



# ***U.S. Update on GNSS Programs, Plans, and International Activities***



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# *Overview*

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- **U.S. Space-Based PNT Policy**
- GPS & Augmentation Programs Status
- International Cooperation Activities
- Summary



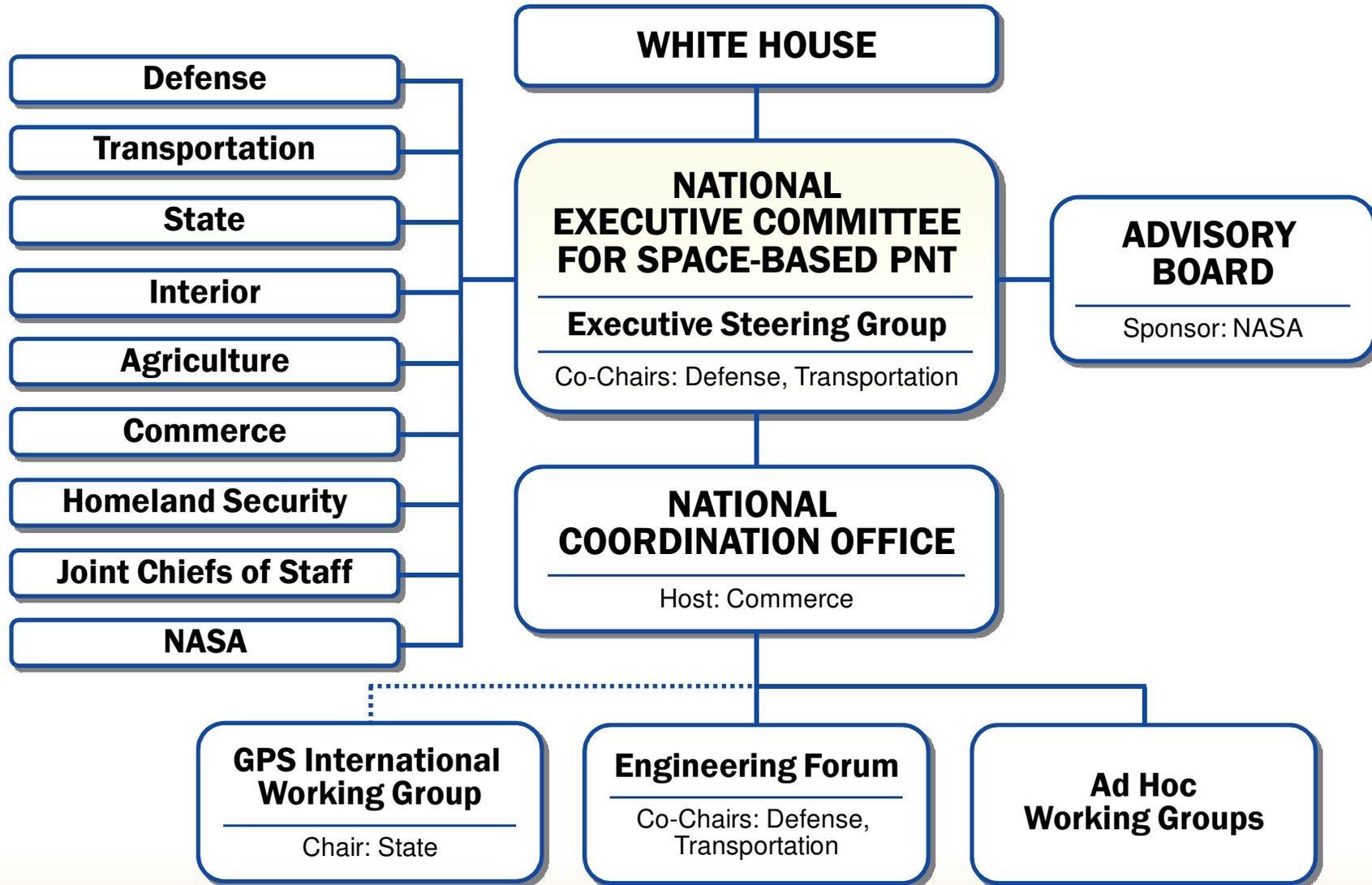
# *U.S. National Space Policy*

## *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. Space-Based PNT Organization Structure





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# *GPS Constellation Status*

