GPS Policy Evolution: Spectrum Access, Stability, and Growth

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First GPS Presidential Decision Directive March 1996

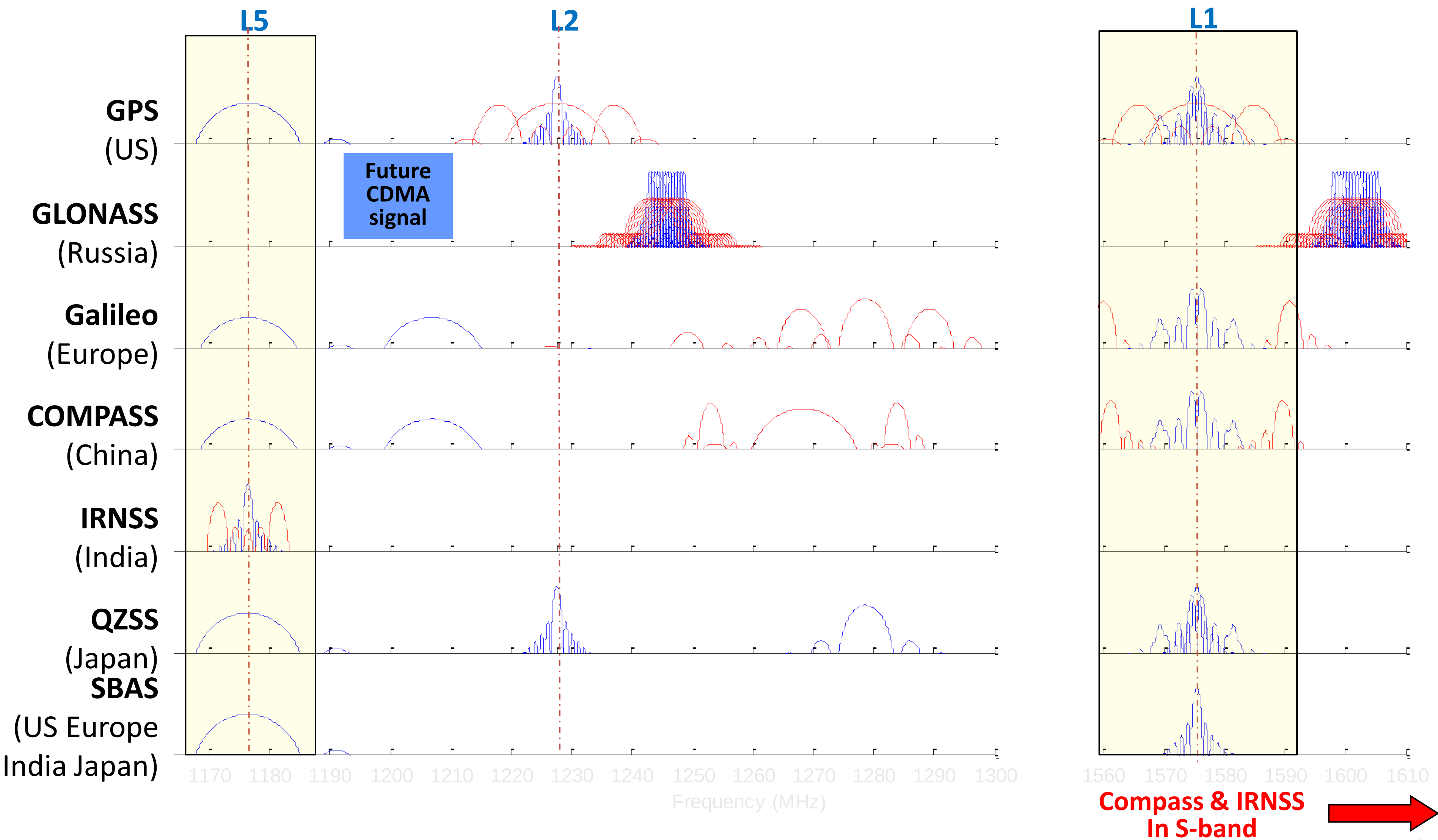
A dual-use strategic vision

- GPS as integral part of global information infrastructure
- GPS SPS signal provided free of direct user fees
- Discontinue Selective Availability (SA) by 2006
- Advocate the acceptance of GPS and U.S. augmentations as international standards
- Develop measures to prevent hostile use of GPS and its augmentations without unduly disrupting civilian uses
- Consult with foreign governments (on) bilateral or multilateral guidelines for the use of GPS

