



**SPACE-BASED POSITIONING
NAVIGATION & TIMING**

NATIONAL COORDINATION OFFICE

GPS and Worldwide GNSS Interoperability

**Disaster Management and
Other Societal Benefits**

**USTTI Seminar
November 2, 2010**

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National Space-Based PNT Coordination Office**

GPS is Essential to Our Economies and National Critical Infrastructures



Satellite Operation



Surveying & Mapping



Power Grids



Precision Agriculture



Transit Operations



NextGen



Trucking & Shipping



IntelliDrive



Telecom



Disease Control



Personal Navigation



Oil Exploration



Fishing & Boating



Overview



- **U.S. Space-Based Positioning, Navigation and Timing (PNT) Policy**
- **International Cooperation Activities**
- **Applications and GNSS Augmentations**



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 augment and strengthen the resiliency of 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



2004 U.S. Space-Based 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:

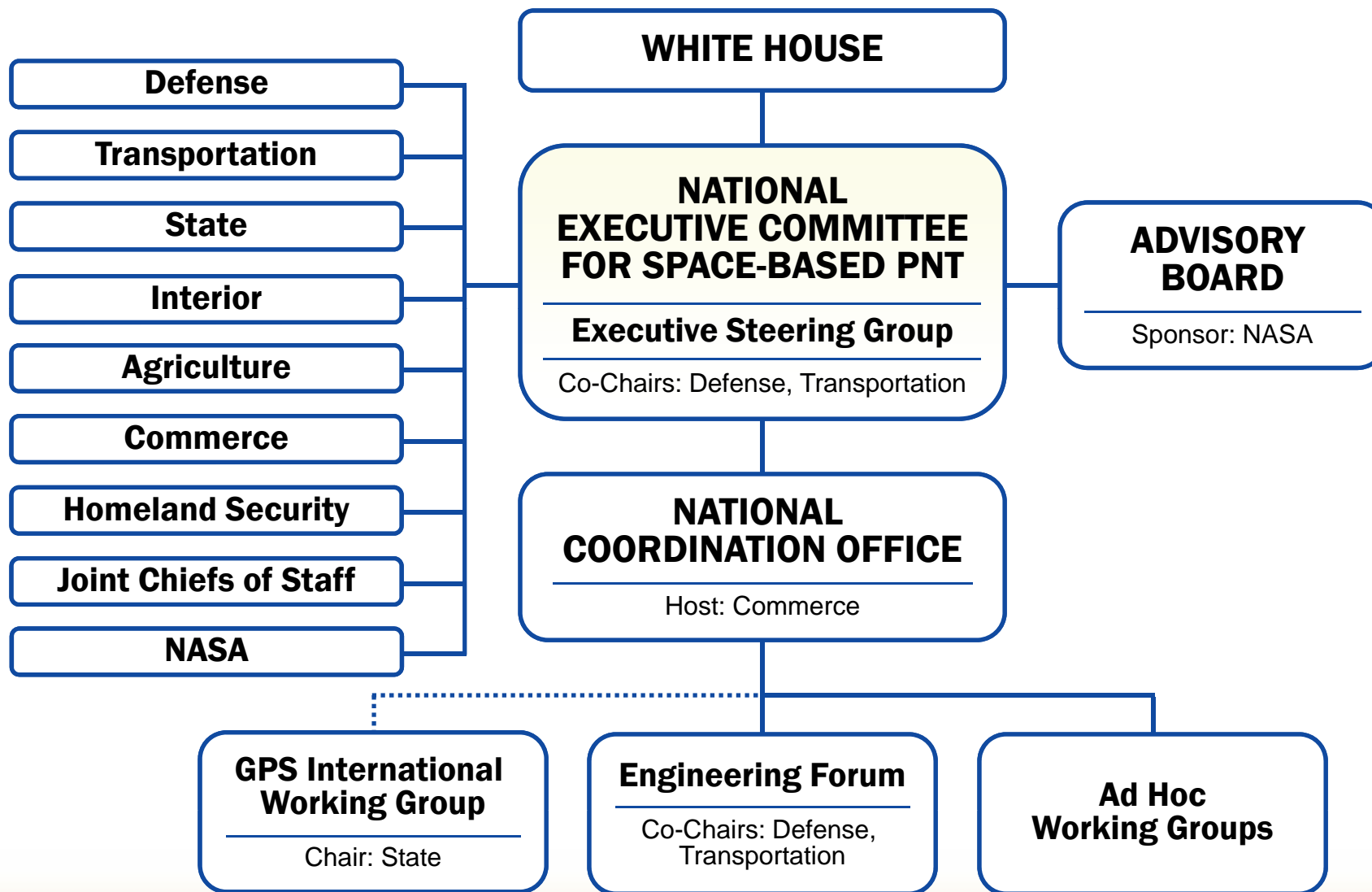
- Encourage foreign development of PNT services/systems based on GPS
 - Seek to ensure foreign space-based PNT systems are interoperable with civil GPS and augmentations
 - At a minimum, ensure compatibility

