U.S. Space-Based PNT International Cooperation and Support in Africa

Satellite Navigation Science and Technology

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U.S. Space-Based Position, Navigation and Timing (PNT) Policy
(Excerpts focused on International Relations)

Goals:

- U.S. space-based PNT systems and services remain essential components of internationally accepted PNT services
- Promote U.S. technological leadership in applications involving space-based PNT services

To achieve this, the United States Government shall:

- Encourage foreign development of PNT services/systems based on GPS
  - Seek to ensure foreign space-based PNT systems are interoperable with civil GPS and augmentations
  - At a minimum, ensure compatibility

The Secretary of State shall:

- Promote the use of civil aspects of GPS and its augmentation services and standards with foreign governments and other international organizations
- Lead negotiations with foreign governments and international organizations regarding civil PNT matters

Planned Global Navigation Satellite Systems (GNSS)

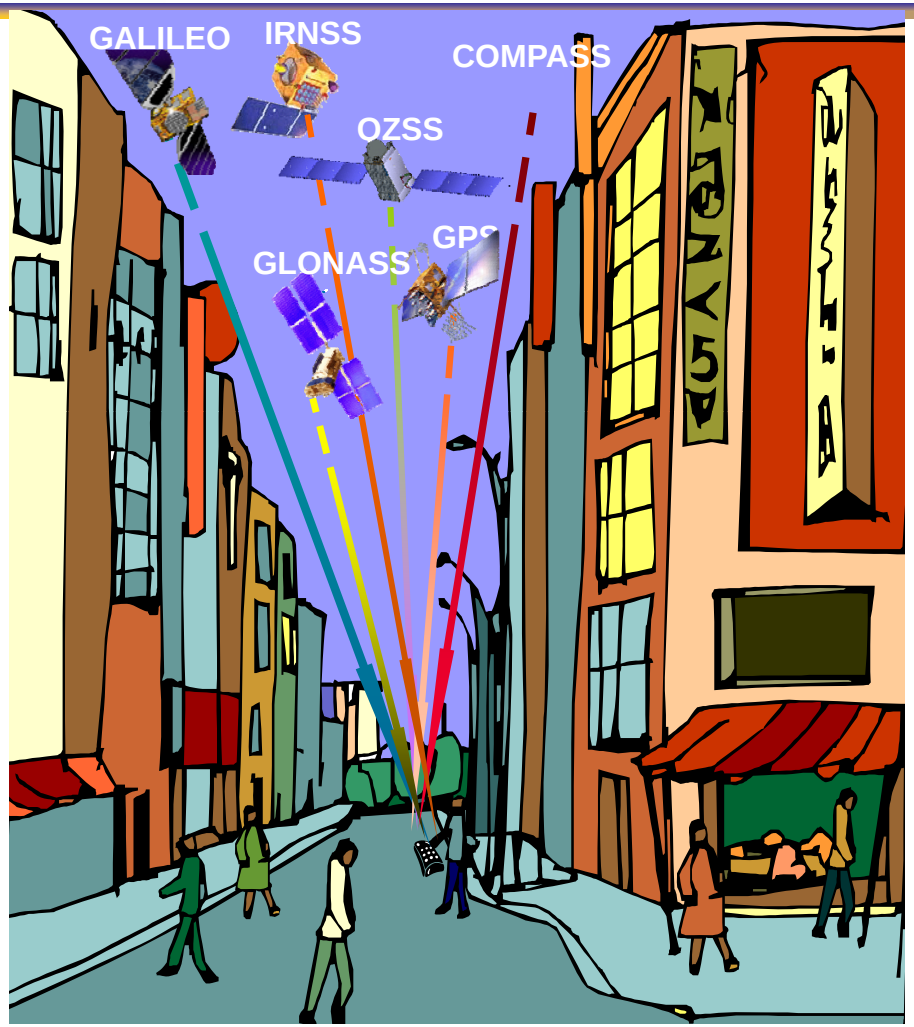
- Global Constellations
  - GPS (24+)
  - GLONASS (30)
  - Galileo (27)
  - Compass (38)
- Regional Constellations
  - QZSS (3)
  - IRNSS (7)
- Satellite-Based Augmentations
  - WAAS (3)
  - MSAS (2)
  - EGNOS (3)
  - GAGAN (3)
  - SDCM (2?)