Current U.S. Policy Promotes Global Use of GPS Technology

- No direct user fees for civil GPS services
  - Provided on a continuous, worldwide basis
  - Including both current and future civil GPS signals
- 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
- Global compatibility and interoperability with GPS
- Service improvements for civil, commercial, and scientific users worldwide
- Protection of radionavigation spectrum from disruption and interference
  - "sustain the radiofrequency environment in which critical U .S . space systems operate" – National Space Policy (2010)

GNSS Signal Plans

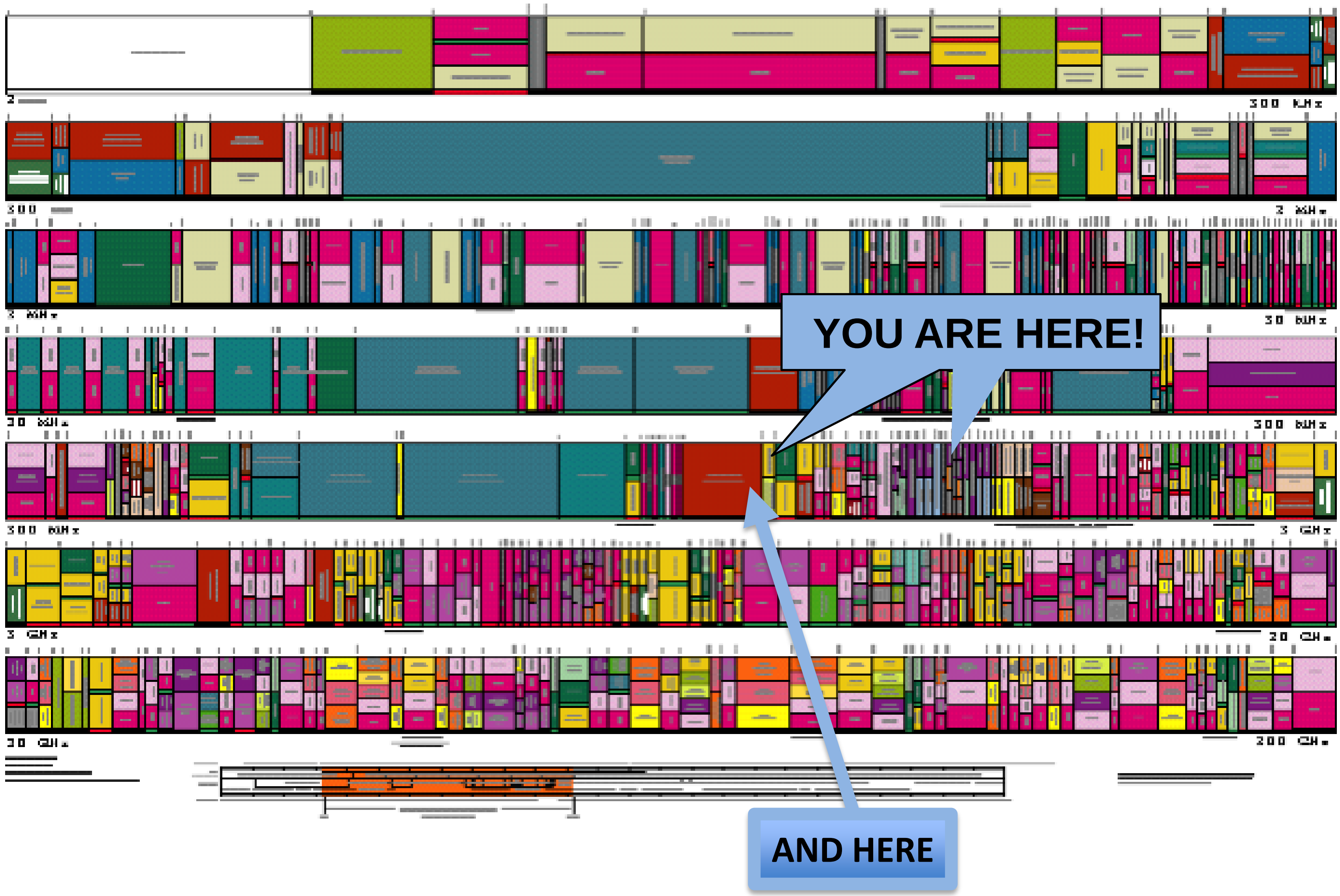


U.S. Objectives for Working with Other GNSS Service Providers

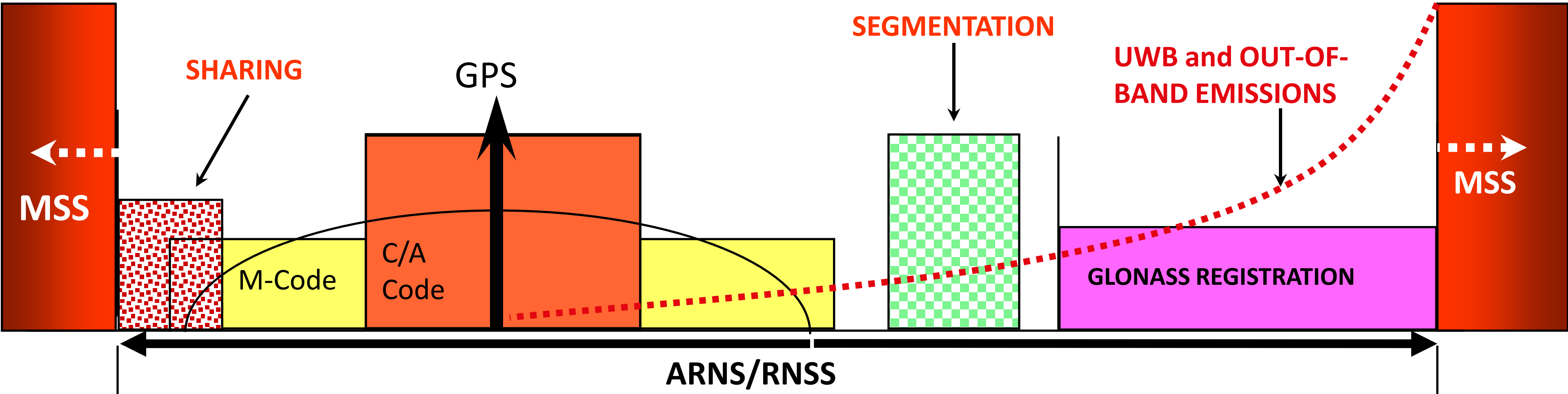
