PNT Evolution:
Future Benefits and Policy Issues

Scott Pace
Director, Space Policy Institute
George Washington University
Washington, D.C.

5 November 2009

GPS is a Critical Component of the Global Information Infrastructure


Satellite Operations


Precision Agriculture


Surveying & Mapping


Aviation


Communications


Disease Control


Power Grids

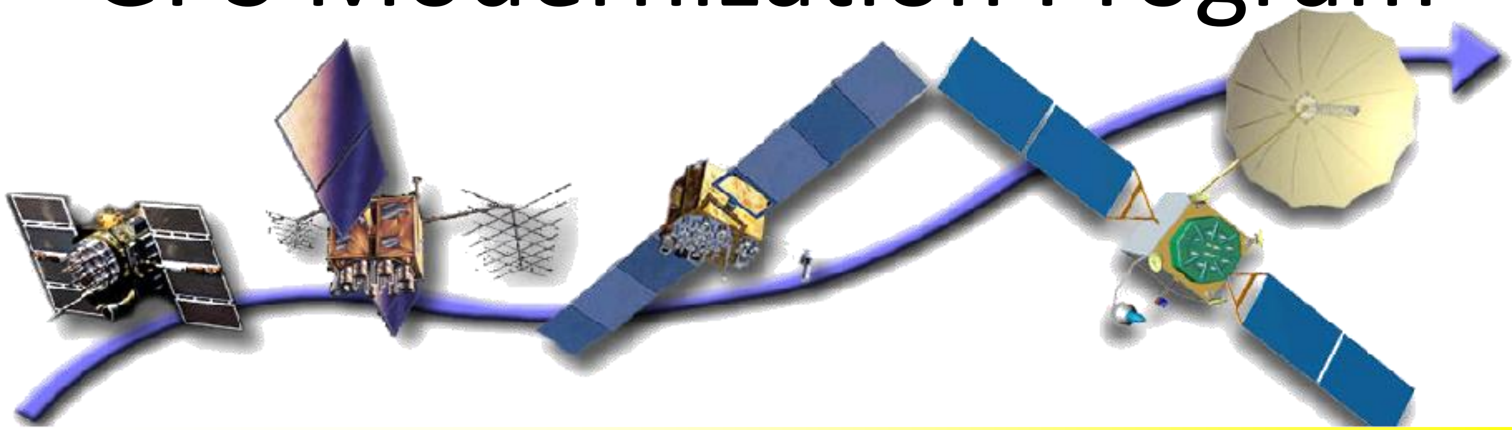

Trucking & Shipping


Oil Exploration


Fishing & Boating


Personal Navigation

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

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

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

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 Bilateral and Multilateral Cooperation

