GPS: Constellation Update and U.S. Activities Supporting International GNSS Interoperability

2010 International Symposium on GPS/GNSS

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GPS is Essential to Our Economies and National Critical Infrastructures

- Satellite Operation
- Surveying & Mapping
- Power Grids
- Precision Agriculture
- NextGen
- Trucking & Shipping
- IntelliDrive
- Personal Navigation
- Disease Control
- Oil Exploration
- Fishing & Boating
- TeleComm
Overview

• U.S. National Space Policy
• GPS Constellation Status
• Compatibility and Interoperability
• International Cooperation Venues
  – Bilateral Cooperation
  – International Committee on GNSS (ICG)
  – APEC GNSS Implementation Team (GIT)
• Summary
New 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. National Space-Based PNT Organization Structure

WHITE HOUSE

NATIONAL EXECUTIVE COMMITTEE FOR SPACE-BASED PNT
Executive Steering Group
Co-Chairs: Defense, Transportation

NATIONAL COORDINATION OFFICE
Host: Commerce

ADVISORY BOARD
Sponsor: NASA

Defense
Transportation
State
Interior
Agriculture
Commerce
Homeland Security
Joint Chiefs of Staff
NASA

GPS International Working Group
Chair: State

Engineering Forum
Co-Chairs: Defense, Transportation

Ad Hoc Working Groups
GPS Constellation Status

31 Operational Satellites
(Baseline Constellation: 24)

- 11 Block IIA
- 12 Block IIR
- 7 Block IIR-M
  - Transmitting new second civil signal
  - 1 GPS IIR-M in on-orbit testing
- 1 Block IIF launched May 27th, 2010
  - First of 12 Block IIF satellites
- 3 additional satellites in residual status
- Global GPS civil service performance commitment met continuously since December 1993
GPS Modernization Program

**Increasing System Capabilities** • **Increasing Defense / Civil Benefit**

**Block IIA/IIR**
Basic GPS
- Standard Service
  - **Single frequency (L1)**
  - Coarse acquisition (C/A) code navigation
- Precise Service
  - Y-Code (L1Y & L2Y)
  - Y-Code navigation

**Block IIR-M, IIF**
IIR-M: IIA/IIR capabilities plus
- **2nd civil signal (L2C)**
- M-Code (L1M & L2M)
IIF: IIR-M capability plus
- **3rd civil signal (L5)**
- Anti-jam flex power

**Block III**
- Backward compatibility
- **4th civil signal (L1C)**
- Increased accuracy
- Increased anti-jam power
- Assured availability
- Navigation surety
- Controlled integrity
- Increased security
- System survivability
GPS Modernization – New Civil Signals

• Second civil signal “L2C”
  – Designed to meet commercial needs
  – Higher accuracy through ionospheric correction
  – Available since 2005 without data message
    • Currently, 7 IIR-Ms transmitting L2C
  – After 2020 with L2C and L5 online, the USG will no longer support semi-codeless access to military GPS signals
  – Full capability: 24 satellites ~2016

• Third civil signal “L5”
  – Designed to meet demanding requirements for transportation safety-of-life
  – Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
  – On orbit broadcast 10 APR 2009 on IIR-20(M) secured ITU frequency filing
    • Is operational on 1st IIF (SVN-62)
  – Full capability: 24 satellites ~2018
GPS Modernization – Fourth Civil Signal (L1C)

• Fourth civil signal “L1C”
  – Designed with international partners for interoperability
  – Modernized civil signal at L1 frequency
    • More robust navigation across a broad range of user applications
    • Improved performance in challenged tracking environments
    • Original signal retained for backward compatibility
  – Specification developed in cooperation with industry recently completed
  – Launches with GPS III in 2014
  – On 24 satellites by ~2021
**SPS Signal in Space Performance**

- **2001 SPS Performance Standard** (RMS over all SPS SIS URE)
- **2008 SPS Performance Standard** (Worst of any SPS SIS URE)