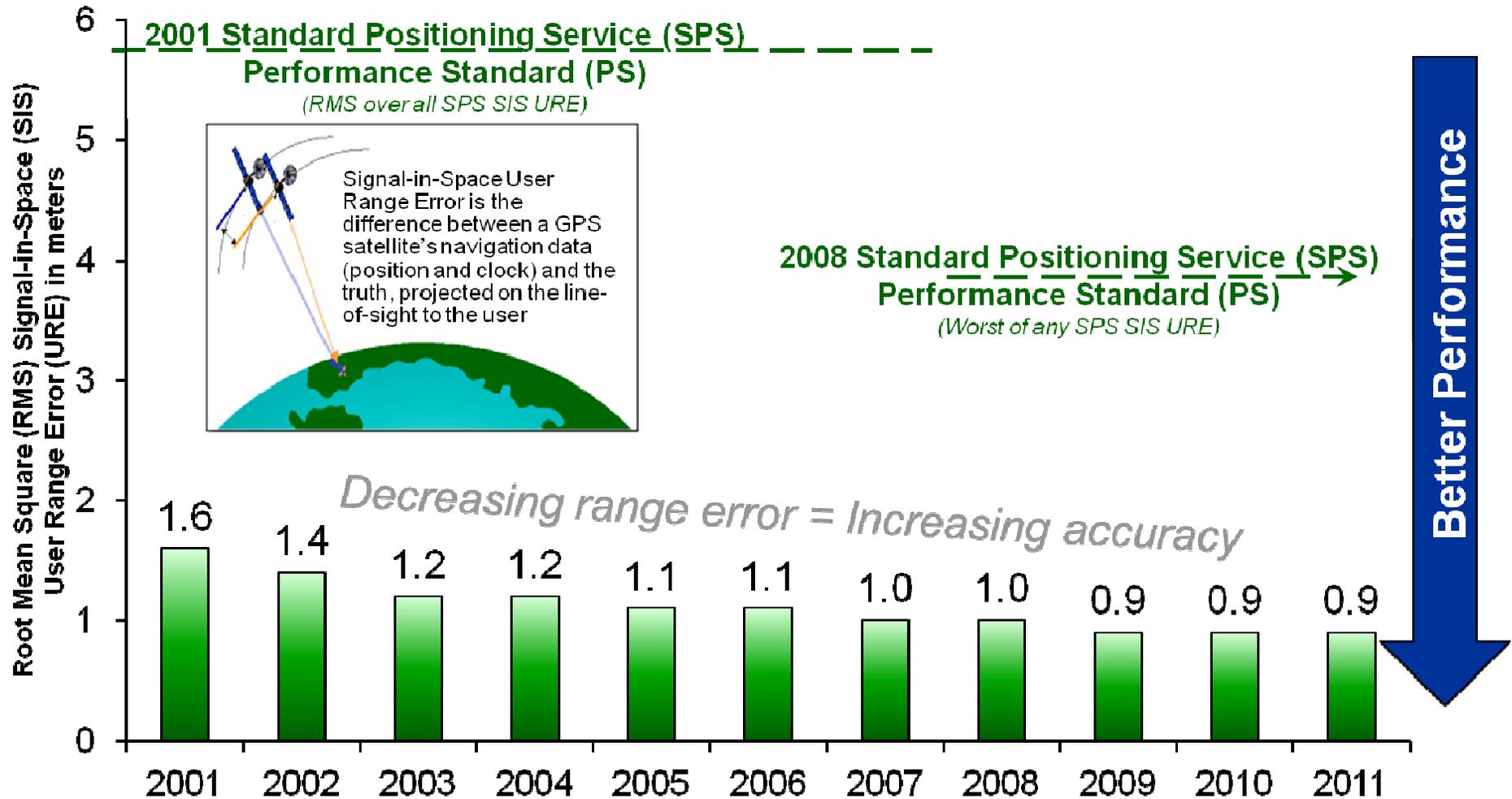
- 31 space vehicles currently operational
  - 10 GPS IIA
  - 12 GPS IIR
  - 7 GPS IIR-M
  - 2 GPS IIF
- 3 additional satellites in residual status
- GPS IIF-2 launched on 16 Jul 2011
  - Satellite Vehicle Number 63 (PRN 1) set healthy 14 Oct 2011
  - Second operational L5 signal
  - Increases the enhanced GPS clock performance coverage
  - Next GPS IIF Launch planned Sep 2012