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

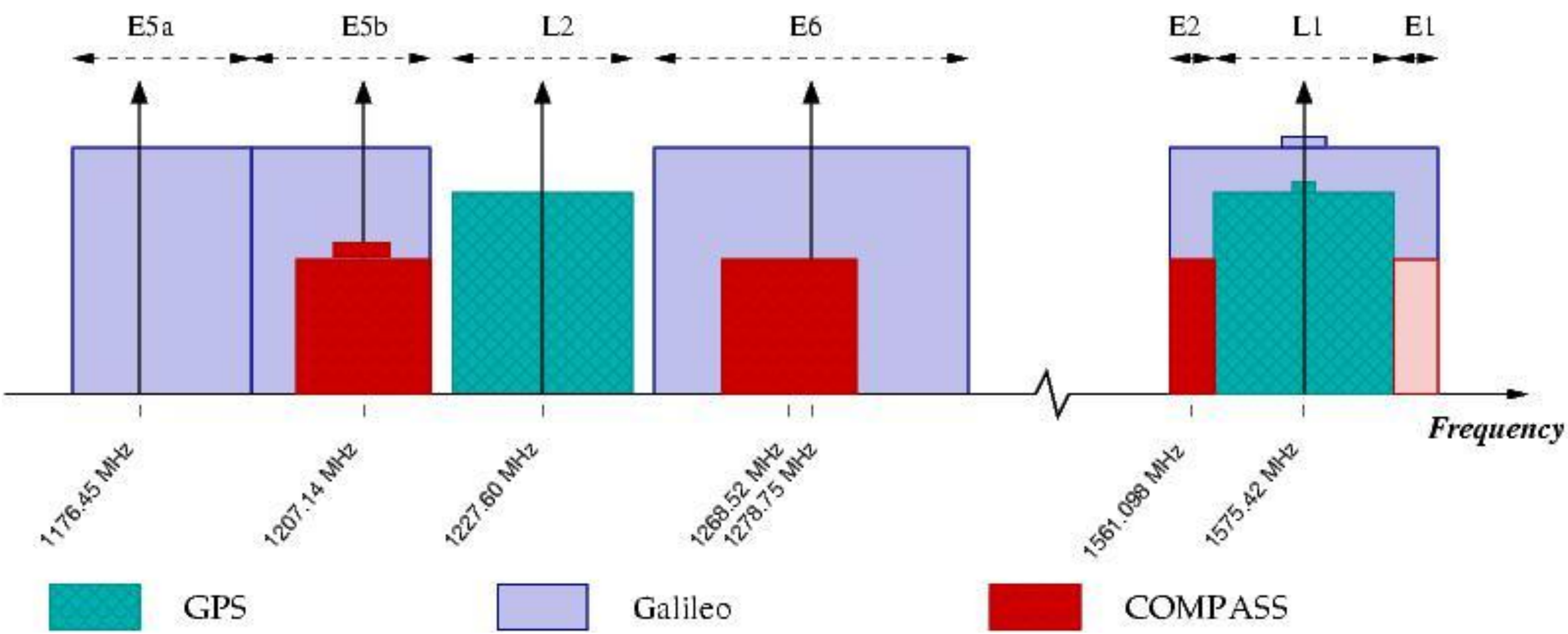
GNSS Policy Challenges

- Spectrum protection
  - Preservation of the RNSS noise floor
  - Coordination among RNSS providers
- Standards and Trade Relations
  - U.S. Trade Representative Report on Galileo
- System modernization and market acceptance of new signals
  - Transparent and stable interface specifications
  - Reliable performance to published standards

Spectrum Protection

- A continuing challenge due to global growth of all types of wireless devices
  - Unwanted emissions from their operation in adjacent bands can create a rise in the RNSS noise floor
  - Past pressure from mobile satellite services in adjacent bands and low-powered devices that sought to operate across all bands (e.g., ultrawideband emitters).
  - In recent years, the value of embedded GNSS signals to many IT applications has became more widely understood
    - industry-level agreements (e.g., low-power digital TV) to restrain the unwanted emissions
- Protection of GNSS spectrum by just one country is inadequate if commercial devices that cause harmful emissions proliferate
  - Future pressure for wireless spectrum to support ubiquitous “cloud computing” and other innovations can be expected
  - International use of unlicensed repeaters, in-band pseudolites
  - Industry-level negotiations, interagency agreements, and international regulatory cooperation will be needed to preserve the RNSS bands for future users.

GPS, Galileo, and Compass Planned Frequency Allocations (Simplified)



COMPASS plans add: L5 signal, L1 MBOC, wider spectrum use around “L6” and other signal design changes

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.

Acceptance of New Signals

- Market-driven acceptance versus regulatory compliance in user acceptance of new signals
  - The former sees productivity benefits while the latter is a form of taxation
  - Public safety applications such as aviation, maritime, and rail transport, tend to be relatively small. Small markets driven by regulatory compliance tend to result in high cost receivers and applications tailored for specific niches, with lower rates of innovation since the required certification limits competition.
  - National regulations which drive customized local compliance can easily segment the global market for an application. This lowers the addressable market and decreases attractiveness for private investment.
- Example: The Galileo program has examined the E6 frequency as part of a "liability service" to insure users against GNSS-related failures.
  - Business difficulties with the costs that would have to be covered, such as securing the signal from unauthorized use, signal certification, the liability insurance itself, organizational overhead, and profit margin.
  - Some combination of direct and indirect fees may be possible, but they would have to be low compared to existing insurance mechanisms.
  - If the number of customers is small, there may be a mandate to use "certified" fee-based Galileo services in European markets. This would amount to a tax on users in those markets, a segmentation of European and global markets for taxed applications, and could discourage broader market acceptance of Galileo signals.

Acceptance of New Signals (cont.)

- GNSS providers need to provide timely access to accurate interface specifications that enable equipment and chip manufactures to develop products using the signals.
  - Delays in publishing ICDs for the Galileo commercial and safety services has made it difficult for manufactures, much less users, to realistically plan to use those services. This delays market acceptance.

- GNSS providers, such at the United States that serve a large installed base, need to provide a benefit-driven transition path to modernized signals, e.g., the transition from semicodeless/codeless use to coded dual civil signals L1 C/A and L2C for high-precision use.
- Federal Register, September 23, 2008: "The United States commits to maintaining the existing GPS L1 C/A, L1 P(Y), L2C and L2 P(Y) signal characteristics until December 31, 2020."
- However, the draft GPS L2C signal IS (IS-GPS-200) specifies that the characteristic of the phase relationship on this signal can change without providing a means for the user equipment to identify which phase relationship is being broadcast.
  - Stable or known phase relationships are critical to all high-precision users of GPS worldwide and in all sectors
  - A variety of technical solutions exist to resolve this uncertainty, but they must be reflected in the Interface Specification that the installed base relies on.
  - ICD is a work in progress that will ensure the successful transition to modernized civil signals.

Concluding Observations

- Global Navigation Satellite Systems are more easily thought of as forms of information technology than aerospace products.
- The successful introduction of new GNSS signals, whether from modernized systems or new entrants, is akin to introducing a new personal 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.

- Market-driven innovation in GNSS application cannot be mandated but it can be encouraged. The fundamental challenge for current and emerging providers are issues of 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 fosters interoperability among diverse GNSS signals.