GNSS Interoperability through International Cooperation

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Overview

- U.S. National Space Policy
- Compatibility and Interoperability
- Bilateral International Cooperation
- International Committee on GNSS (ICG)
- Improving Interoperability (Interchangeability?)
- 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 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
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

**Pursue through Bilateral and Multilateral Cooperation**
The Goal of Civil GNSS Interoperability

- **Ideal interoperability** allows navigation with **one signal each** from four or more systems **with no additional receiver cost or complexity**

*Interoperable = Better Together than Separate*
Bilateral Cooperation

- 1998 **U.S.-Japan** Joint Statement on GPS Cooperation
- **U.S.-EU** GPS-Galileo Cooperation Agreement signed in June 2004
- **U.S.-Russia** Joint Statement issued December 2004
- **U.S.-India** Joint Statement on GNSS Cooperation in 2007
- **U.S.-China** operator-to-operator coordination under ITU auspices
- **U.S.-Australia** Joint Delegation Statement on Cooperation in the Civil Use of GPS in 2007
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
  – First Meeting held in 2006
  – Next meeting – September 4-9, 2011 in Tokyo, Japan

• Members include:
  – GNSS Providers (U.S., EU, Russia, China, India, Japan)
  – Other interested Member States of the United Nations
  – International organizations/associations

ICG Providers Forum

• Six current space segment providers are members
  – Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
  – Exchange detailed information on systems & service provision plans and views on the ICG work plan and activities

• Agreement that all GNSS signals & services must be compatible and **open signals & 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, system time and geodetic reference frame considerations
ICG Working Group on Compatibility and Interoperability (WG-A)

- Co-Chaired by the United States and the Russian Federation
- Work plan focused on assisting Providers in the pursuit of complementary systems
  - Compatibility and Interoperability - consider the perspective of various user applications and equipment manufacturers
  - Open Service Information Sharing - pursue Principle of Transparency: every GNSS provider should publish documentation that describes the signal and system information, the policies of provision and the minimum levels of performance offered for its open services
  - Service Performance Monitoring - potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services
  - Spectrum Protection - Interference Detection, and Mitigation - develop a strategy for supporting mechanisms to detect and mitigate sources of electromagnetic interference
**WG-A Interoperability Questionnaire**

**Purpose:** obtain worldwide technical input from the GNSS industry, academic institutions, and other user community representatives regarding interoperability and the combined use of signals from multiple systems

- Circulated by WG-A after ICG-3, Dec 08, and discussed with user community at four meetings
- Posted online by GPS World, March 2010

**Results to date:**

- **Benefits** of interoperability include better availability, accuracy, and ability to support RAIM
- **Priorities** include common carrier frequencies, common time scale & reference frames, common modulation, and collocation of reference stations
**Ideal Interoperability (Interchangeability?)**

- **Definition:** Navigation with one signal each from four or more systems with no additional receiver cost or complexity

- Do users and manufacturers want it?
  - Not clear

- Is it of value?
  - Maybe for some users
  - Receivers can self-correct for most system differences with enough satellites in view

- **If** it is desirable to improve interoperability …
Improving Interoperability (1)

- Geodetic reference frames of individual systems appear to be converging to within centimeters
  - Maintaining alignment of reference frames with ITRF should ensure this trend continues
- A GNSS ensemble time could be realized by the monitoring of all constellations from common sites
  - Individual system times could then be compared to this “GNSS time” and the resulting corrections could be made available for broadcast through multiple channels
    - Core global constellations, regional systems, SBAS, and the internet are all possibilities
Improving Interoperability (2)

- More Frequency commonality with common signal spectrum
  - Simplifies multi-constellation monitoring
  - Reduces cost of consumer-grade receivers
  - Minimizes time and frequency biases
- Greater service provision transparency
  - Timely and widely available interface specifications and performance standards for individual constellations
  - Transparent operation of common monitoring stations and widely available information on obtaining corrections
Planned GNSS Signals

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<td>SBAS (US, Europe, India, Japan)</td>
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Future CDMA signal

Note: GINS modulations TBD

Compass & IRNSS in S-band
Almost Ideal Interoperability

Greater frequency commonality with transparency

Almost Interchangeability
• U.S. Space-Based PNT Policy encourages **compatibility and interoperability** with GPS
  – Pursued through bilateral and multilateral cooperation
• The U.S. supports the ICG principles of compatibility, interoperability, and transparency
• Efforts to better understand industry and user views on interoperability continue through the ICG
  – **Your input is welcome and encouraged**
• **Ideal Interoperability** or “Interchangeability” and the means to achieve it deserves further consideration
  – Multi-GNSS constellation monitoring will be necessary
Thanks!

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Progress in GNSS 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