U.S. GPS Policy and U.S. International Cooperation Activities

Civil GPS Service Interface Committee
U.S. States and Local Government Subcommittee
Groton, Connecticut
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Overview

• U.S. Space-Based PNT Policy

• International Cooperation Activities
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. Space-Based PNT Organization Structure

WHITE HOUSE

NATIONAL EXECUTIVE COMMITTEE FOR SPACE-BASED PNT
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
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
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
  - Primary focus on the common L1C and L5 signals

*Pursue through Bilateral and Multi-lateral Cooperation*
<table>
<thead>
<tr>
<th>Block</th>
<th>Time Period</th>
<th>Satellites</th>
<th>Description</th>
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</table>
| Block I | 1978 - 1985 | 11 (10) | Demonstration system
| | | | • L1 (CA) Navigation signal
| | | | • L1 & L2 (P Code) Navigation signal
| | | | • 5 Year Design Life
| Block II/IIA | 1989 - 1997 | 28 | Basic GPS Provides Initial Navigation Capabilities
| | | | • Standard Service
| | | | • Single Frequency (L1)
| | | | • C/A code navigation
| | | | • Precise Service
| | | | • Two frequencies (L1 & L2)
| | | | • P (Y) - Code navigation
| | | | • 7.5 Year Design Life
| Block IIR | 1997 - 2004 | 13 (12) | IIA/IIR Capabilities “Plus”
| | | | • 2nd Civil Signal L2 (L2C)
| | | | • Earth Coverage M-Code on L1/L2
| | | | • L5 Demo
| | | | • Anti-Jam Flex Power
| | | | • 7.5 Year Design Life
| Block IIR-M | 2005 - 2009 | 8 | IIR-M Capabilities “Plus”
| | | | • 3rd Civil Signal L5
| | | | • Reprogrammable Nav Processor
| | | | • Increased Accuracy requirement
| | | | • 12 Year Design Life
| Block IIF | 2010 - Present | 12 | IIIA
| | | | • Increased accuracy
| | | | • Increased Earth Coverage power
| | | | • 15 Year Design Life
| | | | • 4th Civil Signal (L1C)
| Block III | 2014 – 2024 | 32 | IIIB
| | | | • Real-time Communications
| | | | • IIIC
| | | | • Navigation Integrity
| | | | • Spot Beam for AJ

**Increasing Space System Capabilities – Increasing Military/Civil User Benefits**
Overview

• U.S. Space-Based PNT Policy
• International Cooperation Activities
Planned GNSS

• Global Constellations
  – **GPS (24+)**
  – GLONASS (30)
  – Galileo (27+3)
  – Compass (30 global and 5 regional satellites)
  – GINS - Global Indian Navigation System (24)

• Regional Constellations
  – QZSS (3)
  – IRNSS (7)

• Satellite-Based Augmentations
  – **WAAS (2+1)**
  – MSAS (2)
  – EGNOS (3)
  – GAGAN (2)
  – SDCM (2)
Bilateral Cooperation

- **U.S.-EU** GPS-Galileo Cooperation Agreement signed in June 2004
  - Four working groups set up under the Agreement

- **U.S.-Japan** Joint Statement on GPS Cooperation 1998
  - 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

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

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

• **U.S.-India** Joint Statement on GNSS Cooperation 2007
  – Technical Meetings focused on GPS-India Regional Navigation Satellite System (IRNSS) compatibility and interoperability held in 2008 and 2009
  – Continuation of ITU compatibility coordination is pending

• **U.S.-Australia** Joint Delegation Statement on Cooperation in the Civil Use of GPS in 2007
  – Bilateral meeting in Washington, D.C., Oct. 26-27, 2010
  – GNSS and applications to be included in expanded space cooperation, as discussed in an October 27 Joint Announcement
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
  – Met annually since 2006

• Members include:
  – **GNSS Providers** — China, EU, India, **Japan**, Russia, **United States**
  – Other interested Member States of the United Nations
  – International organizations/associations
APEC GNSS Implementation Team (GIT)

