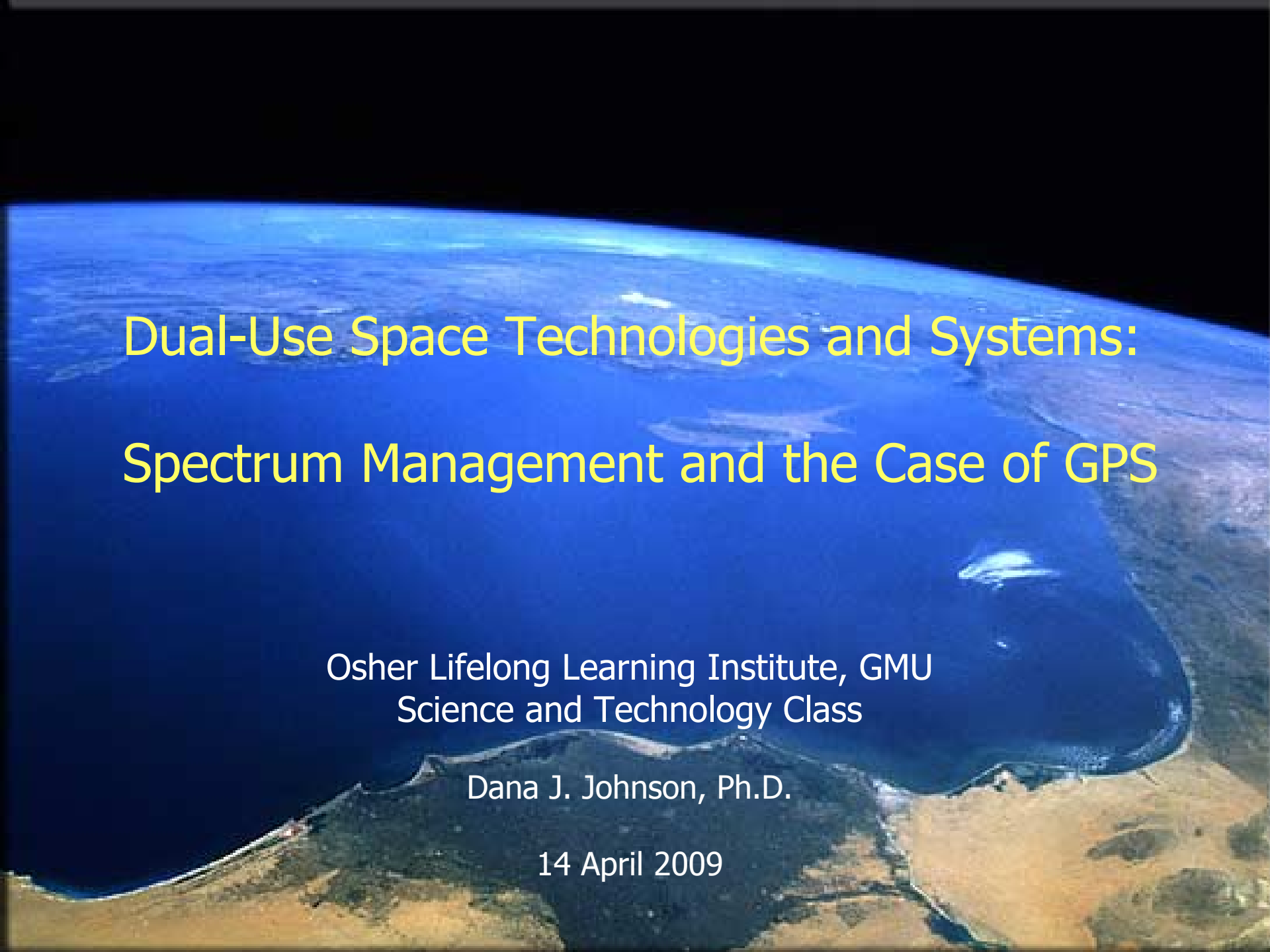


Dual-Use Space Technologies and Systems:

