

# **GPS Policy Evolution:** Spectrum Access, Stability, and Growth

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# First GPS Presidential Decision Directive

## March 1996

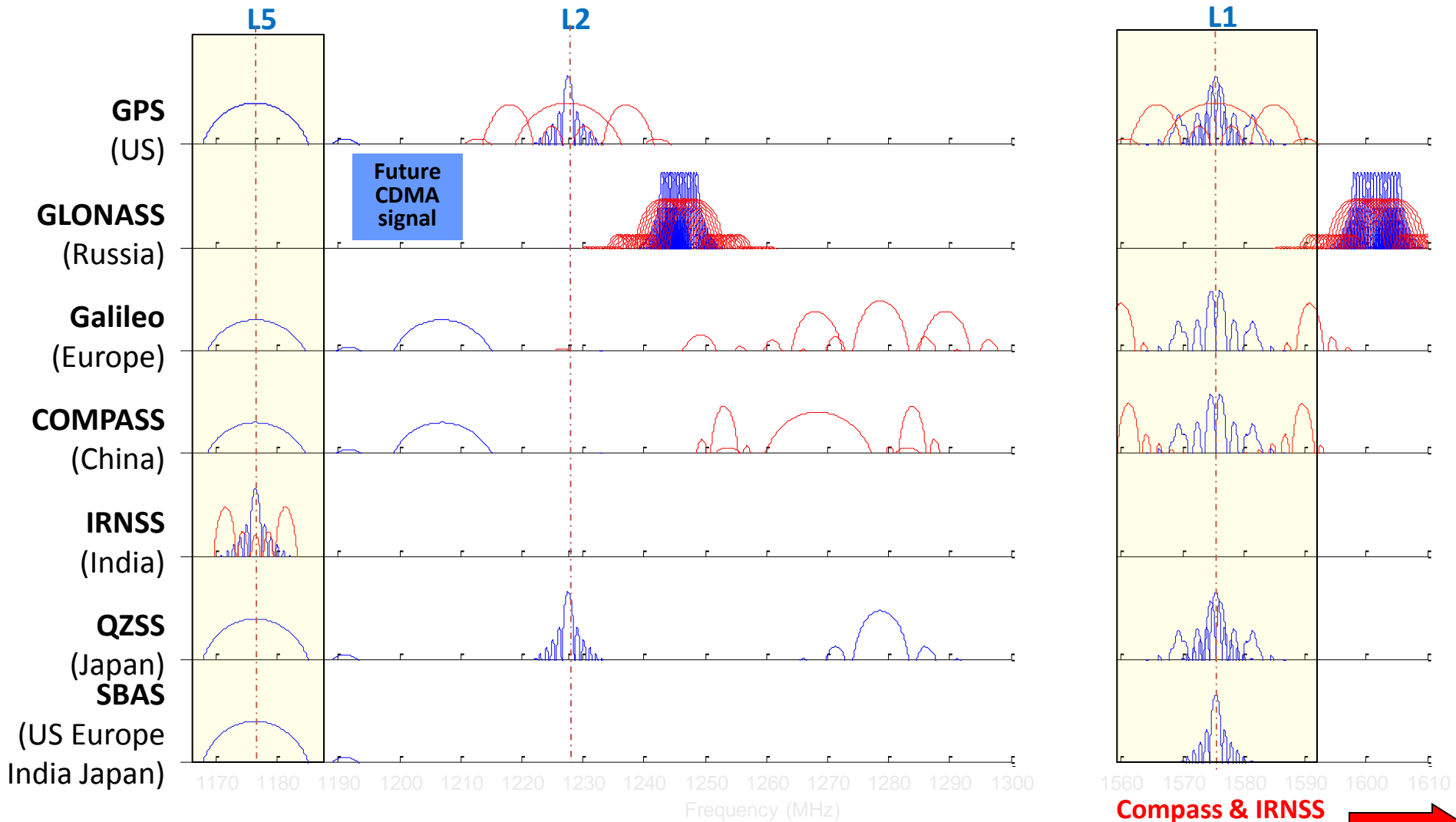
### A dual-use strategic vision

- 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

