U.S. Space-Based PNT International Cooperation

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Overview

- **U.S. Space -Based Positioning, Navigation and Timing (PNT) Policy**
- GPS Program Status
- U.S. International Diplomatic Activities

U.S. Space-Based PNT Policy

- Provide GPS and augmentations free of direct user fees on a continuous, worldwide basis
- Provide open, free access to information needed to develop equipment
- Continue to improve performance of GPS and augmentations
- Encourage **international development** of PNT systems based on GPS
- Seek to ensure **international systems** are interoperable with civil GPS and augmentations
- Address mutual security concerns with **international providers** to prevent hostile use

U.S. Policy Promotes Global Use of GPS/GNSS Technology

- No direct user fees for civil GPS services
  - Provided on a continuous, worldwide basis
- Open, public signal structures for all civil services
  - Promotes equal access for user equipment manufacturing, applications development, and value-added services
  - Encourages open, market-driven competition
- Protection of radionavigation spectrum from disruption and interference
- Service improvements for civil, commercial, and scientific users worldwide
- Global compatibility and interoperability with GPS

Private Sector Competition

- Competition in GNSS receiver/application markets leads to greater innovation, lower costs
- Fair competition means no preferential treatment for any particular companies
  - Equal (if not open) access to markets and information
- Freedom of choice desired for end users
  - Standards and other governmental measures should not effectively mandate use of one GNSS over another
- U.S. agreements with other GNSS providers include language on fair trade and open markets
  - Working Group "B" established under GPS-Galileo Agreement to discuss non-discriminatory approaches to trade in civil applications markets

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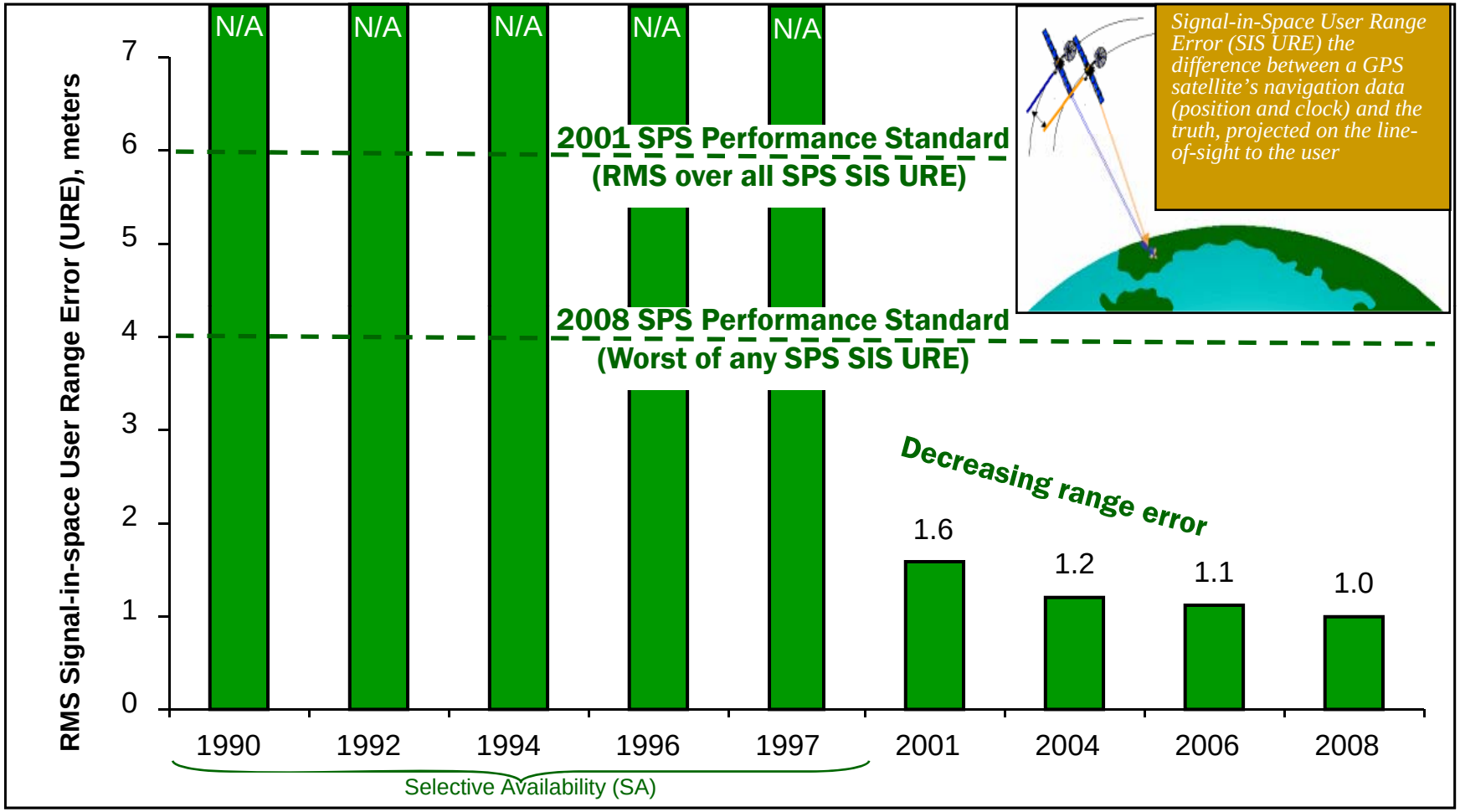
GPS Program Status

