International Developments in Global Navigation Satellite Systems (GNSS)

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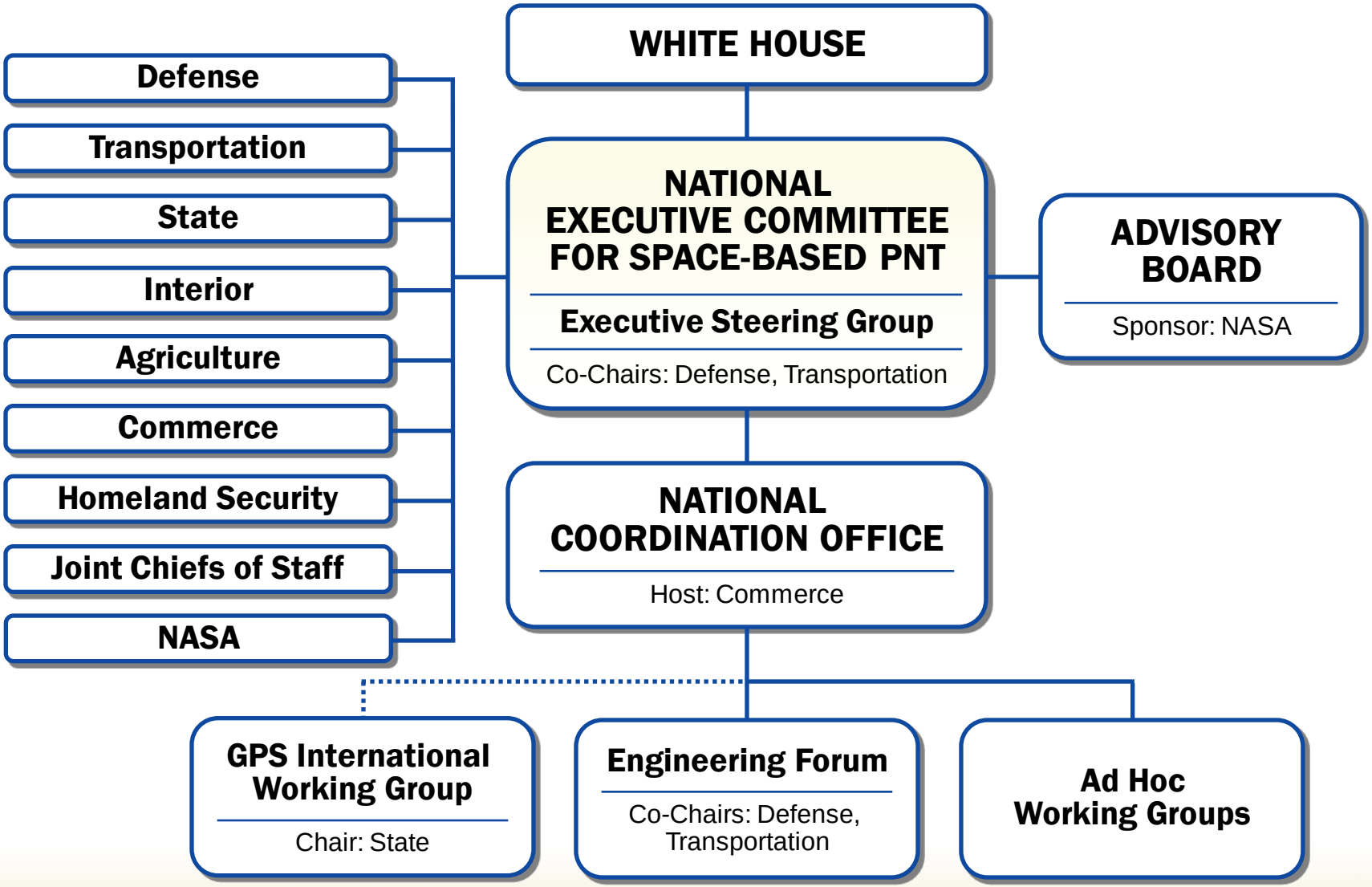
U.S. National Space Policy