- Ensure compatibility — ability of U.S. and non-U.S. space-based PNT services to be used separately or together without interfering with each individual service or signal
  - Radio frequency compatibility
  - Spectral separation between M-code and other signals
- Achieve interoperability — ability of 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 Bilateral and Multilateral Cooperation

Frequency Universe



GPS can be Harmed Several Ways



The ARNS/RNSS spectrum is a unique resource

- **Sharing with higher power services jams weaker signals**
- **Out-of-band and ultra wide-band emissions raise the noise floor**
- **Segmentation prevents future evolution**

Spread spectrum GPS signals are unlike communication signals

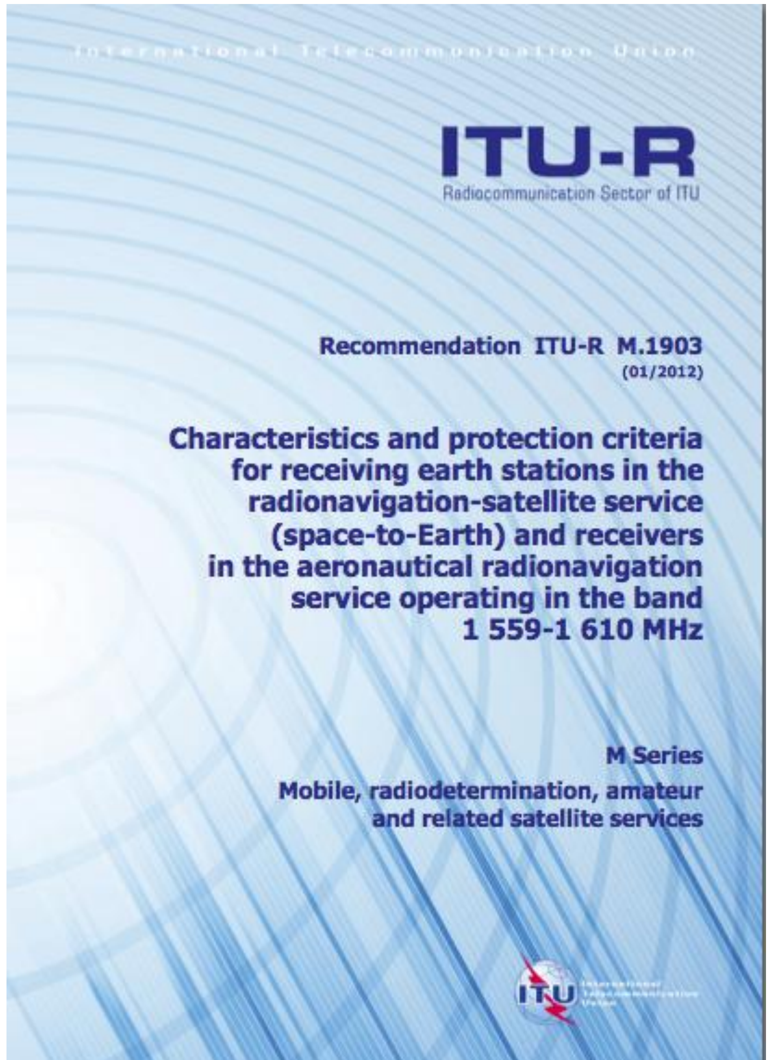
- **10^{-16} W received power, one-way**
- **Any filter can be overwhelmed if exposed to enough power**