- 30 Operating (healthy) satellites on orbit as of May 1
  - GPS IIR(M): 7 Successful launches of modernized satellites
    - 2nd civil signal (L2C) and M-Code (L1M & L2M)
    - Latest satellite launched March 24 also brings 3rd civil signal into use
  - GPS IIF: Completed all functional/performance tests
    - 3rd civil signal (L5) and jam-resistant flex power
  - GPS IIIA: Awarded to Lockheed Martin Space Systems, May 08
    - 4th civil signal (L1C) and Selective Availability "no longer built-in"
- Operational Control Segment (OCS) upgraded, Sep 07
  - Alternate Master Control Station fully functional
- Next Generation Operational Control Segment (OCX)
  - Needed for GPS III satellites & full functionality of modernized signals
  - Awarded Phase A contracts to Northrop-Grumman and Raytheon, Nov 07

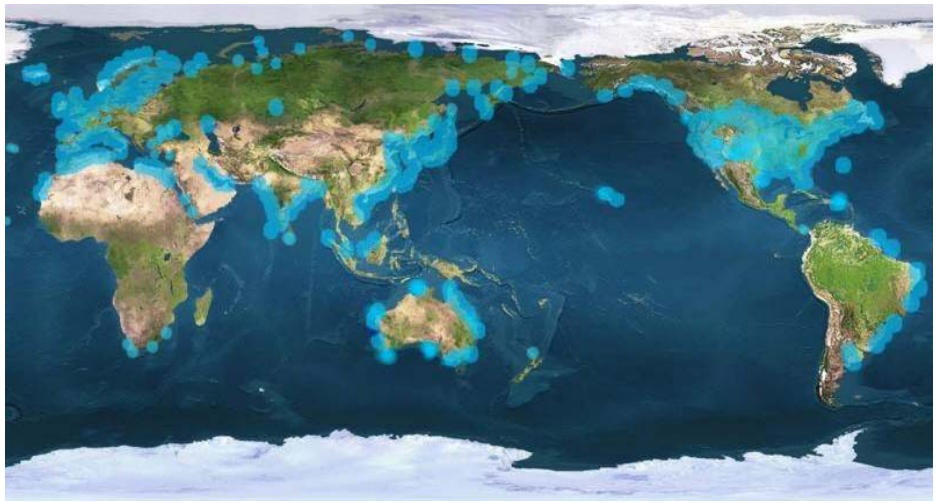
GPS Modernization: *System-wide improvements in accuracy, availability, integrity, reliability & robustness against interference*

