



# ***International Developments in Global Navigation Satellite Systems (GNSS)***

---

***U.S. Technical Training Institute  
George Washington University  
Washington, D.C.***

***Ray E. Clore  
Office of Space and Advanced Technology  
Bureau of Oceans, and International Environmental & Scientific Affairs  
U.S. Department of State***

***23 October 2012***



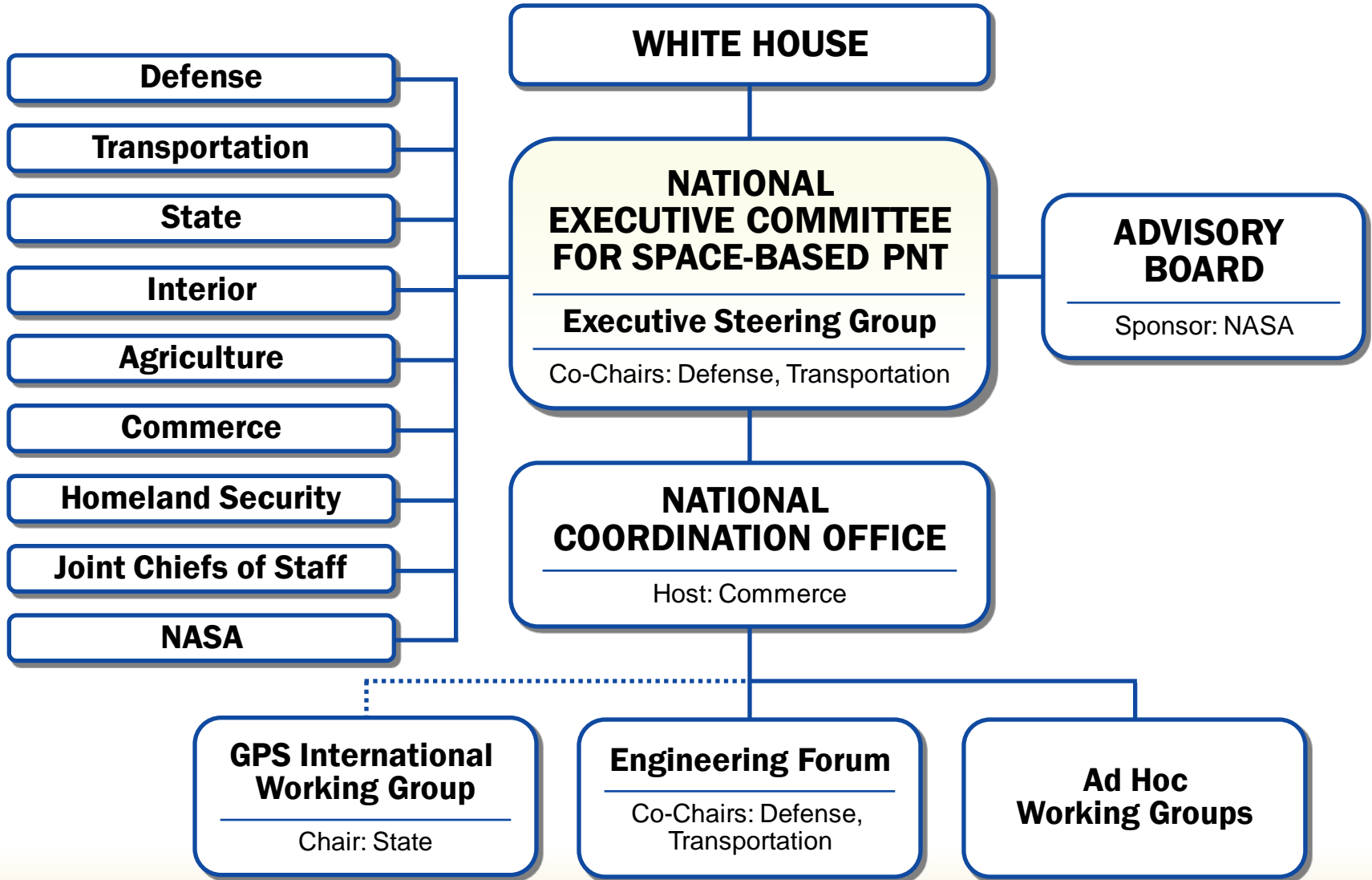
# *U.S. National Space Policy*

## *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





# Planned Space-Based Positioning, Navigation and Timing (PNT) Systems

- **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)**





# China

- **U.S. and China concluded ITU operator-to-operator coordination on GPS-Beidou/COMPASS signal compatibility in September 2010**
- **The U.S. has on-going bilateral discussions with the China Satellite Navigation Office on margins of multilateral international meetings**
- **China has successfully launched five satellites for Beidou this year in an effort to eventually weave a constellation of 35 satellites by 2020**
- **So far, the Beidou/COMPASS system has a total of 15 satellites, five in geostationary orbit, five in inclined geostationary orbit and five in medium Earth orbit, according to the management office. A 16<sup>th</sup> satellite is expected to be launched by the end of October 2012**
- **China is developing the “Xihe” system to pinpoint positions within 0.1 meters in outdoor areas and 3 meters in indoor areas. The Xihe system is designed to enhance the accuracy of space based navigation systems such as GPS and Beidou/COMPASS**
- **China plans to develop an urban positioning system, first in large cities such as Shanghai, and then across the country by the end of the 12th Five Year Plan in 2015**



# *Europe*

- **GPS-Galileo Cooperation Agreement signed in 2004, ratified by EU in December 2011**
  - Four working groups established under Agreement
- **ITU coordination meetings held in September and December 2011**
  - Focused on GPS III, WAAS, EGNOS
- **Working Groups met in June 2012 to further cooperation activities**
- **Second Plenary held in June 2012 in Washington, D.C.**