**System accuracy exceeds published standard**

- Decreasing range error
- Selective Availability (SA)
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 Bi-lateral and Multi-lateral 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
International Cooperation Venues

• Bilateral
  – China
  – Japan
  – India
  – Australia
  – Russia
  – EU

• Multilateral
  – International Committee on GNSS (ICG)
  – Asia Pacific Economic Cooperation (APEC)
Bilateral Cooperation

- **U.S.-China** operator-to-operator coordination under ITU auspices

- **U.S.-Japan** Joint Statement on GPS Cooperation 1998
  - Annual Plenary Meetings
  - Quasi Zenith Satellite System (QZSS) designed to be fully compatible and highly interoperable with GPS
  - Bilateral agreements to set up QZSS monitoring stations in Hawaii and Guam – stations operating!

- **U.S.-India** Joint Statement on GNSS Coop. 2007
  - Technical Meetings focused on GPS-India Regional Navigation Satellite System (IRNSS) compatibility and interoperability held in 2008 and 2009
Bilateral Cooperation (continued)

- **U.S.-Australia** Joint Delegation Statement on Cooperation in the Civil Use of GPS in 2007
  - Next bilateral meeting in Washington, D.C., Oct. 26-27, 2010
  - USCG NAVCEN posts a daily PDOP report in response to concerns over planned GPS outages

- **U.S.-Russia** Joint Statement issued December 2004
  - Working Groups: compatibility/interoperability, search/rescue

- **U.S.-EU** GPS-Galileo Cooperation Agreement signed in June 2004
  - Four working groups set up under the Agreement
  - Improved new civil signal (MBOC) adopted in July 2007
  - First Plenary Meeting successfully held in October 2008
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 interested Member States of the United Nations
  - International organizations/associations
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 must 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
U.S. Participation in the ICG

• U.S. strongly supports the ICG and Providers Forum
  - U.S. hosted ICG-3 in Pasadena, California, December 2008
  - U.S. contributes to UNOOSA as the ICG Secretariat to support ICG meetings and activities
  - U.S. actively participates in ICG working groups

• U.S. pleased with progress made at ICG-4 at St. Petersburg, Russia
  - Adoption of new principle on transparency for open services: 
    *Every provider should publish documentation that describes signal and system information, policies of provision and minimum levels of performance for its open services*

• ICG-5 to be held in October 2010 in Turin, Italy
UN OOSA is the ICG Executive Secretariat

ICG provides:

- Web-based information
- Information brochures
- Training/technical workshops for capacity building in developing countries
- Promoting the use of GNSS technologies as tools for scientific applications

http://www.icgsecretariat.org
APEC GIT Cooperation

- The Asia-Pacific Economic Cooperation (APEC) forum facilitates economic growth, cooperation, trade and investment in the Asia-Pacific region for its 21 member economies.

- The APEC GNSS Implementation Team (GIT) formerly almost exclusively focused on air traffic control and aviation issues.
  - The GIT has broadened its focus to the application of GNSS in all transportation sectors.
  - Additional participation of GNSS government and industry experts at APEC GIT-13 at Singapore in July 2009; project proposal made on surface transportation.
APEC GIT Cooperation (cont.)

- Delegates from 13 Asian-Pacific economies participated
- Goal of discussions was to improve adoption of satellite-based positioning, navigation and timing (PNT) signals into all modes of transportation
- Keynote address given by U.S. Department of Transportation Deputy Assistant Secretary for Policy Joel Szabat
- Delegates adopted a strategy paper
- Agreement to consider four projects to help economies better utilize the advantages offered by space-based PNT
- Next meeting tentatively scheduled for Brisbane, Australia in May 2011
Summary

- **International cooperation** in the context of U.S. National Space-Based PNT Policy is a *top priority* for the U.S. Government

- The U.S. actively engages in **bilateral, and multilateral cooperation** on satellite navigation issues

- As new and restored global and regional space-based navigation systems emerge, **interoperability** continues to be the key to “success for all”
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