SPS Signal in Space Performance

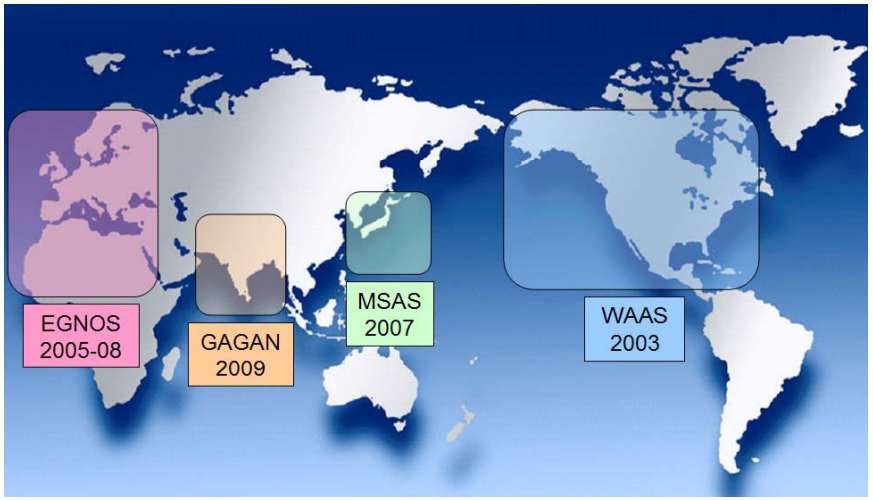


System accuracy exceeds published standard

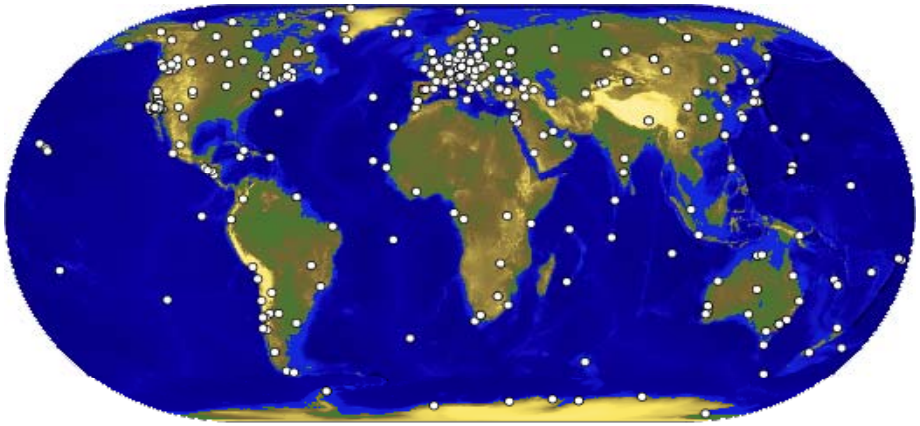
International Augmentations



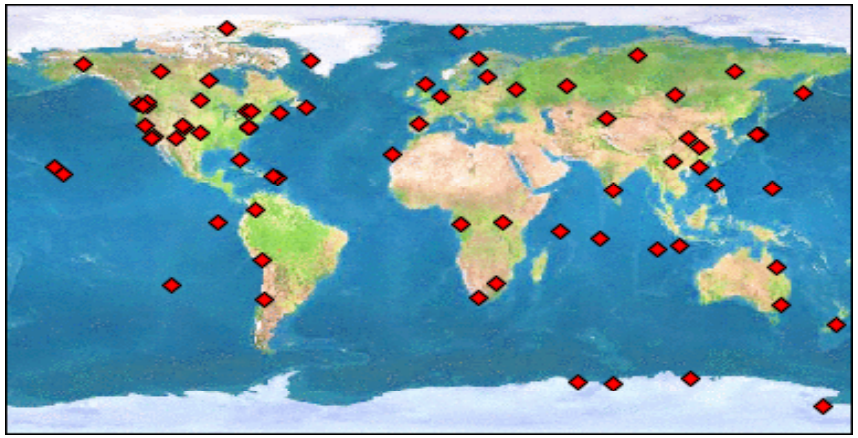
Differential GPS Networks



Space-Based Augmentation Systems



International GNSS Service



Global Differential GPS System

Overview

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- GPS Program Status
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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

Planned GNSS

- Global Constellations
  - **GPS (24)**
  - GLONASS (30)
  - Galileo (27)
  - Compass (30 global and 5 regional satellites)
- Regional Constellations
  - QZSS (3)
  - IRNSS (7)

