Dual-Use Space Technologies and Systems: Spectrum Management and the Case of GPS

Osher Lifelong Learning Institute, GMU Science and Technology Class

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The intersection is a complex situation involving many players, relationships, and organizational dynamics.

Dual-use space systems face these situations.
Defining “Dual-Use” Space Technologies and Systems

Capabilities or systems having government and national security purposes but which may also have civil and commercial applications

• Potential dilemma:
  – May be a “free good” paid for by U.S. taxpayers
  – Develops into “global utility” and becomes critical to U.S. national infrastructure and the economy
  – Posing competing public and private interests

• Examples
  – Weather and remote sensing satellites
  – Global positioning, navigation, and timing satellites
Dual-Use Space Systems: NAVSTAR Global Positioning System (GPS)

- One of the world’s “global utilities”
- Conceived of as military navigational tool, but has evolved into a predictable, reliable, and ubiquitous capability of “information on demand”
- **Military space constellation of 31 satellites** providing positioning, navigation, and timing (PNT)
- Oversight by Deputy Secretary-level National Executive Committee for Space-Based PNT, supported by National PNT Coordination Office and Advisory Board
- Current modernization improvements in:
  - Accuracy, availability, integrity, and reliability
  - Backward signal compatibility
  - Robustness against interference
  - Improved indoor, mobile, and urban use
  - Interoperability with other Global Navigation Satellite Services (GNSS)
Increasing System Capabilities  •  Increasing Defense / Civil Benefit

**Block IIA/IIR**

- Basic GPS
  - Standard Service (16-24m SEP)
    - Single frequency (L1)
    - Coarse acquisition (C/A) code navigation
  - Precise Service (16m SEP)
    - Y-Code (L1Y and L2Y)
    - Y-Code navigation

**Block IIR-M, IIF**

- IIR-M: IIA/IIR capabilities plus
  - 2nd civil signal (L2C)
  - M-Code (L1M and L2M)
    - Eliminates SA for denial
  - Anti-jam flex power
- IIF: IIR-M capability plus
  - 3rd civil signal (L5)
  - Anti-jam flex power

**Block III**

- IIIA:
  - Increased anti-jam power
  - Increased security
  - Increased accuracy
  - Navigation surety
  - Backward compatibility
  - Assured availability
  - Controlled integrity
  - System survivability
  - 4th civil signal (L1C)
GPS Supporting the Warfighter
GPS is a Critical Component of the Global Information Infrastructure

- Satellite Operations
- Power Grids
- Precision Agriculture
- Surveying & Mapping
- Aviation
- Communications
- Trucking & Shipping
- Disease Control
- Oil Exploration
- Fishing & Boating
- Surveying & Mapping
- Disease Control
- Oil Exploration
- Fishing & Boating

Source: PNT National Coordination Office, February 2009.
Options for PNT in Space

Earth Surface to Cislunar Space

Lunar Space

Deep-Space Navigation

Enabling Technologies, including,

- Improved flight dynamics / trajectory modeling
- Space-qualified Atomic Clocks
- Appropriate relativistic time transformations
- Accurate geodetic reference frames (using VLBI, satellite laser ranging, etc. techniques)
- GPS/GNSS monitoring and distribution of differential corrections and integrity messages to space users
- Integrated communications and navigation receivers
- …etc.
All Spacecraft, Including GPS, Communicate Using Spectrum
DoD Spectrum Use

Altitude 20,000-35,000 feet

Altitude 25,000-45,000 feet

Altitude 25,000-45,000 feet

Altitude 20,000-35,000 feet

Tankers

CAP

Air-To-Air Defense

Reconnaissance

Anti-Radar

Bombers

Radar Jammers

Anti-Radar

Air-To-Air Defense

Over 2,400 Emitters

Carrier Battle Group

Border

SOF

UAV

Jammers

Civil Networks

Source: Ms. Paige Atkins, Air Staff, 1997.
GPS’s L-1 and L-2 Bands
U.S. PNT Policy History

- 1978: First GPS satellite launched
- 1978: Legislation requires federal radionavigation planning
- 1983: U.S. President offers free civilian access to GPS
- 1996: First U.S. GPS Policy. Established GPS as a dual-use system under joint civil/military management
- 1997: U.S. Congress passes law requiring the GPS standard positioning service to be provided free of direct user fees
- 2000: U.S. President set Selective Availability to “Zero”
- 2004: U.S. President issued U.S. Policy on Space-Based PNT
- 2007: U.S. President announces Selective Availability will no longer be built into modernized GPS III satellites
## U.S. Space-Based PNT Policy (2004)

**GOAL:** Ensure the U.S. maintains space-based PNT services, augmentation, back-up, and service denial capabilities that...