***Global GPS service performance commitment met continuously since December 1993***



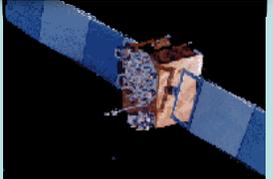
# GPS SPS Signal in Space Performance



**System accuracy exceeds published standard**



# GPS Program Evolution

1978 - 1985	1989 - 1997	1997 - 2004	2005 - 2009	2010 - Present	2014 - 2024
					
<b>Block I</b>	<b>Block II/IIA</b>	<b>Block IIR</b>	<b>Block IIR-M</b>	<b>Block IIF</b>	<b>Block III</b>
<b>11 (10) Satellites</b>	<b>28 Satellites</b>	<b>13 (12) Satellites</b>	<b>8 Satellites</b>	<b>12 Satellites</b>	<b>32 Satellites</b>
<b>Demonstration system</b>	<b>Basic GPS Provides Initial Navigation Capabilities</b>	<b>IIA/IIR Capabilities "Plus"</b>	<b>IIR -M Capabilities "Plus"</b>	<b>IIF Capabilities "Plus"</b>	
<ul style="list-style-type: none"> <li>• L1 (CA) Navigation signal</li> <li>• L1 &amp; L2 (P Code) Navigation Signal</li> <li>• 5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>• Standard Service               <ul style="list-style-type: none"> <li>• Single Frequency (L1)</li> <li>• C/A code Navigation</li> </ul> </li> <li>• Precise Service               <ul style="list-style-type: none"> <li>• Two Frequencies (L1 &amp; L2)</li> <li>• P (Y) -Code Navigation</li> </ul> </li> <li>• 7.5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>• 2<sup>nd</sup> Civil Signal L2 (L2C)</li> <li>• Earth Coverage M-Code on L1/L2</li> <li>• L5 Demo</li> <li>• Anti-Jam Flex Power</li> <li>• 7.5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>• 3<sup>rd</sup> Civil Signal L5</li> <li>• Reprogrammable Nav Processer</li> <li>• Increased Accuracy Requirement</li> <li>• 12 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>SV 1-8               <ul style="list-style-type: none"> <li>• Increased Accuracy</li> <li>• Increased Earth Coverage Power</li> <li>• 15 Year Design Life</li> <li>• 4<sup>th</sup> Civil Signal (L1C)</li> </ul> </li> <li>TBD               <ul style="list-style-type: none"> <li>• Near-Real-Time Commanding</li> <li>• DASS</li> <li>• Navigation Integrity</li> <li>• Spot Beam for AJ</li> </ul> </li> </ul>	
<p><b>Increasing Space System Capabilities - Increasing Military/Civil User Benefits</b></p> 					



# 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
  - 9 satellites currently 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 ~2019