- **Europe launched two In-Orbit-Validation (IOV) satellites in October 2012 – now has four IOV satellites in orbit**
- **EU plans for about 26 Galileo satellites in orbit by late 2015**



# *India*

- **Joint Statement on GNSS cooperation signed 2007**
- **Third U.S.-India Joint Working Group on Civil Space Cooperation held July 2011**
- **Parties agreed to resume work on interoperability between GPS and India's GPS Aided Geo Augmented Navigation (GAGAN) system and Indian Regional Navigational Satellite System (IRNSS)**
- **India recently launched its second GAGAN equipped satellite using an Ariane-5 launcher from Kourou**
- **NASA & ISRO each expressed interest and acknowledged mutual benefit in establishing a core GNSS remote sensing observatory in India**
- **NASA provided overview of core observatory requirements**



# *Japan*

- **Japan plans four Quasi-Zenith Satellite System (QZSS) satellites by the late 2010s and up to seven total satellites for an eventual regional system in the 2020s**
- **Joint Statement on GPS cooperation signed in 1998**
- **Cooperation focuses on compatibility and interoperability between GPS and Japan's QZSS**
- **Bilateral agreements for QZSS monitoring stations in Hawaii and Guam**
- **Annual Plenary meeting held in Washington, D.C., in January 2012**
  - **GPS-QZSS Technical Working Group completed, released report on current activities**
  - **New consultations to coordinate noise floor issues between GPS and planned expanded QZSS**





# *Russia*

- **Russia recently repopulated its GLONASS system and has 24 satellites in orbit available for users**
- **GPS-GLONASS discussions ongoing since 1996**
- **Joint Statement issued December 2004**
- **Working Group 1 met in June 2011 to discuss Russian augmentation system (SDCM), assignment of PRN codes, and GLONASS CDMA signal plans**
- **Working Group 2 met October 2011 to discuss joint search and rescue capabilities**
- **Joint Statements signed in September 2011 and June 2012 reaffirming intent to continue cooperation**
- **Russia seeking GLONASS monitoring sites in U.S.: discussions ongoing**



# *International Committee on GNSS (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 should 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