Spectrum Protection

- Challenged by global growth of all types of wireless devices
  - Unwanted emissions from adjacent bands can raise the RNSS noise floor
  - Excessive power in adjacent bands can overload RNSS receivers (or any other receiver)
  - In the past, incompatible mobile satellite services and low-powered devices have unsuccessfully sought to operate across restricted RNSS bands
  - industry-level agreements (e.g., low-power digital TV, MSS ATC) can and have restrained unwanted emissions

- Protection of GNSS spectrum by just one country is inadequate if commercial devices that cause harmful emissions proliferate
  - Pressure for L-band spectrum to support mobile broadband and other innovations, e.g., unlicensed devices, cloud computing, software radios, etc.
  - International use of unlicensed repeaters and licensed in-band pseudolites, intentional and unintentional spoofers
  - Intergovernmental coordination of space-based L-band radars for EESS applications
  - Industry-level negotiations, interagency agreements, and international regulatory cooperation will be needed to sustain the RNSS bands

Approved ITU Recommendations on Protection Criteria Exist



Potential New Source of In-band Interference: European GNSS Repeaters

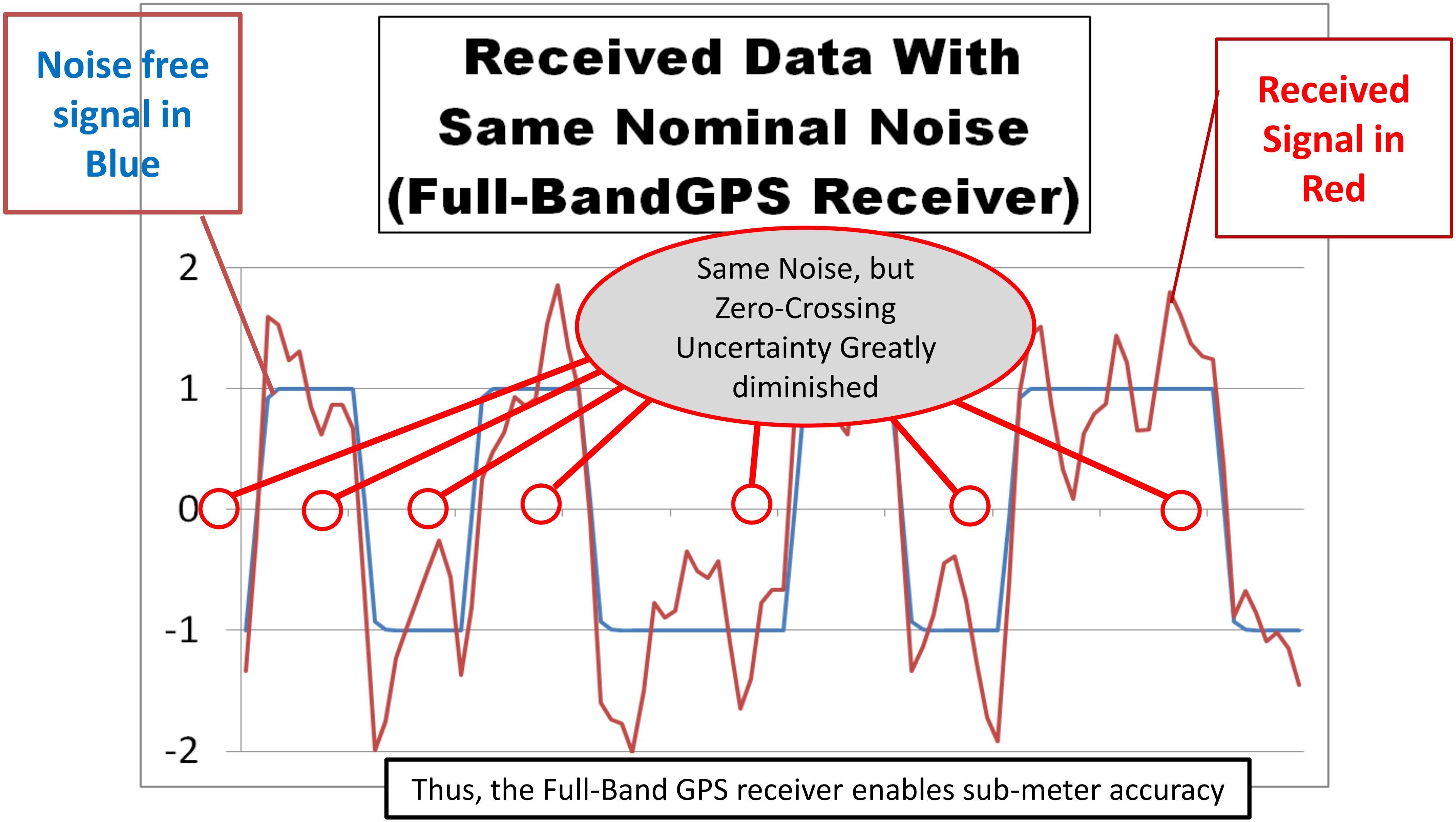
- GNSS repeaters can create unwanted emissions that can harmfully impact RNSS receivers. The ITU bans their use in ARNS/RNSS bands, but Administrations can authorize a "non-conforming use" on a non-interference basis (NIB)
- In the US, GNSS re-radiators are authorized on a NIB, experimental license basis only to the military and certain other organizations under strict conditions
- In the UK, OFCOM rules permit the *licensing* of civilian GNSS re-radiators for indoor operations based on the ETSI standard for GNSS repeaters "that should not have an impact beyond 10 meters."
- The UK rules create a risk of proliferating new interference sources. The draft European Electronic Commission (ECC) Report 128, if approved and followed by an ETSI standard, would enable indoor *and* outdoor operation of commercial pseudolites in Europe. Complete mitigation of risks to GNSS users is unlikely.
- Pseudolites do not have regulatory status but the ECC proposes to allow sharing of RNSS bands between pseudolites and ARNS/RNSS services, which would in effect give co-primary status to pseudolites.