<table>
<thead>
<tr>
<th>Goal</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>ASSURE SERVICE</strong></td>
<td>Provide uninterrupted availability of PNT services</td>
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<tr>
<td><strong>MEET DEMANDS</strong></td>
<td>Meet growing national, homeland, economic security, and civil requirements, and scientific and commercial demands</td>
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<tr>
<td><strong>LEAD MILITARILY</strong></td>
<td>Remain the pre-eminent military space-based PNT service</td>
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<tr>
<td><strong>STAY COMPETITIVE</strong></td>
<td>Continue to provide civil services that exceed or are competitive with foreign civil space-based PNT services and augmentation systems</td>
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<tr>
<td><strong>INTEGRATE GLOBALLY</strong></td>
<td>Remain essential components of internationally accepted PNT services</td>
</tr>
<tr>
<td><strong>LEAD TECHNICALLY</strong></td>
<td>Promote U.S. technological leadership in applications involving space-based PNT services</td>
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- Radio Frequency Spectrum and Orbit Management and Interference Protection
  - Obtain/protect U.S. global access to frequency spectrum and orbital assignments
  - Explicitly address requirements for spectrum and orbital assignments prior to approving acquisitions of new space capabilities
  - Assure, as practicable, space capabilities not affected by harmful interference
  - Seek spectrum regulatory status under U.S. domestic regulations for USG owned/operated earth stations operating through commercial satellites
Key Spectrum Management Organizations

United Nations

International Telecommunications Union (ITU)
- World Radiocommunications Conferences (WRCs)

United States Federal Government

FCC
- Chair (Pres appointee)

NTIA
- Asst Sec'y of Commerce

IRAC
- 20 Federal agencies

DoD

JCS

Dept of State

Dept of Defense

Federal Dept/Agency

Civil Sector Spectrum

Federal Spectrum

FCC\ coordinaiton\ NTIA\ Coordination\ IRAC\ MILDEPs\ DoD\ JCS

* IRAC Members:
  Dept of Army, Dept of Health and Human Services
  Dept of Navy, Dept of Justice
  Dept of Air Force, Dept of Veteran Affairs
  Dept of Agriculture, Federal Aviation Administration
  Dept of Commerce, Federal Emergency Management Agency
  Dept of Energy, General Services Administration
  Dept of State, National Aeronautics and Space Administration
  Dept of Treasury, National Science Foundation
  Dept of Interior, US Information Agency
  US Postal Service

Updated from: Ms. Paige Atkins, Air Staff, 1997.

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Current RNSS Allocations and Threats to GPS

**L1-BAND CONFIGURATION**
- 1570.42 (L1)
- 1580
- 1585
- 1595
- Potential MSS Out-of-Band Effect
- GLONASS Spectrum Occupancy
- GLONASS Registration

**L2-BAND CONFIGURATION**
- 1227.6 (L2)
- Pulsed Radars (TPS-59, FPS-117, etc)
- Future C/A-Code
- Y-Code

**NB:** As of c. 2000
U.S. Policy Promotes Global Use of GPS 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
- Global compatibility and interoperability with GPS
- Service improvements for civil, commercial, and scientific users worldwide
- Protection of radionavigation spectrum from disruption and interference
U.S. Space-Based PNT Organization Structure

WHITE HOUSE

NATIONAL EXECUTIVE COMMITTEE FOR SPACE-BASED PNT
   Executive Steering Group
      Co-Chairs: Defense, Transportation

NATIONAL COORDINATION OFFICE
   Host: Commerce

ADVISORY BOARD
   Sponsor: NASA

Defense
Transportation
State
Interior
Agriculture
Commerce
Homeland Security
Joint Chiefs of Staff
NASA

GPS International Working Group
   Chair: State

Engineering Forum
   Co-Chairs: Defense, Transportation

Ad Hoc Working Groups

Homeland Security
Joint Chiefs of Staff
NASA
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

*U.S. pursuing through bilateral and multilateral cooperation*
Goal of Civil Interoperability

Ideal interoperability provides users a PNT solution using signals from different GNSS systems
- No additional receiver cost or complexity
- No degradation in performance

Interoperable = Better together than separate
Current GNSS Relationships

- **Bilateral**
  - Europe
  - Japan
  - Russia
  - India
  - Australia

- **Multilateral**
  - International Committee on GNSS
  - Asia Pacific Economic Cooperation
  - ICAO, IMO, NATO
U.S.–Europe Cooperation

• GPS-Galileo cooperation agreement signed in 2004
• Four working groups established:
  – Compatibility/Interoperability
  – Trade
  – Next-Generation GNSS
  – Security
• Improved civil signal jointly adopted in 2007
• Plenary meeting held October 2008
• U.S. seeking EC authorization of commercial Galileo simulator sales

June 26, 2004, press conference at U.S.-EU Summit in Ireland (U.S. Sec. of State Colin Powell, Irish Foreign Minister Brian Cowen, EU Vice-President Loyola De Palacio)
U.S. Bilateral Cooperation

• **U.S.-Japan Joint statement on GPS cooperation in 1998**
  – Established foundation for stable policy leading to Japan as a global leader in commercial GPS/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
  – Considering new civil CDMA signals to be interoperable with GPS/Galileo

• **U.S.- India Joint Statement on GNSS Cooperation in Feb 2007**
  – Important topic is ionospheric distortion/solutions to this phenomena
  – Technical Meeting focused on GPS-IRNSS compatibility and interoperability held in January and July 2008
International Committee on GNSS

• Promotes GNSS use and integration into infrastructures, particularly in developing countries
• Encourages system compatibility, interoperability
• Membership: GNSS providers, international organizations and associations
• Providers Forum
  – United States, Europe, Russia, China, India, Japan
  – Focused discussions on compatibility, interoperability
• Next meeting: September 2009 in St. Petersburg, Russia
Private Sector Competition

- Minimize competition between service providers
- Encourage fair competition in the private sector in GNSS receiver and application markets
  - Leads to greater innovation, lower costs
- Fair competition means no preferential treatment for any particular company (s)
  - Equal (if not open) access to information and markets
- 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/open markets (non-discriminatory)
The Way Forward

GPS Modernization

International Cooperation

Spectrum Management