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
- Ensure a level playing field in the global marketplace

Pursue through Bi-lateral and Multi-lateral Cooperation

The Goal of RNSS Civil 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

U.S. - Europe Cooperation

- 2004 U.S.-EU agreement provides foundation for cooperation
- Four working groups were set up under the agreement:
  - Technical, trade, future system, and security issues
- Improved new civil signal (MBOC) adopted in July 2007
- First Plenary Meeting successfully held in October 2008

Oct. 22, 2008 , EU-U.S. Plenary delegations meeting under the auspices of the GPS-Galileo Cooperation Agreement

Signing ceremony for GPS-Galileo Cooperation Joint Statement, Oct. 23, 2008
(Michel Bosco, European Commission;
Kenneth Hodgkins, U.S. Department of State)

U.S. - Japan Cooperation

- Japan's status as a world leader in GPS applications and user equipment makes it an important partner
- Regular policy consultations and technical meetings on GPS cooperation began in 1996 and led to the 1998 Clinton-Obuchi Joint Statement
- Both countries have benefited from the close relationship:
  - QZSS is designed to be totally compatible and highly interoperable with GPS
  - U.S. and Japan's Satellite-Based Augmentation Systems, WAAS & MSAS are highly interoperable and based on GPS
  - U.S. working with Japan to set up QZSS monitoring stations in Hawaii and Guam

U.S. - Russian Federation Cooperation

- U.S.- Russia Joint Statement issued in December 2004
- Negotiations for a U.S.-Russia Agreement on satellite navigation cooperation have been underway since late 2005
- Several very productive technical working group meetings have been held:
  - Active exchange of information regarding future designs
  - GLONASS signal architecture still under discussion with the Russian Government

U.S. - India Cooperation

- Policy and technical consultations on GPS cooperation underway since 2005
  - One aim is to ensure interoperability between the Wide-Area Augmentation System (WAAS) and India's planned GAGAN augmentation system, both based on GPS
  - Another important topic is ionospheric distortion and solutions to this phenomena
- U.S.-India Joint Statement on GNSS Cooperation issued in February 2007 in Washington
  - Bi-lateral meeting held in Bangalore in September 2007
  - Technical Meeting focused on GPS-IRNSS compatibility and interoperability held in 2008 and 2009

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

International Committee on Global Navigation Satellite Systems (ICG)

- ICG-3 held in Dec. 2008 in Pasadena, Cal.
- Providers Forum updated definitions of interoperability and compatibility
- Began implementation of the ICG Work Plan within established working groups:
  - A. Interoperability and compatibility
  - B. Enhancement of performance of GNSS services
  - C. Information dissemination, education, outreach & coordination
  - D. Interaction with monitoring & reference station network organizations, e.g. Geodetic Reference Frames including AFREF
- Russia will host the 4th ICG in St. Petersburg in Sept. 2009 and Italy will host ICG-5 in Dec. 2010

ICG-4 WG-D Recommendations

- Establish a task force on geodetic references
- Establish a task force on time references
- Alignment of geodetic references and synchronization of time reference to international standard
- Consider installing retroreflectors for laser ranging to GNSS satellites

ICG Providers Forum

- Six space segment providers: U.S., EU, Russia, China, India, Japan are members
- Purpose:
  - Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
  - Exchange of detailed information on systems & service provision plans
  - Exchange views on ICG work plan and activities
- Consensus reached at the first meeting on general definitions for compatibility and interoperability
  - Including spectral separation between each system's authorized service signals and other systems' signals

http://www.unoosa.org/oosa/en/SAP/gnss/icg.html

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) has focused on air traffic control and aviation issues
  - The group now seeks to broaden its focus to the application of GNSS in all transportation sectors
  - Additional participation of GNSS government and industry experts is encouraged
  - Next GIT-13 meeting will be held in Singapore in conjunction with the Transportation Work Group

AFREF Background

- Effective use of GNSS applications requires geo-spatial information that based on a uniform & reliable co-ordinate reference frame
- Over 50 countries each with their own system and frame and some with 2 or more systems
- Many private commercial enterprises are setting up own reference frames, e.g. in the oil industry
- AFREF is an initiative to unify African reference frames based on the ITRF through a network of GPS base stations spaced such that users will be less than 1000 km from a base station

AFREF Objectives

- To establish a continental ref. system for Africa
- To establish permanent GNSS base stations so any user will be within 1000 km of at least one base station and from which data are freely available to all users
- To realize a unified vertical datum and to establish a precise African geoid
- To determine the relationship between the existing national reference frames and the ITRF to preserve legacy information
- To provide a sustainable development environment for technology transfer

Usage for GNSS in Africa

- Surveying
- Mapping
- Security-unique international boundary definition
- Science- Atmospheric and Geophysics research
- Disaster mitigation
  - 59% of disasters are hydro-meteorological in nature- drought and flooding (climate monitoring & weather prediction)
- Infrastructure planning & development