# ICG-6 Outcomes

- 6th ICG meeting held in Tokyo, Sept 2011
- The development of **Multi-GNSS monitoring** networks was a major topic of discussion
  - The Committee endorsed the IGS Multi-GNSS Experiment
  - A Subgroup of the Working Group A has been formed to collectively investigate international GNSS monitoring and assessment
- The Compatibility sub-group of Working A 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
- **Interference Detection and Mitigation (IDM) Workshop** endorsed – Workshop held 7-8 June 2012

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



# *Active International Organizations*

- **United Nations Platform for Space-based Information for Disaster Management and Emergency Preparedness – [un-spider.org](http://un-spider.org)**
- **United Nations Office of Outer Space Affairs – [www.unoosa.org](http://www.unoosa.org)**
- **International Association of Geodesy (IAG)**
- **International GPS Service (IGS)**
- **African Reference System (AFREF)**

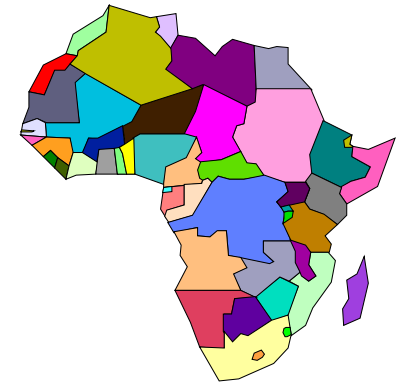


# Realizing a Continental Reference System for Africa

## AFREF

***Communication and internet*** are critical to success & sustainability of GNSS infrastructure

- access to information, global data, products, and technology advances
- increase knowledge base, capacity building



Training, education, access to resources, retention of quality personnel and stability are issues

Collective approach within African nations

- each adopting similar methodologies and technology
- permits progress where practical, implementing a network of GPS stations
- support and training envisioned by IGS/ITRF - seeking resources



# ***AFREF - African Reference System***

- Establish a ***continental reference*** system – with sustainable technology
- Provides the geodetic infrastructure for development throughout Africa
- Key to modernizing national reference systems through satellite and space geodesy: GPS, SLR, GLONASS, future GNSS (Galileo)
  - Three dimensions, horizontal and vertical, and velocities
- Includes gravity measurements as an essential component
- IGS/ITRF methodology at global and regional scales: EUREF (European), SIRGAS (South America) examples of approach and realization



# International Terrestrial Reference Frame (ITRF)

- ITRF is one of the key activities of the International Earth Rotation and Reference System (IERS) an International Association of Geodesy (IAG) Service
- ITRF is defined by combination of technique observations, analysis and products
- Website available, please visit
  - <http://www.ensg.ign.fr/ITRF/>
- ITRF expresses strong support for AFREF
  - Notes the need to integrate existing permanent GPS stations into the International GNSS Service (IGS) Network, the backbone of AFREF





# Summary

- U.S. policy encourages **worldwide use of civil GPS and augmentations**
- **International cooperation** at all levels is a priority
- **Compatibility, interoperability, and transparency** in open service provision are critical

The screenshot shows the GPS.gov website with a navigation bar including links for HOME, WHAT'S NEW, SYSTEMS, APPLICATIONS, POLICY & FUNDING, MULTIMEDIA, and SUPPORT. A search bar is located in the top right corner. The main content area features a large banner with the text "Bienvenidos Welcome أهلاً وسهلاً Bienvenue 歡迎光臨" and an image of people holding hands around a globe. Below the banner, there is a section for "Multilingual Content" with links for Español, Français, and 中文. The 中文 section includes links for "首页", "全球定位系统", "GPS的增强系统", and "GPS的应用". To the right, there is a section for "GPS Cooperation with Other Nations" listing countries like Australia, China, Europe, India, Japan, Russia, and the International Committee on GNSS. Below this, there are images of "GPS Outreach Handouts" and a section for "International GPS User Support" featuring the U.S. Coast Guard Navigation Center (NAVCEN) logo and text explaining its role in providing GPS user support to civilians outside the United States.

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



***THANK YOU!***

***Ray E. Clore***

***Office of Space and Advanced Technology***

***U.S. Department of State***

***OES/SAT, SA-23, Suite 410***

***Washington, D.C. 20520***

**<http://www.state.gov/e/oes/sat/>**