# GPS Modernization – Fourth Civil Signal



*Under Trees*



*Urban Canyons*

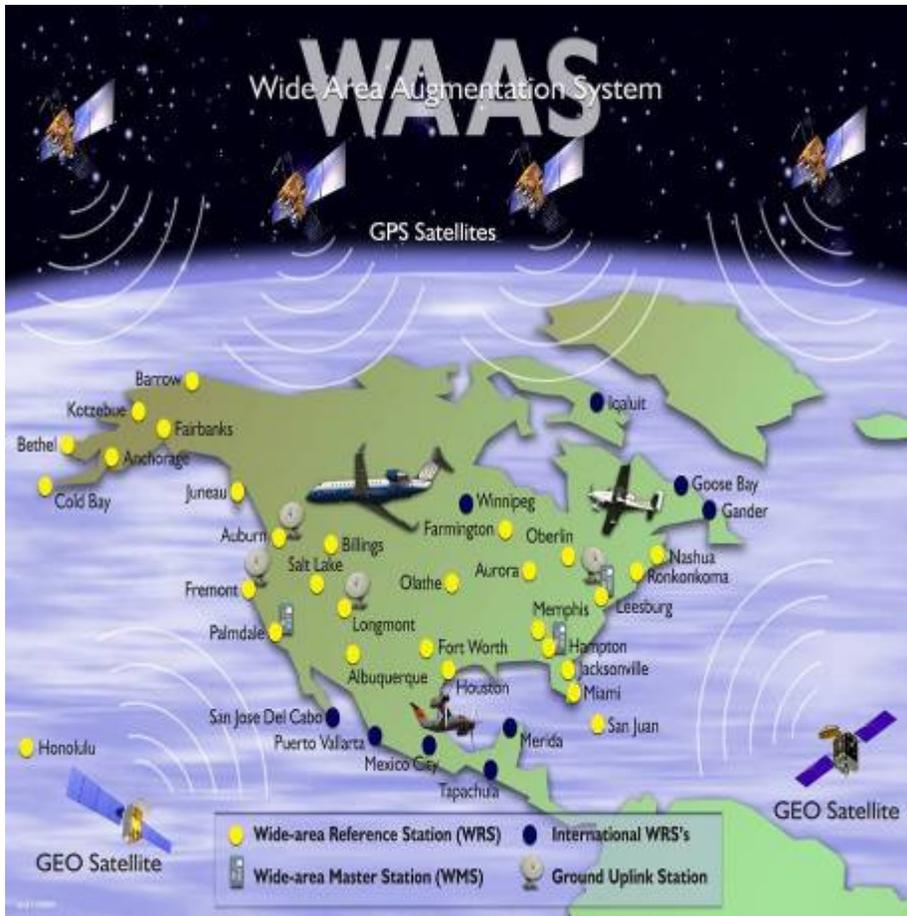
## Fourth civil signal “L1C”

- 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

<http://www.gps.gov/systems/gps/modernization/civilsignals/>



# Wide Area Augmentation System (WAAS) Architecture





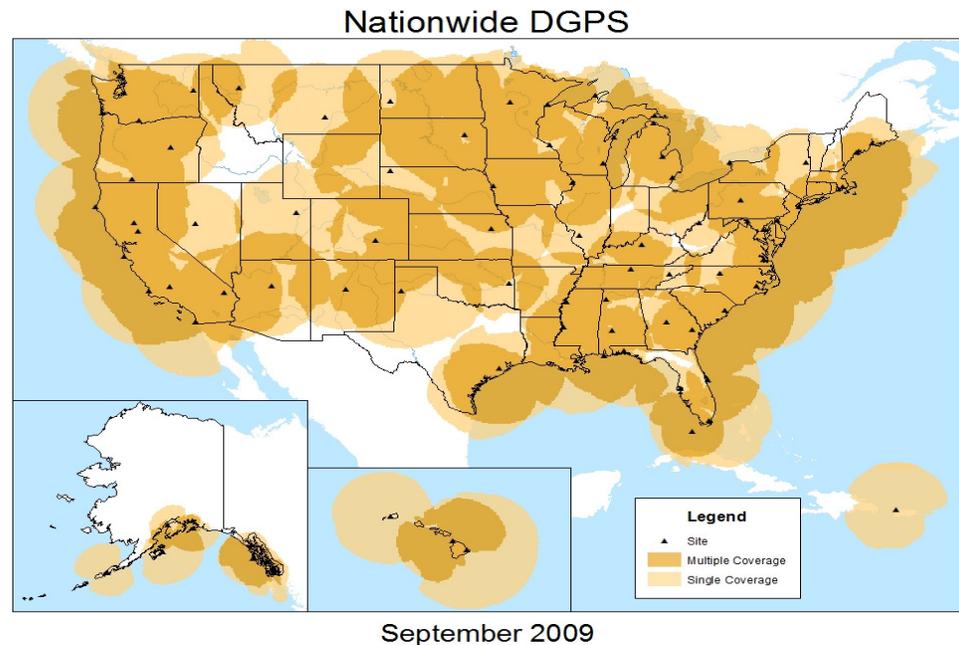
# ***WAAS Implementation***

- **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)**
  - **Development, modifications, and enhancements to include tech refresh**
  - **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 (2014 – 2028)**
  - Complete GPS L5 transition
  - Will significantly improve availability and continuity during severe solar activity
  - Will continue to support single frequency users
  - Steady state operations and maintenance



# Nationwide Differential GPS

- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries
- 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 over 92% of Continental United States (CONUS) ; double coverage over 65% of CONUS***



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# Planned GNSS

- Global Constellations
  - **GPS (24+)**
  - GLONASS (30)
  - Galileo (27+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)