GNSS network in '05

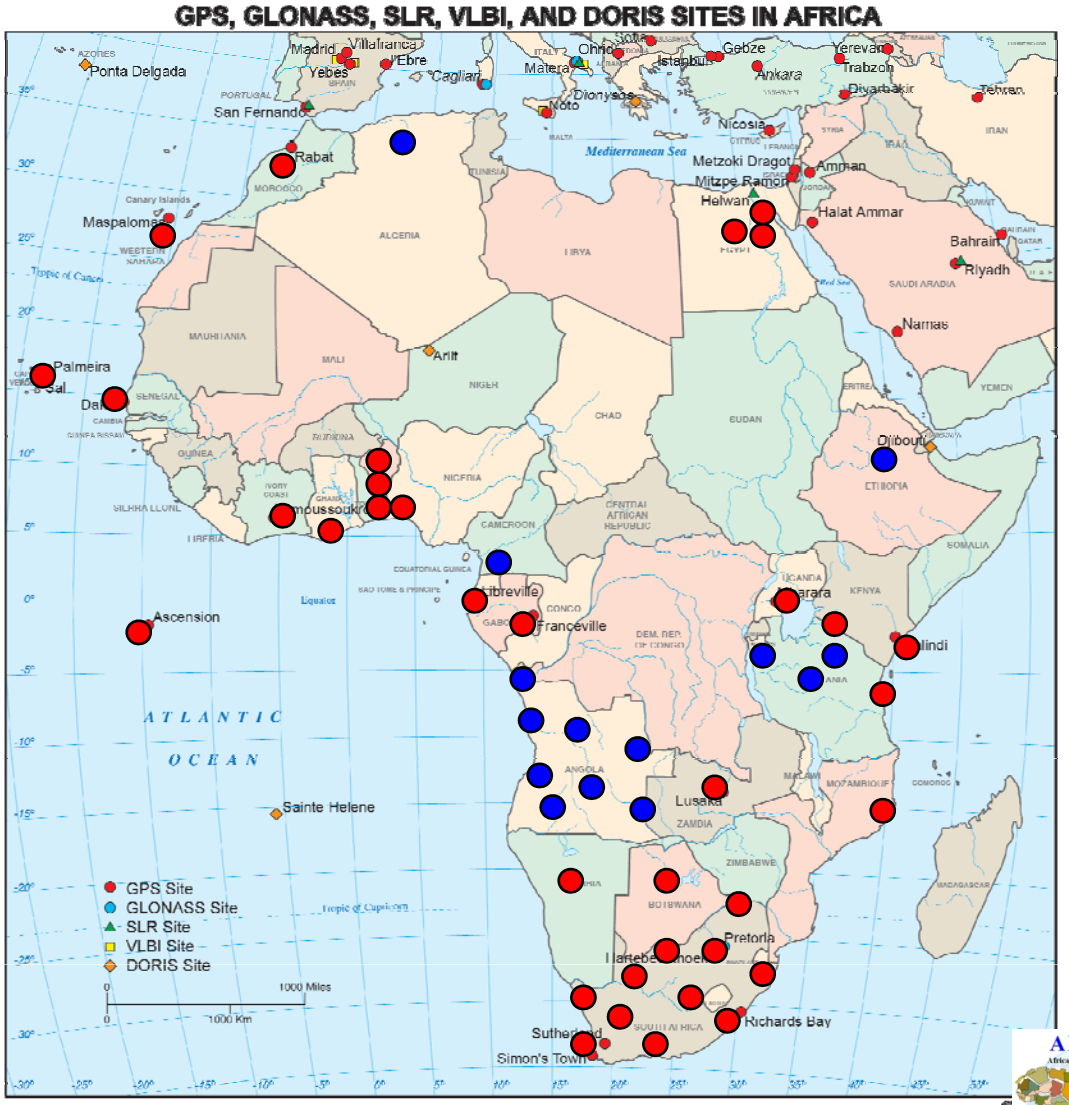
Installed and operational IGS stations ~2005

GNSS network '07

planned GNNS station Sept 2007

(Not all stations shown for clarity)

- **Installed**
- **Planned**



Who Endorses AFREF?

- Organizations accepted/supported AFREF:
  - African Union (AU)
  - UN ECA CODI (Committee on Development Information)
  - UN OOSA (UN Office for Outer Space Affairs)
  - IAG (International Association of Geodesy)
  - IGS (International GNSS Service)
  - FIG (International Federation of Surveyors)
  - UNAVCO (University NAVSTAR Consortium Incorporated)
  - NEPAD (New Partnership for Africa's Development)

U.S. Supports AFREF Development

- AFREF is an African initiative
- ICG WG-D addresses references frame including AFREF
- In 2008 through UNOOSA/ICG, State/OES facilitated the travel of twenty Africans to AFREF workshop at the AfricanArray Conf. held at University of Witswatersrand, Johannesburg, RSA
- U.S. would continue to support the AFREF development through AfricaArray, the UNOOSA and other existing international initiatives

Summary

- **International cooperation** in the context of U.S. Space-Based PNT Policy principles is a **top priority** for the U.S. Government
- The U.S. is actively engaged in bi-lateral, regional, and multi-lateral cooperation on satellite navigation issues-compatibility and interoperability
- U.S. supports the development of AFREF and the use of GNSS technologies/applications
- AFREF is gaining momentum but needs international support

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