- In contrast, FCC Part 15 rules for unlicensed device operation *exclude* the restricted ARNS/RNSS bands.

There are fundamental differences between Radio Communications and Radio Navigation

- Digital Radio **<u>Communications</u>**:
  - Incoming ***<u>message is not known</u>*** – finding it is the whole point
  - Must determine whether each signal "bit" is a one or a zero
  - Use sophisticated methods to correct errors
- Digital Radio **<u>Navigation</u>**
  - Incoming signal sequence (ones and zeros) is totally known by user
  - The goal of the user is to ***<u>precisely time</u>*** the ***<u>transition</u>*** from one to zero (and zero to one)

Courtesy: Brad Parkinson

To Achieve the Maximum Accuracy, the Full Band GPS receiver has "sharper transitions," reducing the effect of noise and allowing a more precise timing measurement



Courtesy: Brad Parkinson

GPS is a <u>Unique</u> IT Application that Complements other Applications

- GNSS applications should be thought of as information technology rather than an aerospace product. Loss of use is a cyber-security threat to global infrastructure.
- The successful introduction of new GNSS signals, whether from modernized systems or new entrants, is akin to introducing a new computer operating system. Consideration has to be given to backwards compatibility with the installed base, user expectations of stability and reliability must be met, and benefit-driven upgrade paths have to be present to induce users to shift to new signals.
- Regulatory-driven receiver standards, except where required by mission needs (e.g., public safety and national security slows innovation by constraining competition and imposes performance penalties on GPS applications. They may thus create international competitive vulnerabilities.

- Market-driven innovation in GNSS applications are fostered by trust.
  - The trust of the installed base of existing users is maintained through reliable GNSS signal performance and open, transparent standards.
  - The trust of private investors in GNSS applications is maintained through predictable, stable government policies that do not distort international markets.
  - The trust of commercial innovators willing to explore new GNSS applications is encouraged by international cooperation that protects radio spectrum and enables interoperability among diverse GNSS signals.