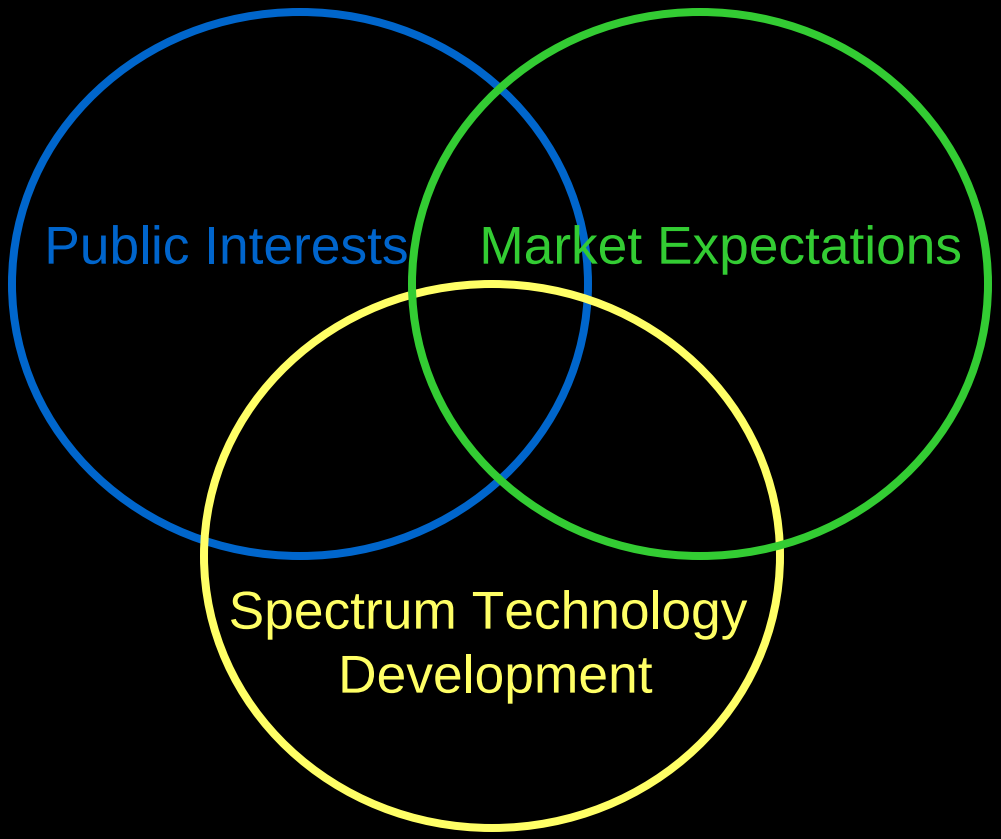
Spectrum Management and the Case of GPS

Osher Lifelong Learning Institute, GMU
Science and Technology Class

Dana J. Johnson, Ph.D.

14 April 2009

Overview



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)