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
 - And, as appropriate in coordination with the SECDEF, military PNT matters



U.S. Space-Based PNT Organization Structure





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 Bi-lateral and Multi-lateral Cooperation



Planned GNSS

- **Global Constellations**
 - GPS (24+)
 - GLONASS (24)
 - Galileo (27)
 - Compass (35)
- **Regional Constellations**
 - QZSS (3)
 - IRNSS (7)
- **Satellite-Based Augmentations**
 - WAAS (3)
 - MSAS (2)
 - EGNOS (3)
 - GAGAN (3)
 - SDCM (2?)



GPS Constellation Status

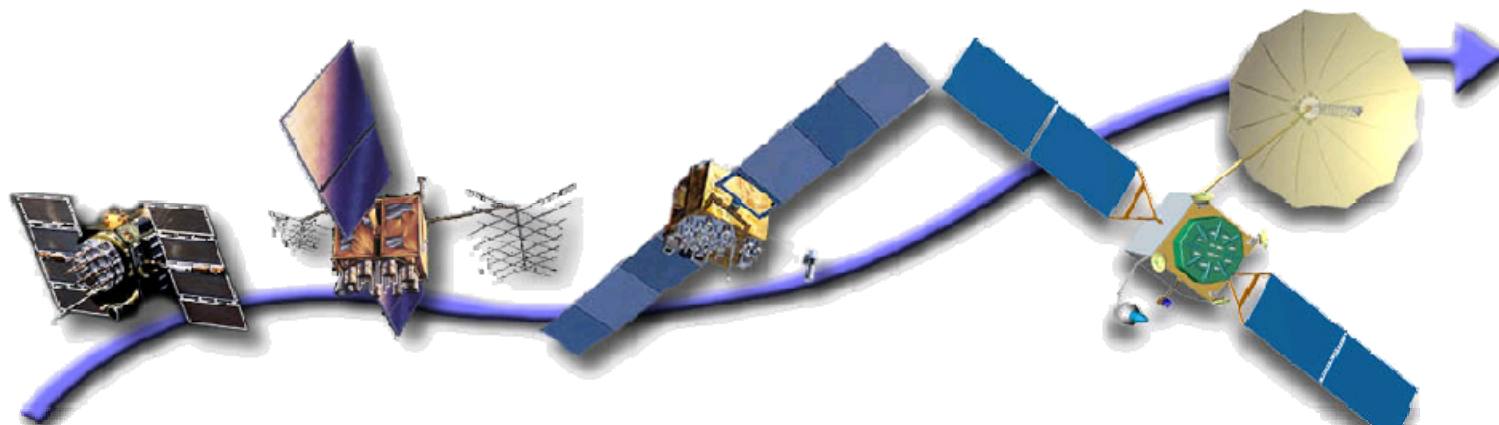
***31 Operational Satellites
(Baseline Constellation: 24)***

- **11 Block IIA**
- **12 Block IIR**
- **7 Block IIR-M**
 - Transmitting new second civil signal
- **1 GPS IIR-M in on-orbit testing**
- **1 Block IIF launched May 27th, 2010**
 - First of 12 Block IIF satellites
- **3 additional satellites in residual status**
- **Global GPS civil service performance commitment met continuously since December 1993**





GPS Modernization Program



Increasing System Capabilities ♦ Increasing Defense / Civil Benefit

Block IIA/IIR

Basic GPS

- Standard Service
 - Single frequency (L1)
 - Coarse acquisition (C/A) code navigation
- Precise Service
 - Y-Code (L1Y & L2Y)
 - Y-Code navigation

Block IIR-M, IIF

IIR-M: IIA/IIR capabilities plus

- 2nd civil signal (L2C)
- M-Code (L1M & L2M)