Meeting GPS Policy Challenges

- Spectrum protection
  - Preservation of the RNSS noise floor to include compatible neighbors
  - Coordination among RNSS providers to deter and mitigate harmful emissions from all sources
- Regulatory stability at minimal cost
  - Continue reliable operational performance
  - Transparent and stable interface specifications
  - Be market-driven, not regulatory-driven, except for reasons of safety or national security

Backup

GPS is a Critical Component of the Global Information Infrastructure


Satellite Operations


Precision Agriculture


Surveying & Mapping


Aviation


Communications


Disease Control


Power Grids

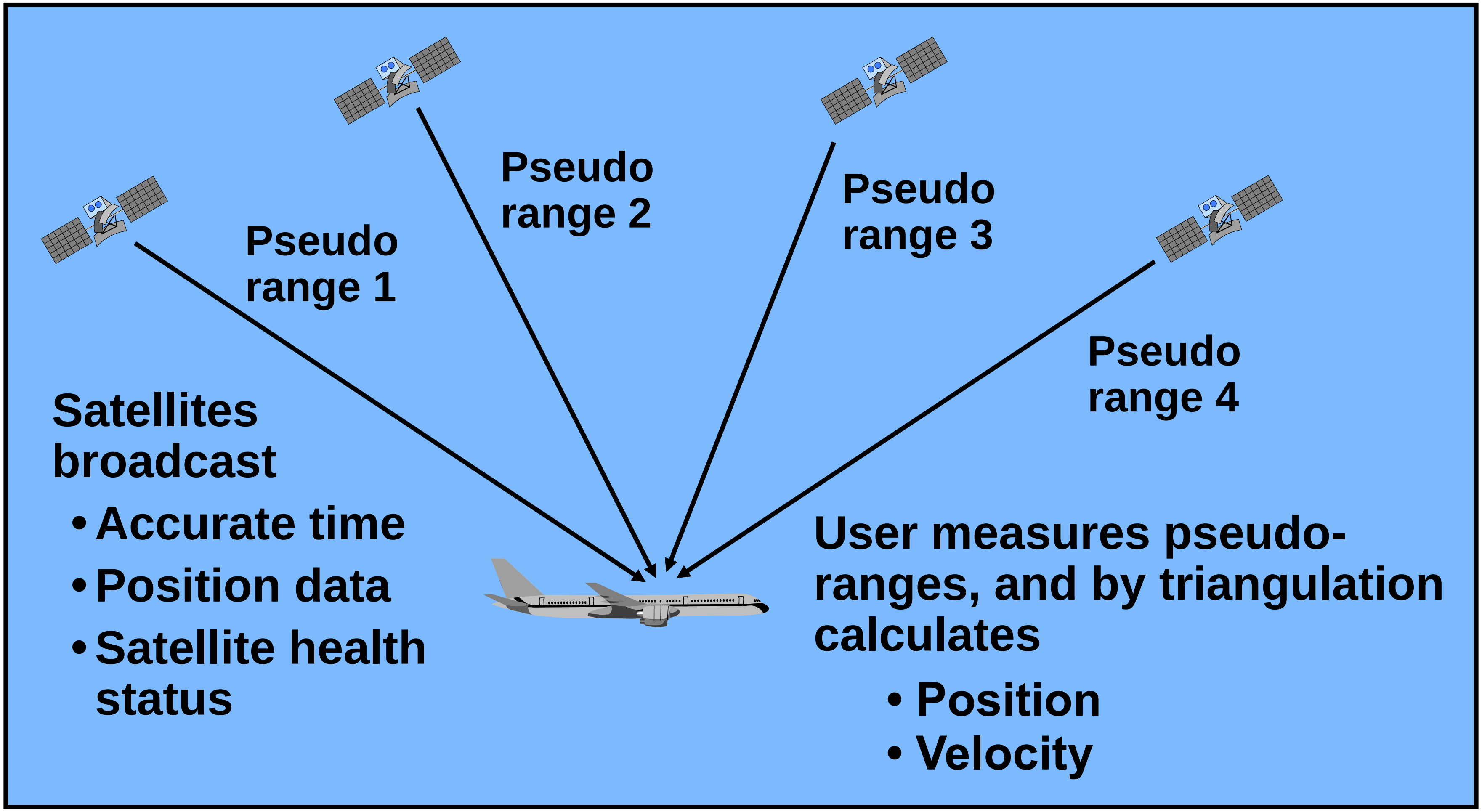

Trucking & Shipping


Oil Exploration

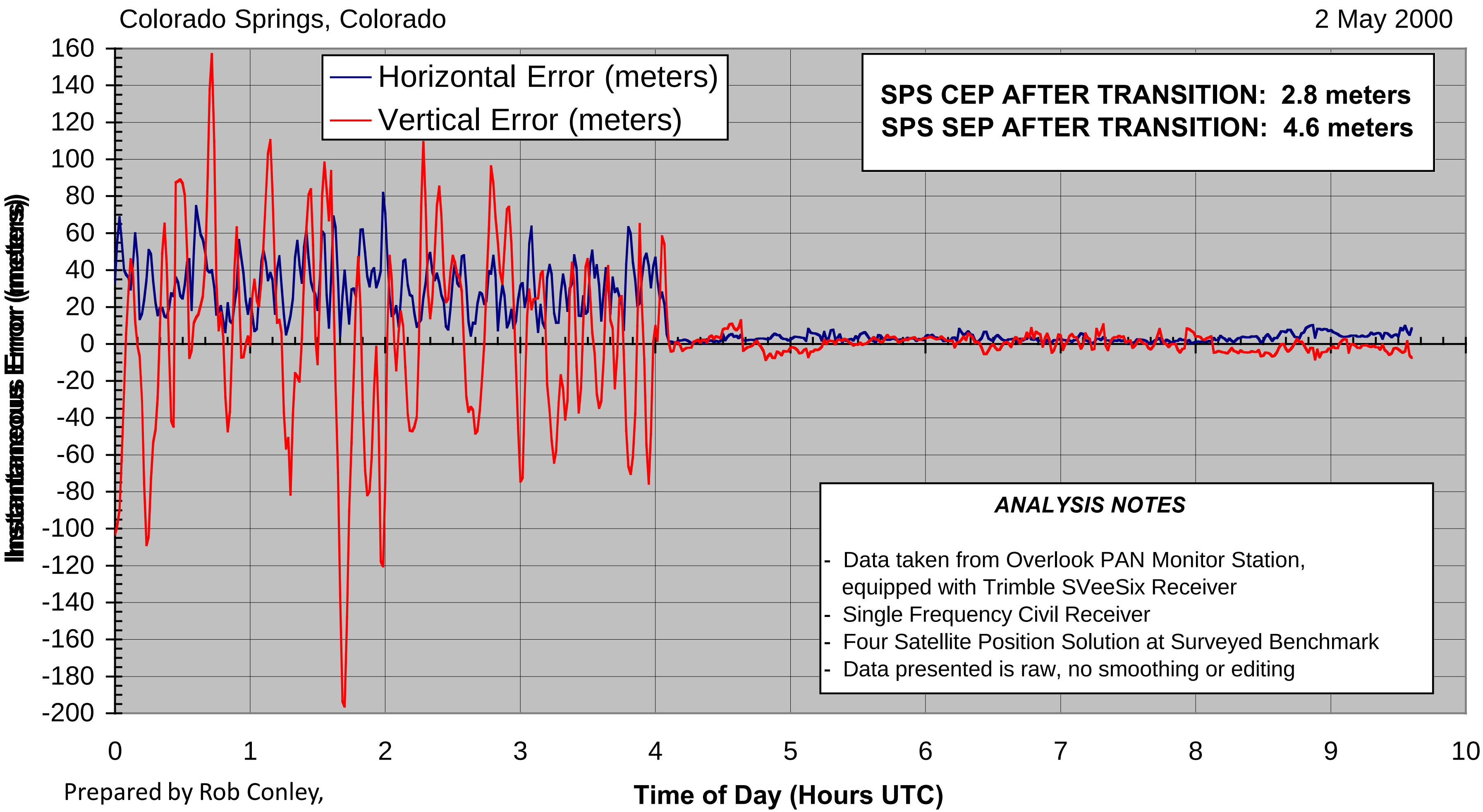

Fishing & Boating


Personal Navigation

The Global Positioning System: Clocks in Space



SA Transition -- 2 May 2000



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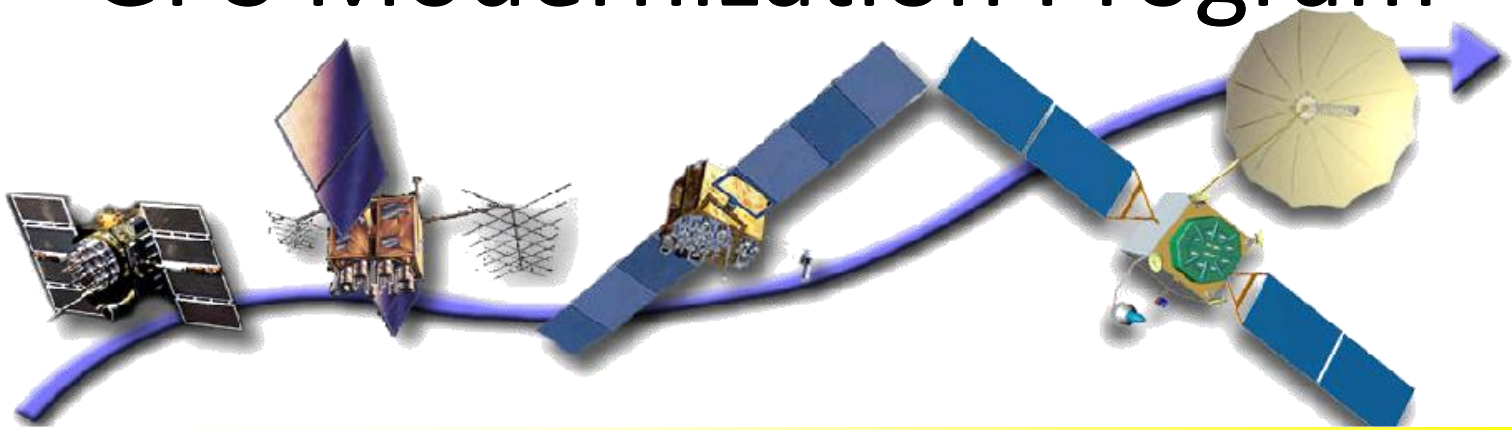
GPS Modernization Program



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

Multiple GNSS Providers

Country	System	Nominal Constellation	Status
United States	GPS	24+ Medium Earth Orbit (MEO)	29-31 in service (October 2009)