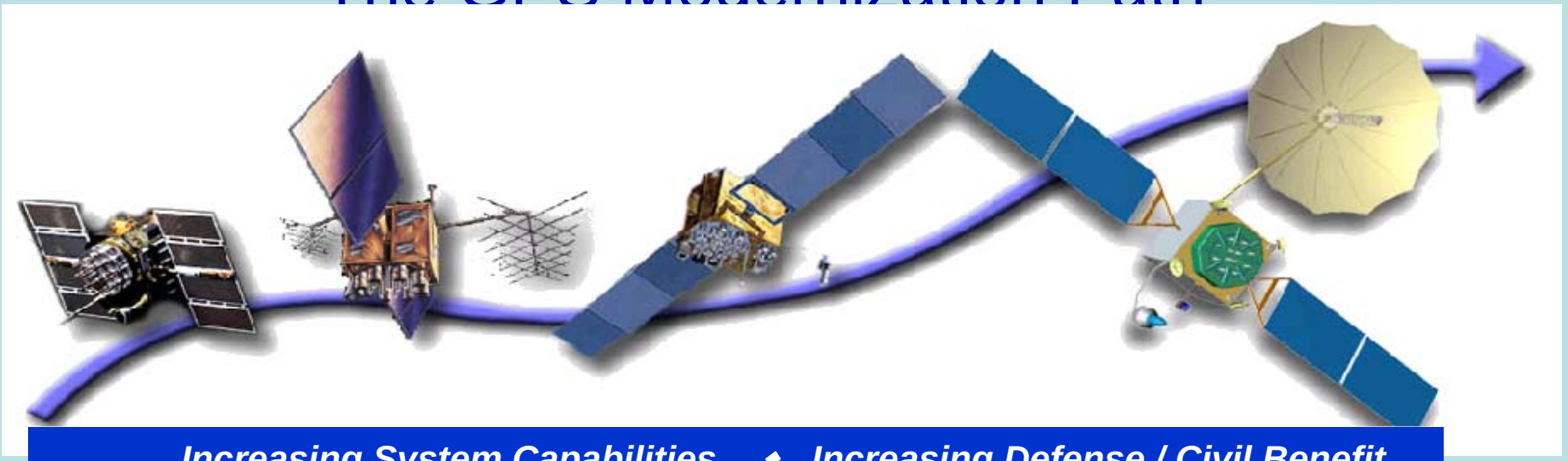
GPS Constellation and Operational Concept

GPS Constellation

GPS Operational Concept

Source: Defense Science Board Task Force, *The Future of the Global Positioning System*, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington, D.C., October 2005, pp. 26, 28.