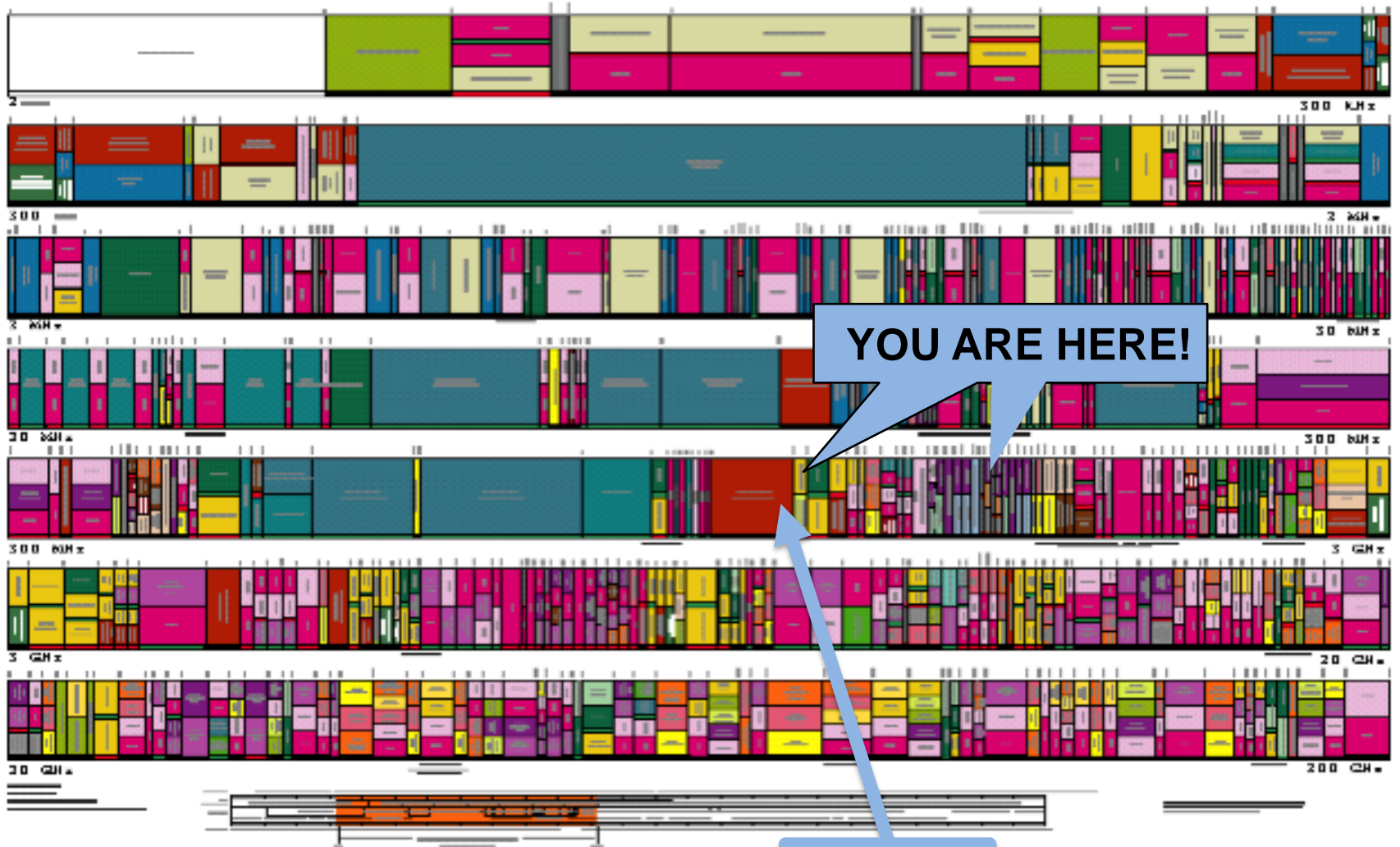


# U.S. Objectives for Working with Other GNSS Service Providers

- 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**

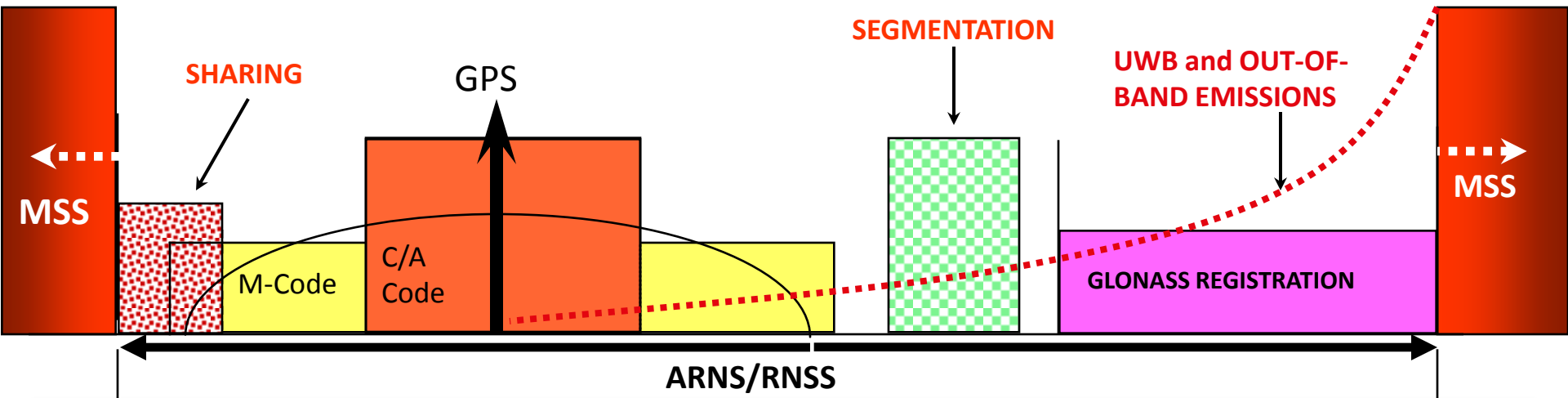
# Frequency Universe



**YOU ARE HERE!