IIF: IIR-M capability plus

- 3rd civil signal (L5)
- Anti-jam flex power

Block III

- Backward compatibility
- 4th civil signal (L1C)
- Increased accuracy
- Increased anti-jam power
- Assured availability
- Navigation surety
- Controlled integrity
- Increased security
- System survivability



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



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
 - Will be operational on 1st IIF
- Full capability: **24 satellites ~2018**





Overview



- **U.S. Space-Based Positioning, Navigation and Timing (PNT) Policy**
- **International Cooperation Activities**
- **Applications and GNSS Augmentations**



U.S. - Europe Cooperation



- U.S.-EU agreement signed in 2004 provides solid foundation for cooperation
- Action is now divided among four working groups set up by the agreement:
 - Technical, trade, and security issues working groups have met
- Improved new civil signal (MBOC) adopted in July 2007



June 26, 2004, press conference at U.S.-EU Summit in Ireland (U.S. Sec. of State Colin Powell, Irish Foreign Minister Brian Cowen, EU Vice-President Loyola De Palacio)



U.S. - Russian Federation Cooperation



- **U.S.- Russia Joint Statement issued in December 2004**
- **Several very productive technical working group meetings have been held:**
 - **Russia WG-1 chair proposed adopting two new civil CDMA signals at L1, L5 to be interoperable with GPS**
 - **Still under discussion within the Russian Government**
- **Negotiations for a U.S.-Russia Agreement on satellite navigation cooperation have been underway since late 2005**



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 have been held since 1996 and led to the 1998 Clinton-Obuchi Joint Statement**
- **Both countries have benefited from the close relationship:**
 - **QZSS is designed to be compatible and interoperable with GPS**
 - **U.S. and Japan set up QZSS monitoring stations in Hawaii and Guam**



U.S. - India Cooperation



- **Policy and technical consultations on GPS cooperation underway since 2005**
 - One aim is to ensure interoperability between GPS augmentation system WAAS and India's planned GAGAN augmentation system based on GPS
 - Another important topic is ionospheric distortion and solutions
- **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 January 2008



U.S. - Australia Cooperation



- **Long history of GPS cooperation between U.S. and Australia**
- **U.S.-Australia Joint Delegation Statement on Cooperation in the Civil Use of GPS signed April 19, 2007**
 - **The U.S. and Australia will work closely together to facilitate broad and effective use of GNSS augmentation systems that may be considered for use as civil regional augmentations to the GPS.**
- **U.S. Coast Guard NAVCEN posts a daily Position Dilution of Precision (PDOP) report in response to Australia's concerns over planned GPS outages**



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-2 held in September, 2007, in Bangalore, India**
- **Established Providers Forum to address common issues**
- **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**
- **Recent meeting in October 2010, Turin Italy**



ICG Providers Forum



- **Six space segment providers listed previously are members**
- **Purpose:**
 - Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
 - Exchange of detailed information on systems and 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

www.icgsecretariat.org



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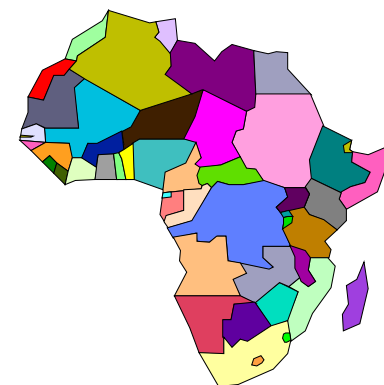
Realizing a Continental Reference System for Africa



AFREF

Roles:

- International Association of Geodesy
- International GPS Service
- UN-Office of Outer Space Affairs





Overview



- **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



AFREF - Rationale

- **Communication and internet are critical to success and 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



International Terrestrial Reference Frame



- 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



UN-00SA GNSS Action Team



- **Charter for the Action Team on Global Navigations Satellite Systems:**

“Using space applications for human security, development and welfare, action should be taken ... to improve the efficiency and security of transport, search and rescue, geodesy, and other activities by promoting the enhancement of universal access to and compatibility of space-based navigation and positioning systems.”