Russia	GLONASS	30 MEO	17-19 in service (October 2009) 30 GLONASS-M Operational 2011
European Union	Galileo	27 MEO	2 demo (May 2009) Fully operational ~2016
China	COMPASS	30 MEO global + 5 Geosynchronous Earth Orbit (GEO) for additional regional coverage	1 demo (April 2007) Operational 2015-2020

Wide-area augmentations: WAAS, EGNOS, MSAS, GAGAN
Regional augmentations: QZSS, IRNSS

International Committee on GNSS

- Global Navigation Satellite Systems (GNSS) and their applications are overarching, enabling space technologies
- ICG Membership is open to GNSS providers or users of GNSS services
  - 9 nations and the European Community
  - 15 organizations (UN system entities, IGOs, NGOs)
- To date 4 Meetings of the ICG have been held
  - Adopted the ICG Work Plan and Terms of Reference
  - Established a Providers Forum
- UNOOSA acts as the ICG Secretariat

ICG International Committee on Global Navigation Satellite Systems

Report to Congress on U.S. Equipment Industry Access to the Galileo Program and Markets, July 2009

- Congress requested that the Office of the U.S. Trade Representative (USTR) report on the status of U.S. equipment industry access to the European Community (EC) Galileo program and European markets.

- The USTR report focused on three concerns:
  (1) Lack of information on how to secure licenses to sell products and/or protect intellectual property rights derived from Galileo Open Service documentation,
  (2) Unequal access to Galileo Open Service signal test equipment, and
  (3) Lack of information regarding the three other Galileo PNT services, e.g., Safety-of-Life, Commercial, and Public Regulated Service for licensing commercial products and associated IPR.

- The terms and conditions for obtaining the Galileo Open Service ICD requires manufacturers to get a license from the EC prior to using ICD information for commercial purposes. Unfortunately, Galileo has not yet established licensing procedures. The EC has indicated that it hopes to soon implement provisional licensing process that would enable non-discriminatory commercial development by all firms.
- The delay in issuing licenses for commercial use of the ICD also delayed European manufacturers of Galileo signal simulators from exporting their test equipment to the United States. Galileo signal simulators for the Galileo Open Service are being exported to the United States and USTR noted that it expects formal EC approval to be forthcoming – perhaps as part of the EC provisional licensing approach.