**

**AND HERE**

# 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



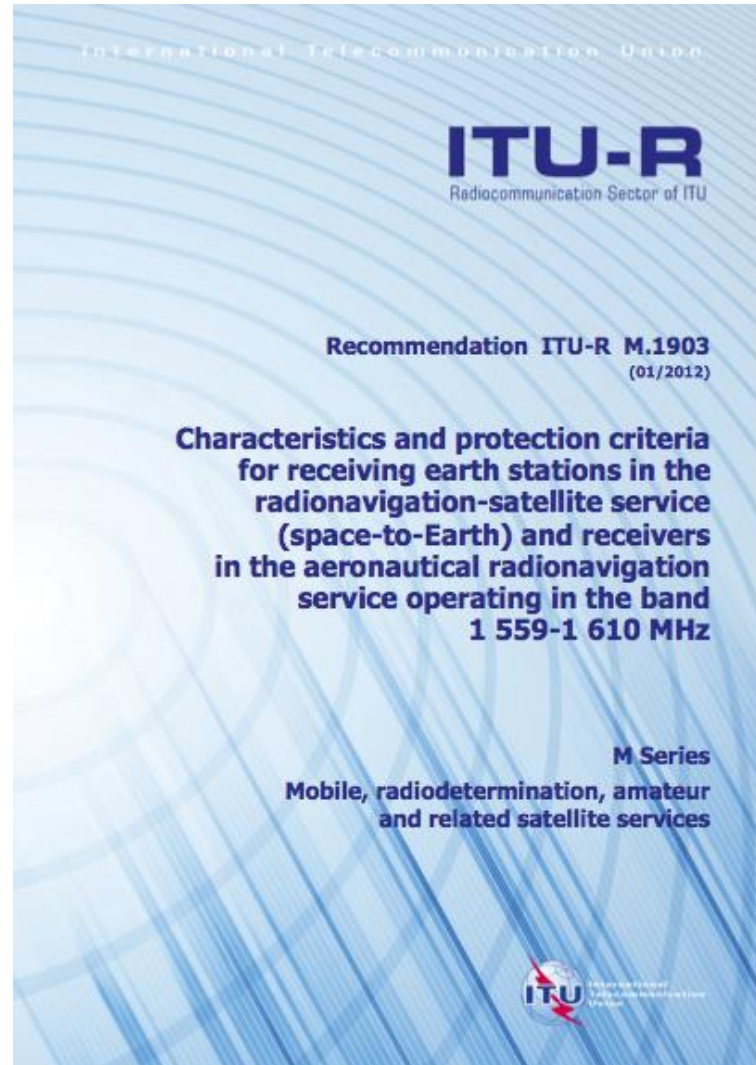
# Spectrum Protection



- 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

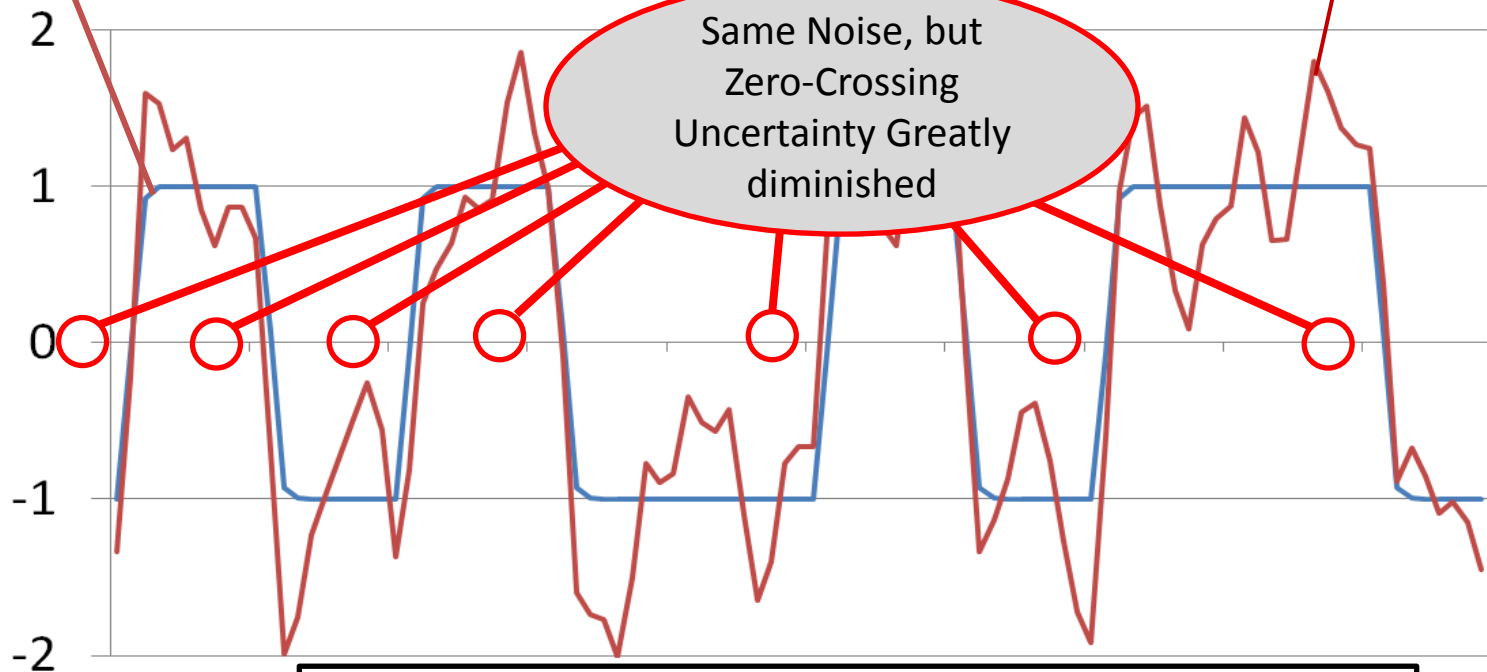
- Digital Radio **Communications**:
  - Incoming **message is not known** – finding it is the whole point
  - Must determine whether each signal “bit” is a one or a zero
  - Use sophisticated methods to correct errors
- Digital Radio **Navigation**
  - Incoming signal sequence (ones and zeros) is totally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