The GPS Modernization Path



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

Block 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


Precision Agriculture


Surveying & Mapping


Aviation


Communications


Disease Control


Power Grids


Trucking & Shipping


Oil Exploration

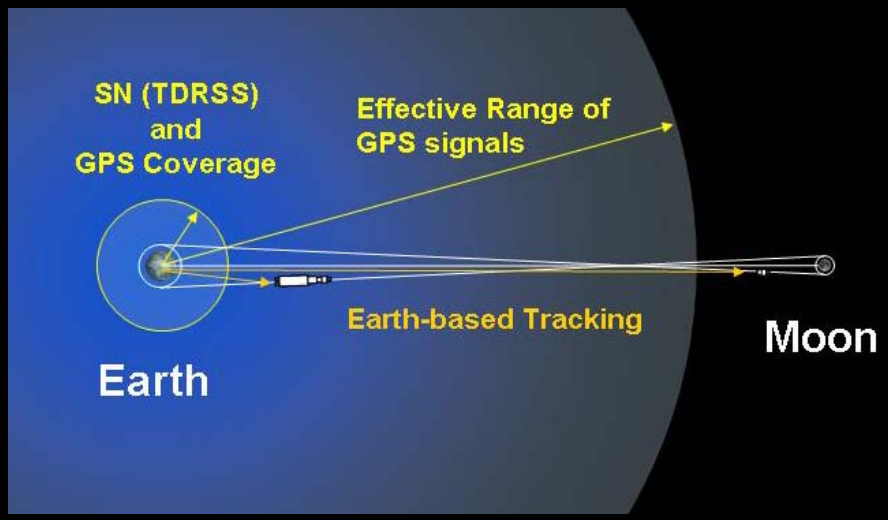

Fishing & Boating


Personal Navigation

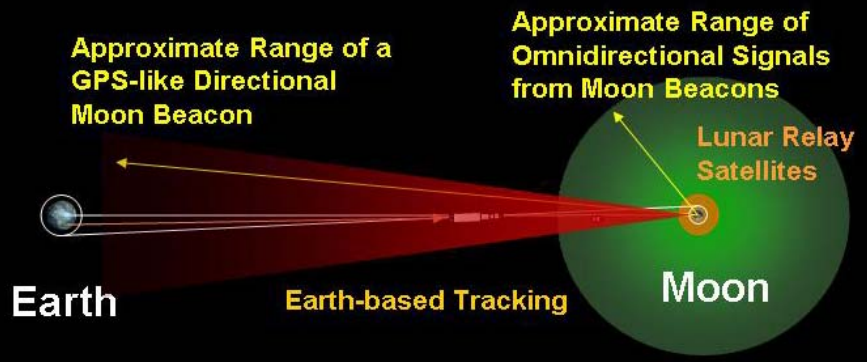
Source: PNT National Coordination Office, February 2009.