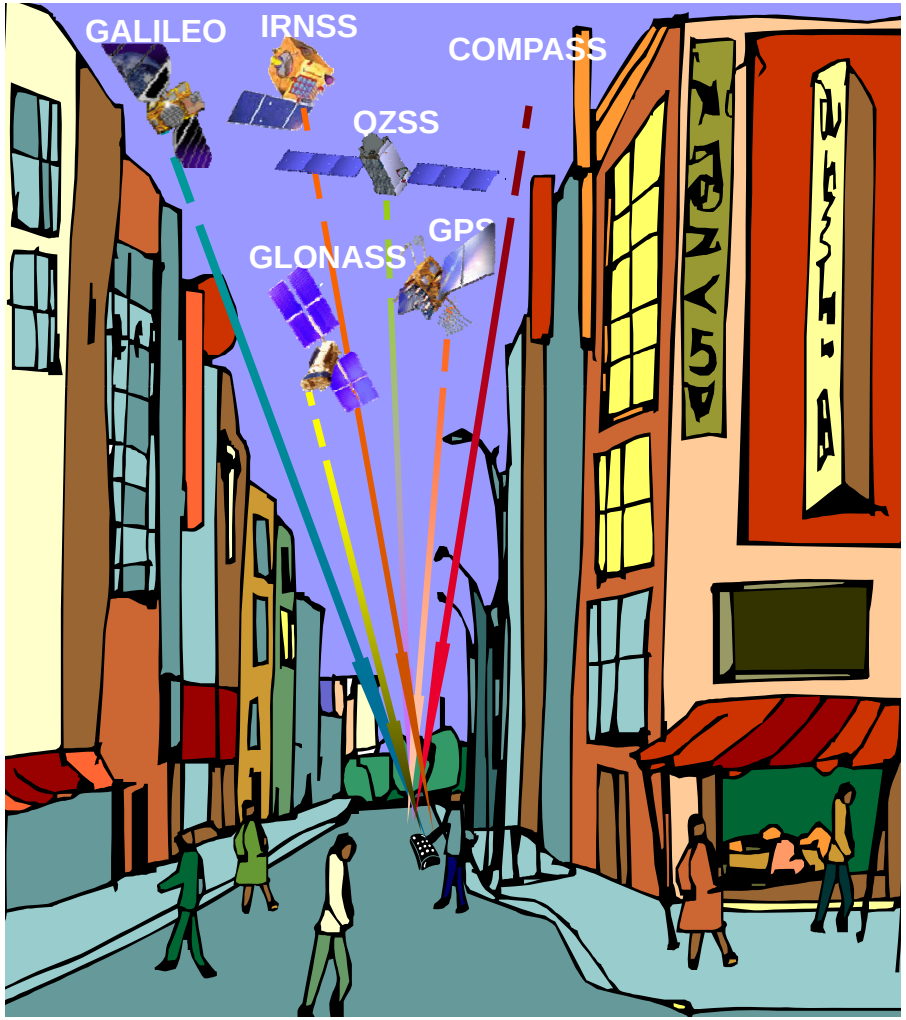
- Satellite-Based Augmentations
  - **WAAS (2+1)**
  - MSAS (2)
  - EGNOS (3)
  - GAGAN (2)
  - SDCM (2)

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

International Cooperation Venues

- Bilateral to include
  - Europe
  - Russia
  - Japan
  - India
  - Others
- Multilateral
  - International Committee on GNSS
  - Asia Pacific Economic Cooperation
  - ICAO, IMO, and ITU

U.S. - Europe Cooperation

- 2004 U.S.-EU agreement provides foundation for cooperation
- Four working groups were set up under the agreement:
  - Technical, trade, and security issues working groups have met
- 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)

Additional Bilateral Cooperation

- U.S.-Japan Joint Statement on GPS Cooperation in 1998
  - Japan is a global leader in applications and commercial GNSS markets
  - Japan's Quasi Zenith Satellite System (QZSS) designed to be fully compatible and highly interoperable with GPS
  - U.S. working with Japan to set up QZSS monitoring stations in Hawaii and Guam in exchange for data access
- U.S.-Russia Joint Statement issued in Dec 2004
  - Negotiations for a U.S.-Russia Agreement on satellite navigation cooperation underway since late 2005
  - Working Groups on compatibility/interoperability, search and rescue
- U.S.- India Joint Statement on GNSS Cooperation in 2007
  - Technical Meetings focused on GPS-India Regional Navigation Satellite System (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

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

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 must 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 -3 – December 2008, Pasadena

- Progress on implementing ICG Work Plan within established working groups:

  A. Compatibility and Interoperability

  - Plans established for two workshops on interoperability to be held before ICG-4

  C. Information dissemination, education, outreach & coordination

  - Regional UN Centres for Space, Science and Technology Education will act as ICG Information Centers
  - ICG and UNOOSA to support regional workshops

  D. Interaction with monitoring & reference station network organizations

  - Task Forces on Geodetic References & Time References established

ICG-4 and 3rd Providers Forum to meet Sep. 14-18, 2009, in St. Petersburg, Russia

Summary

- **International cooperation** in the context of National Space Policy and Space-Based PNT Policy is a **top priority** for the U.S. Government
- The U.S. is actively engaged in **bi-lateral, and multi-lateral cooperation** on satellite navigation issues
- As new regional and global navigation satellite systems are emerging, **interoperability** is the key to **"success for all"**