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

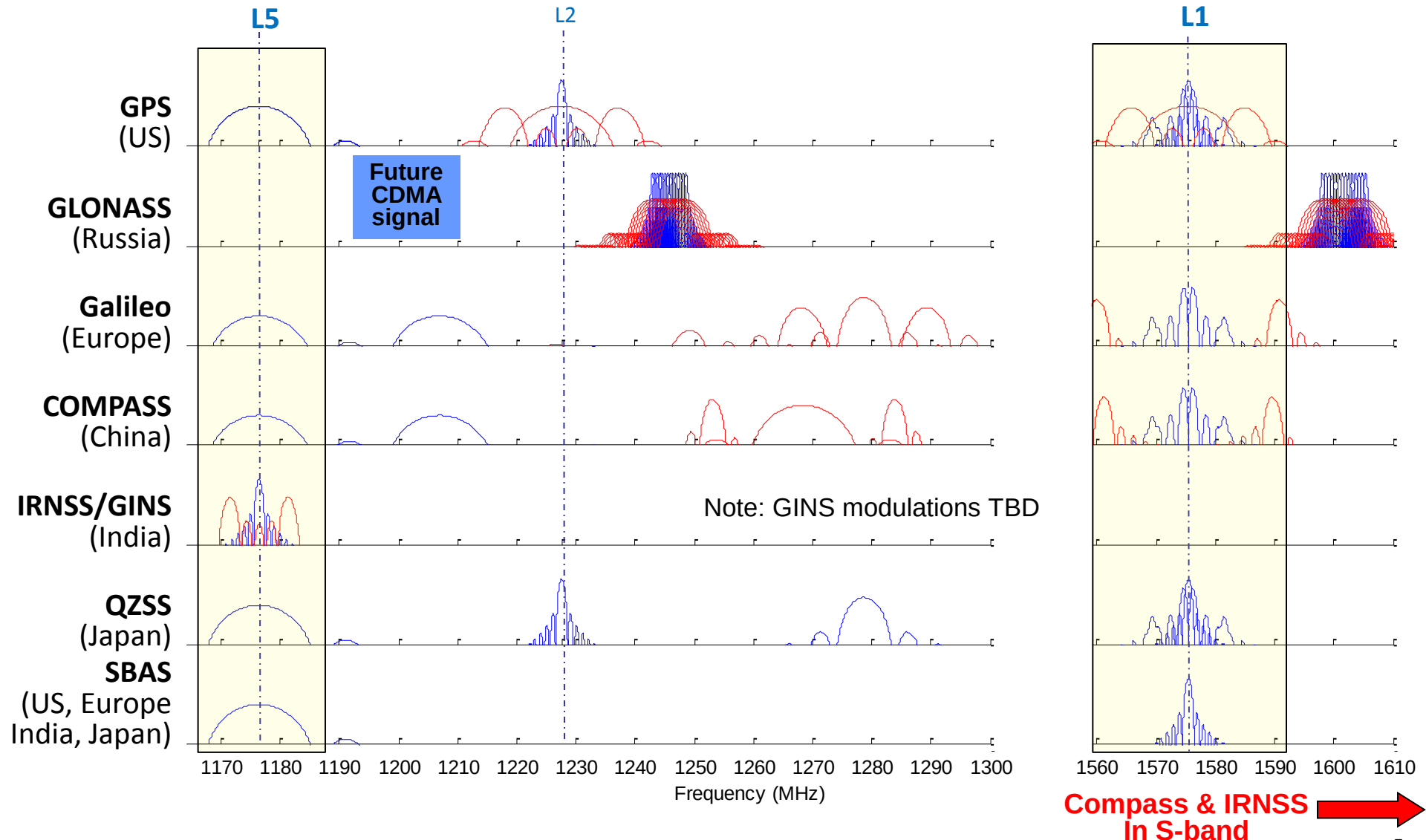


Planned Space-Based Positioning, Navigation and Timing (PNT) Systems

- Global Constellations
  - GPS (24+)
  - GLONASS (24+)
  - 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)

Current International Signal Plans



China

- U.S. and China concluded ITU operator-to-operator coordination on GPS - 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 plans a global constellation of 35 satellites by 2020
- So far, the 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.
- 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 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 for last few years – next meeting scheduled for December 2013
  - Focused on GPS III, WAAS, EGNOS
- Working Groups met in June 2012 to further cooperation activities – Working Groups A and C most active
- Second Plenary held in June 2012 in Washington, D.C. Next plenary scheduled for summer 2014 in Europe
- Four IOV satellites in orbit – some launch delays
- EU plans for about 26 Galileo satellites in orbit by late 2015

India

- Joint Statement on GNSS cooperation signed 2007
- Fourth U.S.-India Joint Working Group on Civil Space Cooperation held in March 2013 in Washington, D.C.
- Agreement was reached on measures to ensure the compatibility of the U.S. Global Positioning System (GPS) and its Indian counterpart GNSS program (IRNSS)
- Second GAGAN equipped satellite in orbit - launched by Ariane-5 from Kourou
- NASA & ISRO have expressed interest and acknowledged mutual benefit in establishing a core GNSS remote sensing observatory in India

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
- 10th Plenary meeting held in Tokyo in July 2013
- New consultations to coordinate noise floor issues between GPS and planned expanded QZSS
- Current discussion about planned Indoor Messaging Service (IMES) and possibility to interfere with GPS

Russia

- Russia recently repopulated its GLONASS system and has 24 satellites (plus three spares) in orbit available for users
- GPS-GLONASS discussions ongoing since 1996
- Joint Statement issued December 2004
- Continuing discussions on next generation search and rescue capabilities building on COSPAS-SARSAT system
- Joint Statements signed in September 2011 and June 2012 reaffirmed intent to continue cooperation
- Russia seeking GLONASS civil 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-7 (China Nov 2012) Outcomes

- Endorsement of two Workshops (Honolulu, HI, U.S. – April 2013)
  - Second Workshop on Interference Detection and Mitigation, following a successful first Workshop in June 2012
  - Interoperability Workshop focused on industry feedback regarding signal design and parameters
- Multi-GNSS monitoring: Tasks and a Work Plan for the ICG International GNSS Monitoring and Assessment (IGMA) Subgroup were approved
  - Identify what service parameters should be monitored
  - Define the level and methods for carrying out the monitoring
- ICG to adopt the International Terrestrial Reference System (ITRS) as the theoretical reference system for the alignment of GNSS terrestrial reference frames
- Consensus that achieving a fully interoperable GNSS space service volume would provide significant performance benefits that no single system could provide on its own

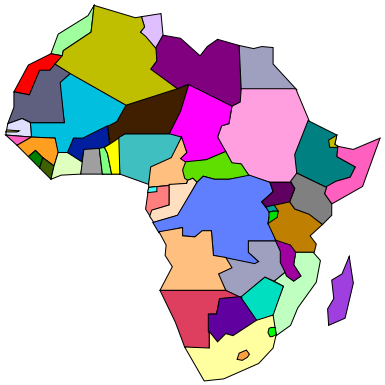
ICG-8 will be hosted by the UAE in Dubai, November 2013

Active International Organizations

- United Nations Platform for Space-based Information for Disaster Management and Emergency Preparedness – un-spider.org
- United Nations Office of Outer Space Affairs – 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

http://www.gps.gov/

THANK YOU!

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