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

Noise free signal in Blue

**Received Data With Same Nominal Noise (Full-Band GPS Receiver)**

Received Signal in Red



Thus, the Full-Band GPS receiver enables sub-meter accuracy

# GPS is a Unique 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



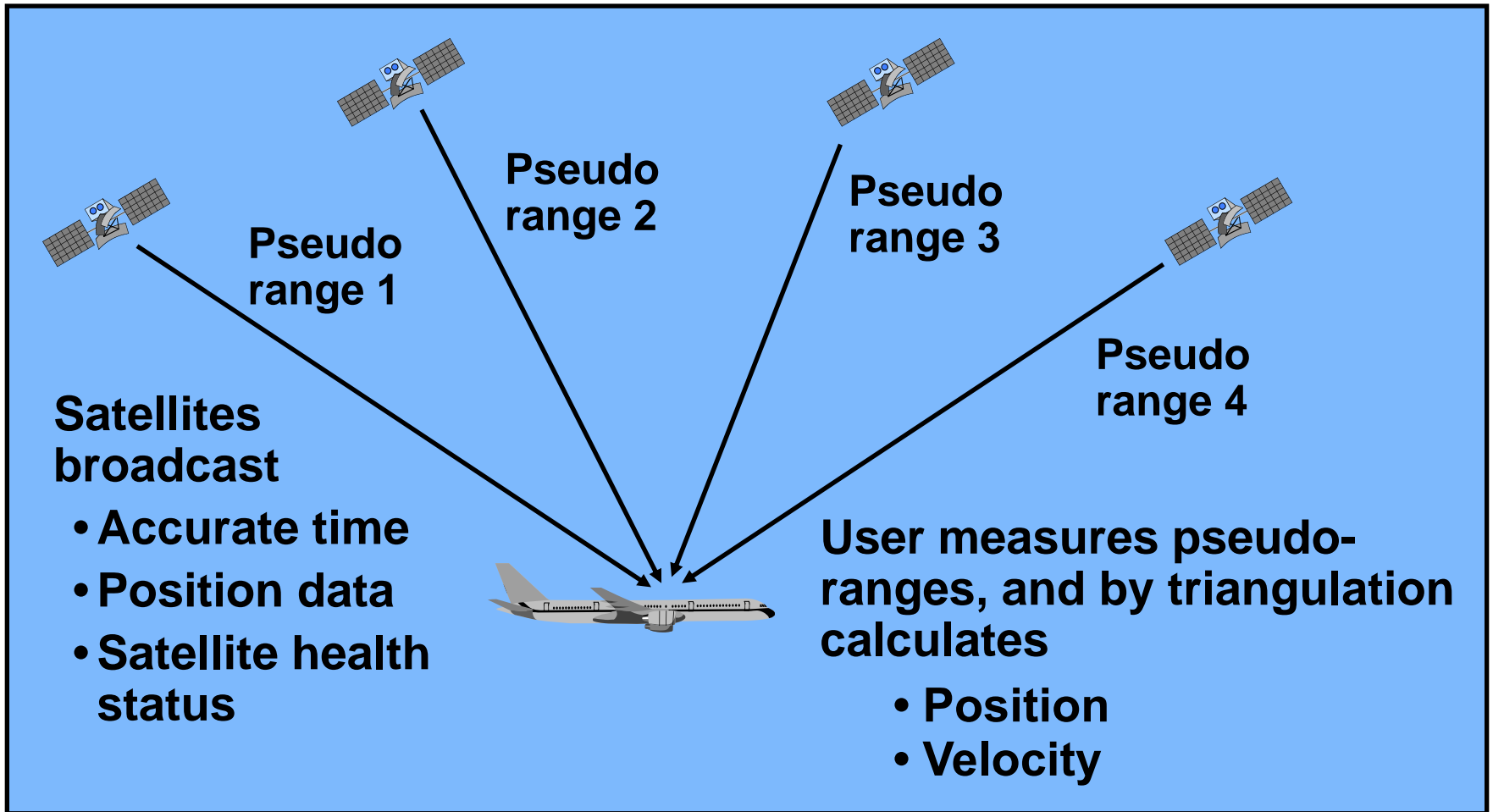
Fishing & Boating



Personal Navigation