- Established in 2002

- Promote implementation of regional GNSS augmentation systems to enhance inter-modal transportation and recommend actions to be considered in the Asia Pacific Region

- Reports to Transportation Working Group (TPT-WG) through the Inter-modal Experts Group (IEG)

- Adopted a GNSS Strategy designed to promote adoption of GNSS technologies throughout the Asia Pacific region, especially with regard to transportation
Summary

• GPS performance is better than ever and will continue to improve
  – Augmentations enable even higher performance
  – New civil GPS signal available now
  – Many additional upgrades scheduled

• U.S. policy encourages worldwide use of civil GPS and augmentations

• International cooperation is a priority
  – Compatibility and interoperability very important
Contact Information

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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
- 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
- Full capability: 24 satellites ~2018
GPS Modernization – 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
Modernized Operational Control Segment (OCX)

- **Architecture Evolution Plan (AEP)**
  - Transitioned in 2007
  - Increased worldwide commanding capability
  - Increased capacity for monitoring of GPS signals
  - Modern distributed system replaced 1970s mainframes
  - Current software version (5.5D) enabled SAASM functionality

- **Next Generation Control Segment (OCX)**
  - Controls more capable constellation, and monitors all GPS signals
  - $1.5B contract awarded 25 February 2010
  - Capability delivered incrementally to reduce risk
  - On track for Preliminary Design Review in ~April 2011
  - Full Capability by ~2016
Wide Area Augmentation System (WAAS) Architecture

- 38 Reference Stations
- 3 Master Stations
- 4 Ground Earth Stations
- 2 Geostationary Satellite Links
- 2 Operational Control Centers
WAAS Phased Upgrades

- **Phase I: IOC (July 2003) Completed**
  - Provided LNAV/VNAV/Limited LPV Capability

  - Improved LPV availability in CONUS and Alaska
  - Expanded WAAS coverage to Mexico and Canada

  - Software enhancements, hardware upgrades
  - Steady state operations and maintenance
  - Transition to FAA performed 2nd level engineering support
  - Begin GPS L5 transition activities

- **Phase IV: Dual Frequency (L1,L5) Operations (2013 – 2028)**
  - Complete GPS L5 transition
  - Will significantly improve availability and continuity during severe solar activity
  - Provide additional protection against GPS interference
  - Will continue to support single frequency users
Nationwide Differential GPS (NDGPS) is a National PNT Utility

- Operated/managed by U.S. Coast Guard as a Combined NDGPS (Maritime + Department of Transportation sites + ACOE sites)

- System Specifications
  - Corrections broadcast at 285 and 325 kHz using Minimum shift Keying (MSK) modulation
  - Real-time differential GPS corrections provided in Radio Technical Commission for Maritime Services (RTCM) SC-104 format
  - No data encryption
  - Real-time differential corrections for mobile and static applications

- Single coverage terrestrial over 92% of Continental United States (CONUS); double coverage over 65% of CONUS
Nationwide Differential GPS

- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries
Terrestrial NDGPS Capabilities and Uses

• Transportation operational requirements:
  – Federal Highway Administration (FHWA)
    – on behalf of state and local DOT stakeholders
  – routine use in Federal-Aid Program
  – survey, construction, quality, asset management
  – roadside management
  – law enforcement
  – Association of Am. Railroads
    – baseline reference
  – National Governor’s Association
    – use by state DOTs,
    – resource management agencies
National Continuously Operating Reference Stations (CORS)

- Enables highly accurate, 3-D positioning
  - Centimeter-level precision
  - Tied to National Spatial Reference System
- 1,200+ sites operated by 200+ public, private, academic organizations

- NOAA’s Online Positioning User Service (OPUS) automatically processes coordinates submitted via the web from around the world
- OPUS-RS (Rapid Static) declared operational in 2007
- NOAA considering support for real-time networks