- **In parallel, Regional Workshops on GNSS organized under UN auspices**
 - AFREF concepts addressed, great venue for discussion and planning
 - Report available from UN-00SA:
<http://www.oosa.unvienna.org/SAP/gnss/index.html>



International Association of Geodesy



- **Three pillars of modern geodesy**
 - geometric shape of the Earth
 - Earth's gravity field, and
 - orientation of the Earth in space
- **AFREF initiative has strong support of the IAG Executive Committee**
- **IAG is a mechanism to engage and support AFREF**
 - **Commission 1, Reference Frames (Prof. Herman Drewes)**
 - Sub-commission 1.3, Regional Reference Frames (Zuheir Altamimi)
 - Sub-commission 1.3d Africa (Richard Wonnacott)
- **IAG new project the Global Geodetic Observing System (GGOS)**
 - **Focuses on importance of long term geodetic measurements as integral component of Earth system science**
 - <http://www.iag-aig.org/>



International GPS Service



- IGS was established in 1994, now known as International GNSS Service.
- Mission:
 - ‘... committed to providing the highest quality data and products as the standard for global navigation satellite systems (GNSS) in support of Earth science research, multidisciplinary applications, and education. ... as well as to facilitate other applications benefiting society....’
- 200 organizations, 80+ countries, and a 350+ ground tracking network of both GPS and Galileo receivers
- Most precise GPS/GLONASS data and products available anywhere, orbits, clocks, station positions
- IGS contributions to ITRF enable densification, while further allowing users ready access to the ITRF
 - See IGS Website: <http://igscb.jpl.nasa.gov/>



IGS and IAG Support AFREF



- The economics of GPS make the measurement technology readily available and globally accessible to all users
- The organization and outreach of the IGS enables users to take advantage of data, systems, and products developed cooperatively with the top international GPS/GNSS experts
- Standards are developed and adopted worldwide through the IGS activities
 - contributing to robust, homogenous reference system
 - implementing common processes
- IGS is a supporting global foundation for nearly all regional and national GPS and GLONASS geodetic networks, projects, and numerous applications worldwide
- Must ensure appropriate evolution, coordination, and interoperation of multiple GNSS systems for *societal and scientific benefit*
- IGS has long term commitment to AFREF
 - AFREF is for Africa, must be an African led project
 - Success is a long term effort
 - Count on strong partnership with IGS



AFREF



- **AFREF has great promise and tremendous potential**
- **Excellent time to move forward**
- **Cooperation is implicit within Africa and internationally**
- **Regional structures with an agreed to continental agenda will ensure progress**
- **International organizations described in this presentation are strong partners and will work to assist wherever possible**



Application – Disaster Management



- **Communication**
 - Staff Safety/Security
 - Humanitarian Operations
 - Monitoring/Evaluation
- **Navigation**
 - Staff Safety/Security
 - Humanitarian Operations
 - Monitoring/Evaluation
- **Information Management**
 - Geographic Element
 - Location of Displaced Persons/Field Hospitals
- **Mapping**



Asia Pacific Economic Cooperation



- **Promote implementation of regional GNSS augmentation systems to enhance inter-modal transportation and recommend actions to be considered in the Asia Pacific Region**
- **APEC GNSS Implementation Team Reports to Transportation Working Group (TPT-WG) through the Inter-modal Experts Group (IEG)**
- **APEC Task Force on Emergency Response has an active schedule within APEC**



Websites

- African Geodetic Reference Frame
<http://geoinfo.uneca.org/afref/>
- U.S. National Space-Based PNT Coordination Office
<http://www.pnt.gov/>
- Asia Pacific Economic Cooperation
<http://www.apec.org.sg>
- International Committee On Global Navigation Satellite Systems
<http://www.icgsecretariat.org/>
- United Nations Platform for Space-based Information for Disaster Management and Emergency Response
<http://www.ungiwg.org/cgi-bin/mailman/listinfo/unspider>
- U.S. Coast Guard Navigation Center
<http://www.navcen.uscg.gov>
- GPS Applications
<http://www.gps.gov>
- USAID/OFDA
http://www.usaid.gov/our_work/humanitarian_assistance/disaster_assistance/



Summary



- **As new space-based GNSS are emerging globally, interoperability is the key to “success for all”**
- **Modernization of GPS will increase accuracy and reliability**
- **U.S. is actively engaged in bi-lateral, regional, and multi-lateral cooperation on space-based navigation issues**
- **International cooperation in the context of National Space-Based PNT Policy principles is a top priority for the U.S. Government**



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Motion of African Plate