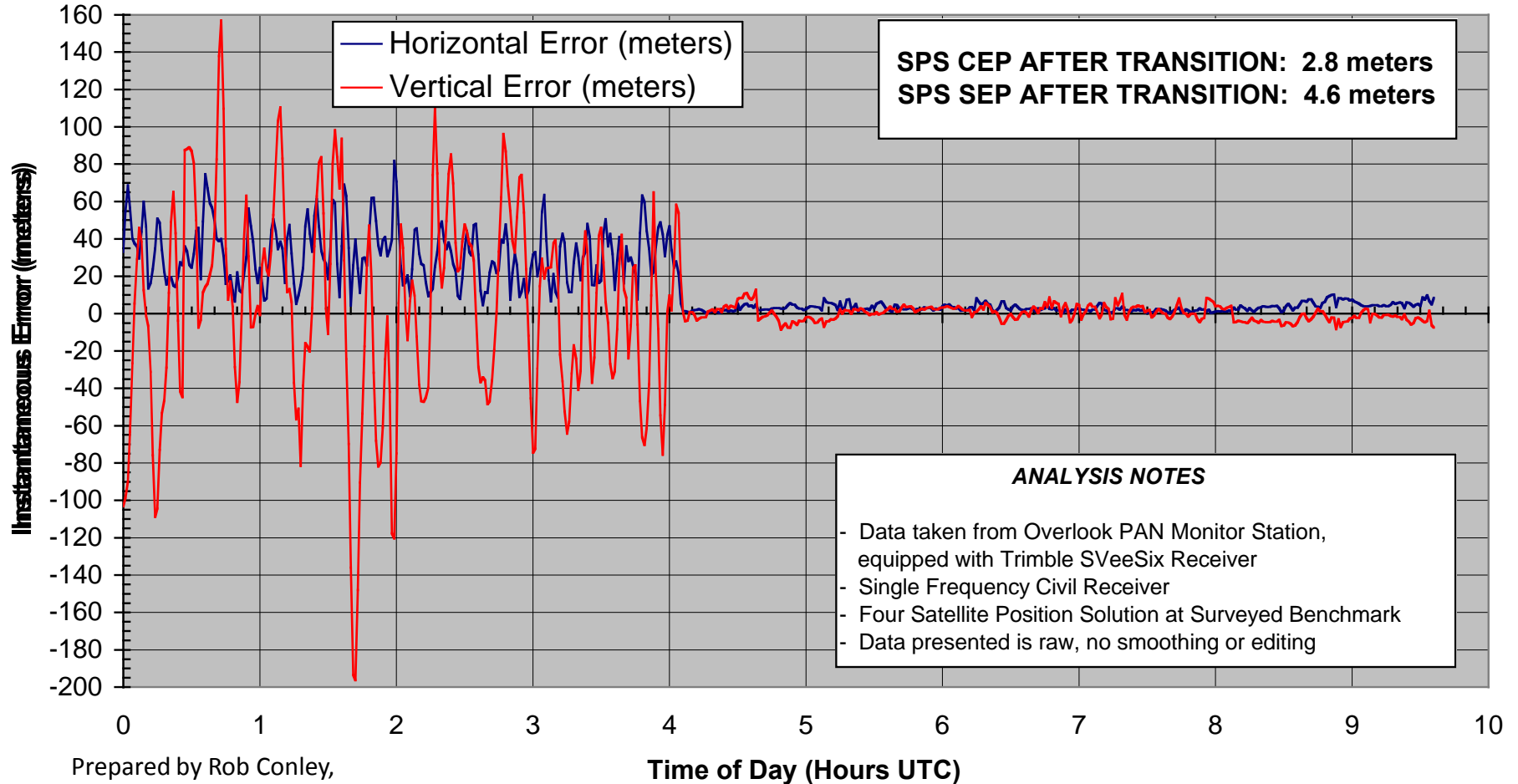
# The Global Positioning System: Clocks in Space



# SA Transition -- 2 May 2000

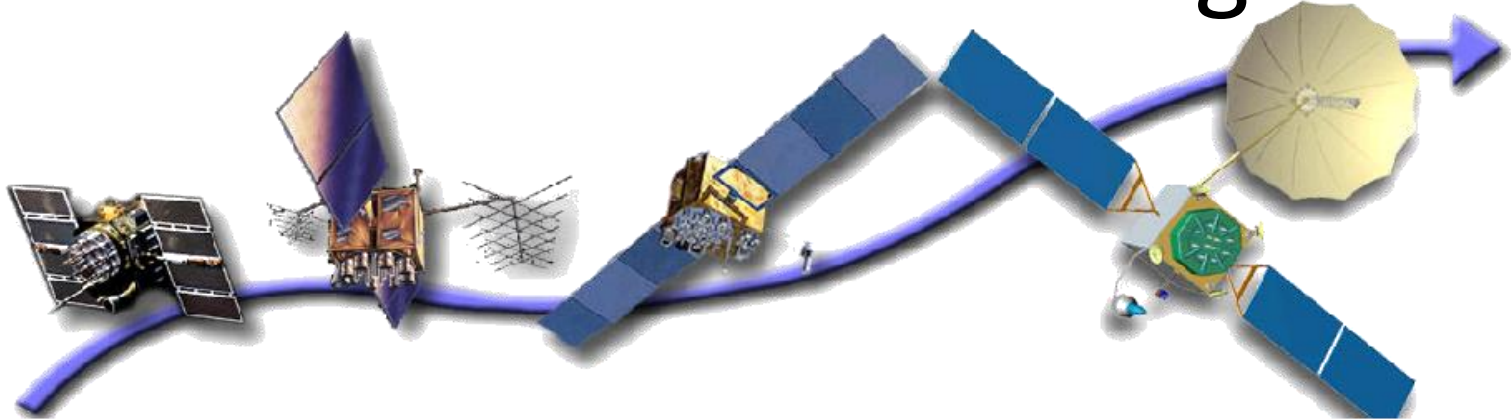
Colorado Springs, Colorado

2 May 2000



Prepared by Rob Conley,  
Overlook Systems Technologies, Inc.

# 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



# *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.