Options for PNT in Space

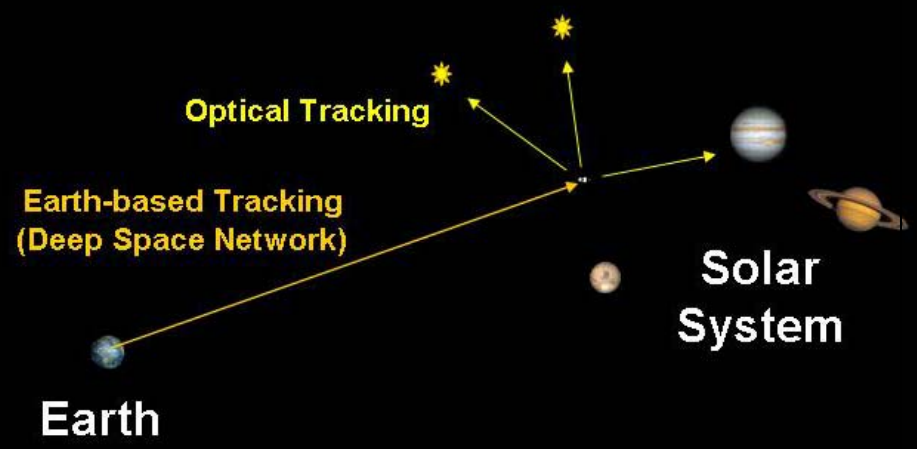
Earth Surface to Cislunar Space



Lunar Space



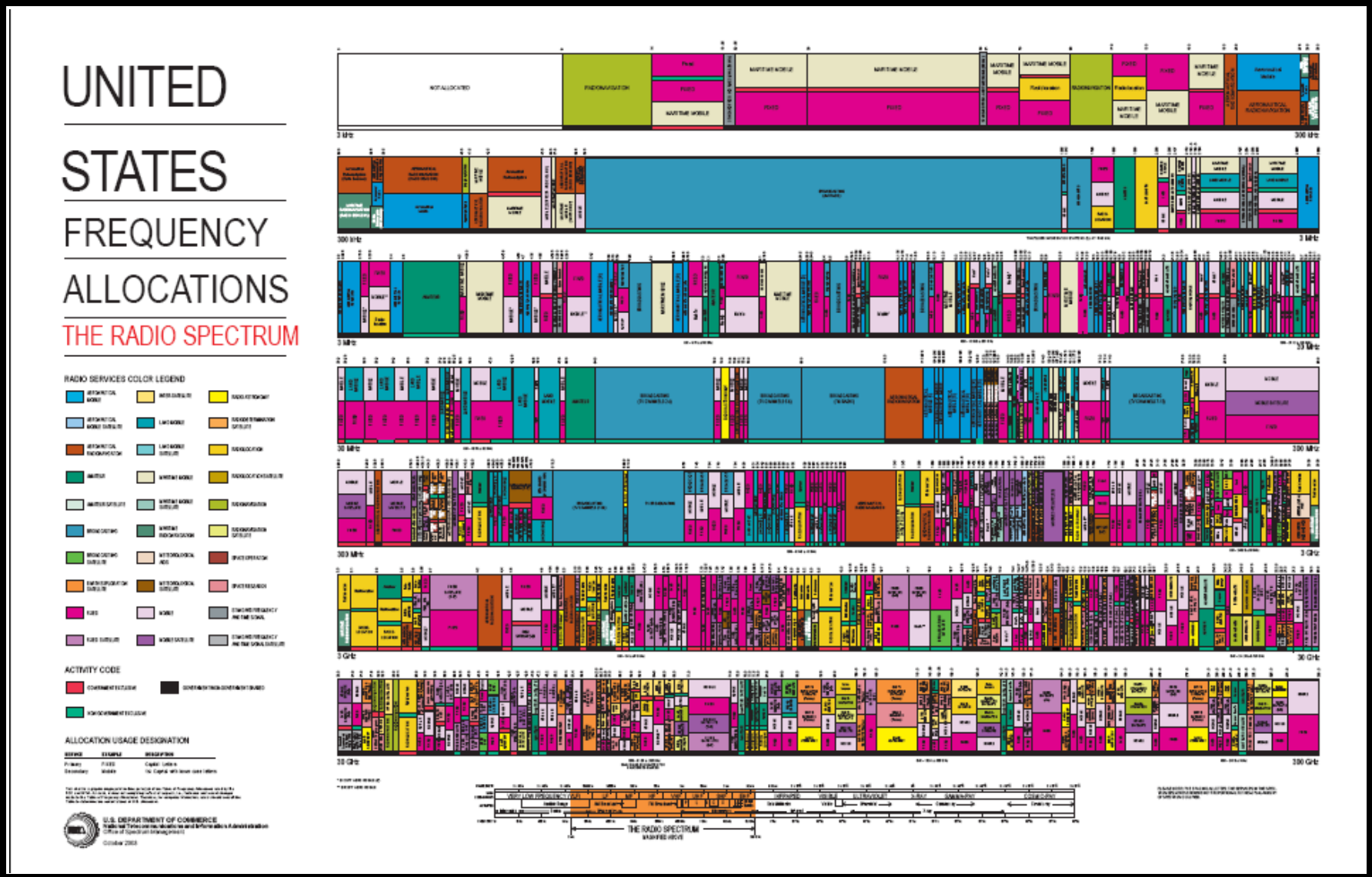
Deep-Space Navigation

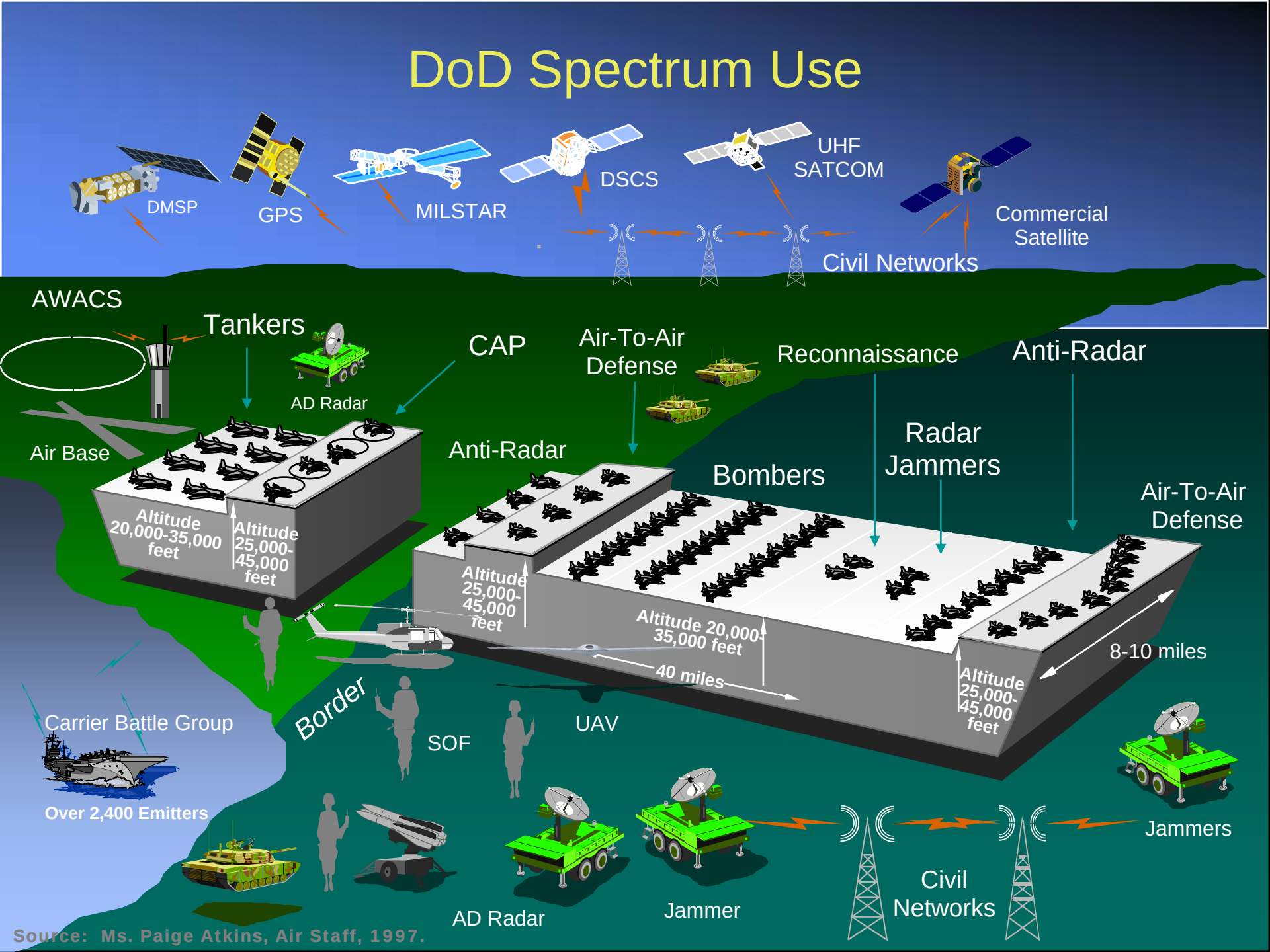


Enabling Technologies, including,

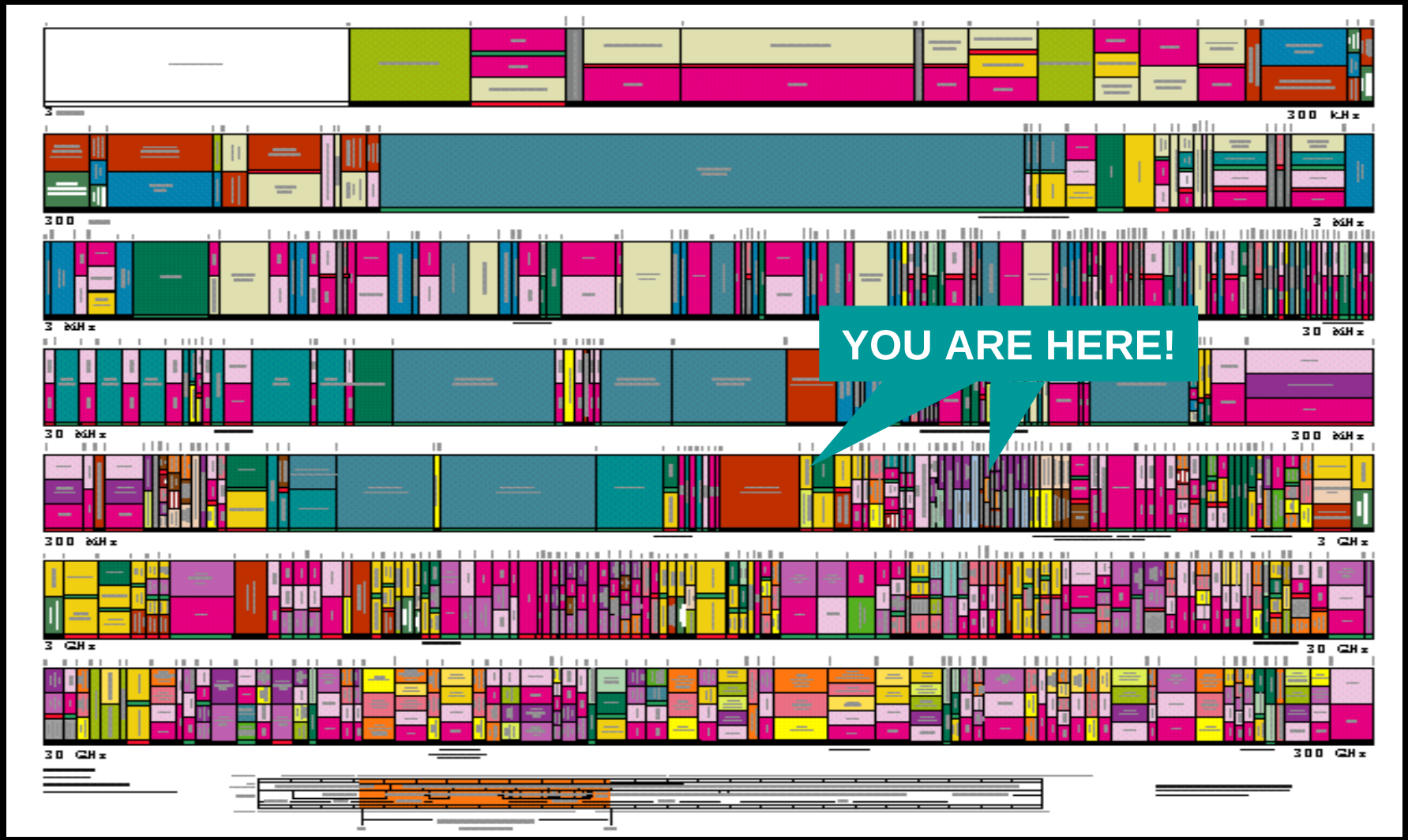
- Improved flight dynamics / trajectory modeling
- Space-qualified Atomic Clocks
- Appropriate relativistic time transformations
- Accurate geodetic reference frames (using VLBI, satellite laser ranging, etc. techniques)