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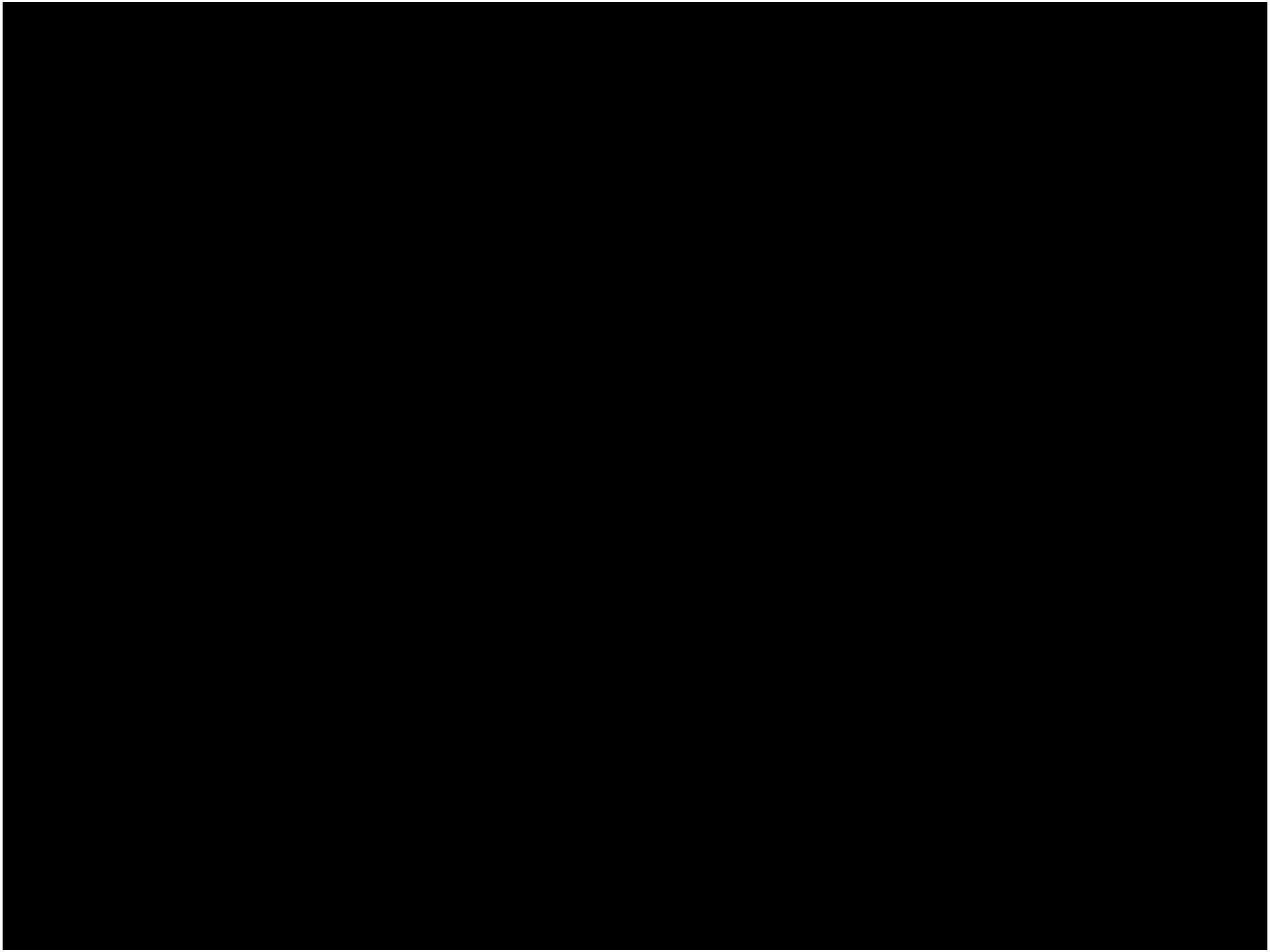