## ***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***



# *Bilateral Cooperation*

- **U.S.-Russia** Joint Statement issued Dec 2004
  - Working Groups on GNSS compatibility/interoperability and search & rescue service cooperation
  - Last meeting in U.S., October 2011
  - Reaffirmation of intent to cooperate signed Sep 2011
- **U.S.-EU** GPS-Galileo Cooperation Agreement signed in June 2004
  - Four working groups set up under the 2004 Agreement
  - Plenary meeting scheduled for June 2012 in Washington, D.C.
- **U.S.-Japan** Joint Statement on GPS Cooperation 1998
  - Last plenary meeting in Jan 2012 in Washington, D.C.
  - Bilateral agreements for QZSS monitoring stations in Hawaii and Guam
- **U.S.-India** Joint Statement on GNSS Cooperation 2007
  - ITU compatibility coordination and civil space talks pending



## ***U.S. Bilateral Cooperation with China***

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- Operator-to-operator coordination under ITU auspices for GPS & Beidou/Compass was completed in September 2010
- The U.S. is interested in engaging in further bilateral discussions with China on civil GNSS services and applications
  - Successful Workshop on GNSS conducted by the Chinese Academy of Engineering and U.S. National Academy of Engineering immediately following CSNC 2011
  - Bilateral meeting between the CAAC (中国民用航空局) and U.S. FAA focused on aviation satellite navigation issues also occurred following CSNC 2011
  - On going discussions with China Satellite Navigation Office on the margins of multilateral international meetings



# *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-6 Outcomes*

- The development of **Multi-GNSS monitoring** networks was a major topic of discussion
  - The Committee endorsed the IGS Multi-GNSS Experiment
  - A Subgroup of WG-A will be formed to collectively investigate international GNSS monitoring and assessment
- The Compatibility sub-group of WG-A, with participation from all interested system providers, will initiate discussions and **collaboration on Open Service GNSS performance parameters**, including definitions and calculation methods
- Templates describing the **geodetic and timing references for all systems** have been completed and will be available on the ICG website
- **Interference Detection and Mitigation (IDM) Workshop** was approved by the Committee

***ICG-7 will be hosted by China in November 2012***



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# Summary

- **GPS performance is better than ever and will continue to improve**
  - Modernization of GPS is on track
  - Augmentations enable even higher performance
- U.S. policy encourages **worldwide use of civil GPS and augmentations**
- The U.S. is committed to **International cooperation** in pursuit of systems **Compatible** and **Interoperable** with GPS

The screenshot displays the GPS.gov website interface. At the top, there are language options: English, Español, Français, 中文, and عربي. The main header reads "GPS.gov Official U.S. Government information about the Global Positioning System (GPS) and related topics". Below the header is a navigation menu with links for HOME, WHAT'S NEW, SYSTEMS, APPLICATIONS, POLICY & FUNDING, MULTIMEDIA, and SUPPORT. A central banner features the word "Welcome" in multiple languages: "Bienvenidos", "أهلاً وسهلاً", "Welcome", "歡迎光臨", and "Bienvenue". To the right of the banner, a text box states: "To improve global understanding about GPS, we are pleased to offer key portions of this website in multiple languages. Please note that some pages may link back to English-language content." Below the banner is a "Multilingual Content" section with links for Español, Français, 中文, and عربي. The "Español" section includes links for "Página Principal", "El Sistema de Posicionamiento Global", "Ampliaciones al SPG", and "Aplicaciones del SPG". The "Français" section includes links for "Accueil", "Le Système de Positionnement Mondial", "Compléments GPS", and "Applications du GPS". The "International GPS User Support" section features the U.S. Coast Guard Navigation Center (NAVCEN) logo and text: "The U.S. Coast Guard Navigation Center (NAVCEN) is the designated point of contact within the U.S. government for GPS user support to civilians outside the United States, including international civil aviation users. Through their website and email list, NAVCEN disseminates information to". To the right of this section is a "GPS Cooperation with Other Nations" box listing countries: Australia, China, Europe, India, Japan, Russia, International Committee on GNSS, and Other International Organizations. At the bottom right, there are images of "GPS Outreach Handouts" and a graphic titled "U.S. Policy on Global GPS Access".

<http://www.gps.gov/>



谢谢

***THANK YOU!***

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