U.S. GPS Policy, Programs & International Cooperation Activities

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May 24, 2011
Overview

• U.S. Space-Based PNT Policy

• GPS & Augmentation Programs Status

• International Cooperation Activities

• 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 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
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GPS Constellation

- 31 space vehicles currently operational
  - 11 GPS IIA
  - 12 GPS IIR
  - 7 GPS IIR-M
  - 1 GPS IIF
- 3 additional satellites in residual status
- IIF SV-2 scheduled to launch in July 2011
- IIIA SV-1 scheduled launch 2014
- Continuously assessing constellation health to determine launch need

Global GPS service performance commitment met continuously since December 1993
GPS SPS Signal in Space Performance

Signal-in-Space (SIS) User Range Error (URE) is the difference between a GPS satellite’s navigation data (position and clock) and the truth, projected on the line-of-sight to the user.

- **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
## GPS Modernization Program

### 1978 - 1985
- Block I
- 11 (10) Satellites
- Demonstration system
  - L1 (CA) Navigation signal
  - L1 & L2 (P Code) Navigation signal
  - 5 Year Design Life
- Basic GPS
  - Standard Service
  - Single Frequency (L1)
  - C/A code navigation
  - Precise Service
  - Two frequencies (L1 & L2)
  - P (Y) -Code navigation
  - 7.5 Year Design Life

### 1989 – 1997
- Block II/IIA
- 28 Satellites
- Basic GPS
  - Provides Initial Navigation Capabilities
  - 2nd Civil Signal L2 (L2C)
  - Earth Coverage M-Code on L1/L2
  - L5 Demo
  - Anti-Jam Flex Power
  - 7.5 Year Design Life

### 1997 – 2004
- Block IIR
- 13 (12) Satellites
- IIA/IIR Capabilities “Plus”
  - 3rd Civil Signal L5
  - Reprogrammable Nav Processer
  - Increased Accuracy requirement
  - 12 Year Design Life

### 2005 - 2009
- Block IIR-M
- 8 Satellites
  - IIR -M Capabilities “Plus”
  - Increased accuracy
  - Increased Earth Coverage power
  - 15 Year Design Life
  - 4th Civil Signal (L1C)

### 2010 - Present
- Block IIF
- 12 Satellites
  - Increased Earth Coverage power
  - 15 Year Design Life

### 2014 – 2024
- Block III
- 32 Satellites
  - Increased accuracy
  - Increased Earth Coverage power
  - 15 Year Design Life
  - IV
  - Increased accuracy
  - Increased Earth Coverage power
  - 15 Year Design Life
  - 4th Civil Signal (L1C)

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### Increasing Space System Capabilities – Increasing Military/Civil User Benefits
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

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
GPS Modernization – Semi-codeless Transition

- GPS receivers attain very high accuracy by using "codeless" or "semi-codeless" techniques that exploit the encrypted military GPS signals without actually decoding them
  - Techniques will no longer be necessary once the new civil GPS signals are fully operational
- U.S. Government published a notice for users to transition to GPS civil-coded signals by 31 December 2020
  - Provided time for an orderly and systematic transition
  - Based on launch schedule and projected budget
- U.S. Government led community-wide collaboration on this transition plan
- U.S. is committed to continually improving GPS services as users complete a timely transition to dual-coded civil GPS equipment
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
- **Phase II:** Full LPV (FLP) (2003 – 2008) Completed
  - Improved LPV availability in CONUS and Alaska
  - Expanded WAAS coverage to Mexico and Canada
- **Phase III:** Full LPV-200 Performance (2009 – 2013)
  - 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**

- 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
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
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Planned GNSS

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

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

• Regional Constellations
  – QZSS (3)
  – IRNSS (7)
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
International Cooperation Venues

• Bilateral to include:
  – Japan
  – Europe
  – Russia
  – India
  – China
  – Others (Australia)

• Multilateral:
  – Asia Pacific Economic Cooperation
  – International Committee on GNSS
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
  - GNSS and applications to be included in expanded space cooperation, as discussed in an October 27 Joint Announcement
U.S. Bilateral Cooperation with China

- Operator-to-operator coordination under ITU auspices
  - Geneva, Switzerland - June 2007
  - Xian, China - May 2008
  - Geneva, Switzerland - October 2008
  - Hainan, China – December 2009
  - Coordination completed in Chengdu, China in September 2010
- U.S. is interested in engaging in further bilateral discussions with China on civil GNSS services and applications
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

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 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
• GNSS Implementation Team (GIT) established in 2002

• Mission – 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 through the Inter-modal Experts Group

• Adopted a GNSS Strategy designed to promote adoption of GNSS technologies throughout the Asia Pacific region, especially with regard to transportation
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• 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
  – In pursuit of systems Compatible and Interoperable with GPS
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http://www.state.gov/g/oes/sat/
http://www.gps.gov/internationals/
Global Differential GPS (GDGPS) and TDRSS Augmentation Service for Satellites (TASS)

Sponsor: NASA
GDGPS: More than 100 real-time tracking sites
  - Real-Time Positioning, Timing, and Orbit-Determination
TASS: Future plans to disseminate GDGPS corrections to satellites for autonomous orbit determination and science missions
Ground Based Augmentation System (GBAS)

- **Architecture**
  - Ground Station/Processing Unit/Power Supply (one shelter on airport property)
  - 4 Reference Receivers/Antennas
  - VHF Data Link Antenna

- **Specifications**
  - Supports Category I approach with growth to Category III
  - Single facility can provide service up to 23 mile radius