ICG Providers Forum Definition of Compatibility

Compatibility refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service

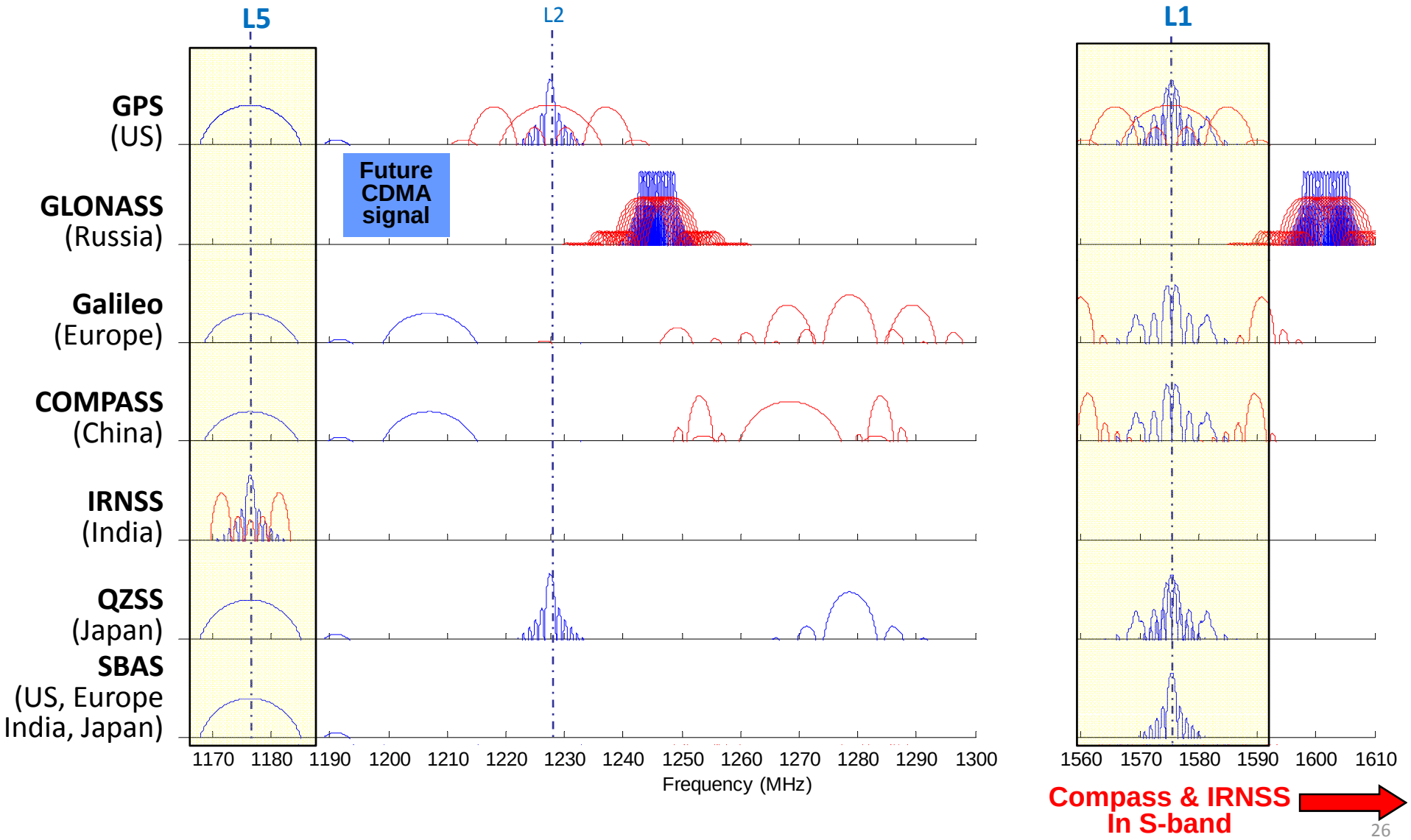
- The International Telecommunication Union (ITU) provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals.
- Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually-acceptable solution.
- Any additional solutions to improve compatibility should be encouraged.

ICG Providers Forum Definition of Interoperability

Interoperability refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system

- **Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity.**
- **Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured.**
- **Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical.**
- **Any additional solutions to improve interoperability are encouraged.**

Current International Signal Plans



U.S.-China Coordination

- Operator-to-operator coordination under ITU auspices

- Bi-lateral Meetings at Geneva June 2007; Xian, China May 2008; and Geneva October 2008

- Discussions at multi-lateral Providers Forum in Bangalore, India September 2007; and Pasadena, California, December 2008

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 signal designs
  - GLONASS signal architecture still under discussion within the Russian Government

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 aim is to improve solutions for ionospheric effects
- U.S.-India Joint Statement on GNSS Cooperation issued in February 2007 in Washington
  - Bi-lateral meeting held in Bangalore in September 2007
  - Technical Meetings focused on GPS-IRNSS compatibility and interoperability held in January and July 2008, and January 2009

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 compatible and highly interoperable with GPS
  - U.S. signed agreements with Japan to set up QZSS monitoring stations in Hawaii and Guam