination agreement on compatibility between GPS and Galileo signed, July 2014

• Working Group A (compatibility and Interoperability) met Sep 15-16
  – Agenda included pseudolite interference, timing offset and spectrum issues
Bilateral Cooperation: India

• U.S.–India Joint statement signed in 2007
  – Cooperation on GPS and augmentations
  – Expanded effort to ensure interoperability between GPS/WAAS and GAGAN

• ITU compatibility coordination – Meeting in early 2013

• U.S.-India Civil Space Joint Working Group (CSJWG) bilateral meeting held in Washington, D.C. in March 2013
  – Agreement was reached on measures to ensure the compatibility of the U.S. Global Positioning System (GPS) and its Indian counterpart GNSS program (IRNSS)
Bilateral Cooperation: Japan

- Presidential/Prime Minister level Joint Statement signed in 1998
- Cooperation focuses on compatibility and interoperability between GPS and Japan’s Quasi-Zenith Satellite System (QZSS)
- U.S. continues to host QZSS monitoring stations in Hawaii and Guam
- GPS-QZSS Technical Working Group met in May 2014 to discuss compatibility coordination under the ITU auspices
- Second U.S.-Japan Comprehensive Space Dialogue held in Washington, D.C., May 2014
  - Included GNSS discussions
Bilateral Cooperation: Russia

- GPS-GLONASS discussions since 1996, Joint Statement issued December 2004
- Working Group on search and rescue discussed next generation MEOSAR capabilities
- The U.S. is not currently engaged with Russia in any bilateral discussions regarding the potential placement of GLONASS monitoring stations in the United States
  - Current U.S. law requires DoD and ODNI certification or waivers before the installation of new foreign GNSS monitoring stations on U.S. soil can be pursued
  - We remain open to constructive discussions with Russia on civil space cooperation in the area of GNSS, in particular with regard to data from scientific stations currently in place in both the United States and Russia
International Committee on GNSS (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.icgsecretariat.org
ICG Providers Forum

• Six space segment providers listed previously are members

• Purpose:
  – Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
  – Exchange detailed information on systems & service provision plans
  – Exchange views on ICG work plan and activities

• Providers have agreed that all GNSS signals and services should be compatible and open signals and services should also be interoperable to the maximum extent possible
  – Working definition of **compatibility** includes respect for spectral separation between each system’s authorized service signals and other systems’ signals
  – **Interoperability** definition addresses signal, geodetic reference frame realization, and system time steerage considerations
• Interference Detection and Mitigation (IDM) Task Force established
  – Focus on developing a common set of information to be reported to GNSS civil service centers – U.S. and China are Task Force Leads

• Interoperability Task Force established – U.S. & China are TF Leads
  – Focus on analyzing the results of Interoperability Workshops

• 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
ICG-10 to be hosted by the U.S. in Colorado, November 2015
ICG Interoperability Workshops

• First Workshop held April 2013, hosted by the U.S. in Honolulu

• Three other workshops held in 2014
  – Russia hosted Workshop in April
  – China hosted Workshop in May
  – Japan hosted Workshop in August

• Workshops focused on getting industry/user feedback on GNSS Interoperability

• IDM Task Force created under Working Group A
  – Future objective is to analyze data from the workshops and address what the results mean to each system
Active International Organizations

- International Association of Geodesy (IAG)
- International GNSS Service (IGS)
- African Reference Frame (AFREF)
Realizing a Continental Reference Frame for Africa

AFREF

*Communication and internet* are critical to success & sustainability of GNSS infrastructure
- access to information, global data, products, and technology advances
- increase knowledge base, capacity building

Training, education, access to resources, retention of quality personnel and stability are issues

Collective approach within African nations
- each adopting similar methodologies and technology
- permits progress where practical, implementing a network of GPS stations
- support and training envisioned by IGS/ITRF - seeking resources
Establish a **continental reference system** – with sustainable technology

Provides the geodetic infrastructure for development throughout Africa

Key to modernizing national reference systems through satellite and space geodesy: GPS, SLR, GLONASS, future GNSS (Galileo)

- Three dimensions, horizontal and vertical, and velocities

Includes gravity measurements as an essential component

IGS/ITRF methodology at global and regional scales: EUREF (European), SIRGAS (South America) examples of approach and realization
ITRF is one of the key activities of the International Earth Rotation and Reference System (IERS) an International Association of Geodesy (IAG) Service

ITRF is defined by combination of technique observations, analysis and products

Website available, please visit
  - http://www.ensg.ign.fr/ITRF/

ITRF expresses strong support for AFREF
  - Notes the need to integrate existing permanent GPS stations into the International GNSS Service (IGS) Network, the backbone of AFREF
APEC GNSS Implementation Team (GIT)

- Established in 2002
- Reports to Transportation Working Group (TPT-WG) through the ITS and Inter-modal Experts Group (IIEG)
- Adopted a GNSS Strategy designed to promote implementation and adoption of GNSS technologies, including regional augmentation systems, throughout the Asia Pacific region
  - Focus is on seamless intermodal transportation
- 19th GIT meeting held April 2014 in Christchurch, New Zealand
  - Much interest in Multi-GNSS demonstration for ITS applications and GNSS interference, detection, and mitigation
Summary

- U.S. policy encourages worldwide use of civil GPS and augmentations
- International cooperation at all levels is a priority
- Compatibility, interoperability, and transparency in open service provision are critical

http://www.gps.gov/
THANK YOU!

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