- GPS/GNSS monitoring and distribution of differential corrections and integrity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

All Spacecraft, Including GPS, Communicate Using Spectrum




DoD Spectrum Use
DMSP
GPS
MILSTAR
DSCS
UHF SATCOM
Commercial Satellite
Civil Networks
AWACS
Tankers
AD Radar
CAP
Air-To-Air Defense
Reconnaissance
Anti-Radar
Air Base
Anti-Radar
Radar Jammers
Bombers
Air-To-Air Defense
Altitude 20,000-35,000 feet
Altitude 25,000-45,000 feet
Altitude 25,000-45,000 feet
Altitude 20,000-35,000 feet
40 miles
Altitude 25,000-45,000 feet
8-10 miles
Carrier Battle Group
Over 2,400 Emitters
Border
SOF
UAV
Jammers
AD Radar
Jammer
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…

ASSURE SERVICE	Provide uninterrupted availability of PNT services
MEET DEMANDS	Meet growing national, homeland, economic security, and civil requirements, and scientific and commercial demands
LEAD MILITARILY	Remain the pre-eminent military space-based PNT service
STAY COMPETITIVE	Continue to provide civil services that exceed or are competitive with foreign civil space-based PNT services and augmentation systems
INTEGRATE GLOBALLY	Remain essential components of internationally accepted PNT services
LEAD TECHNICALLY	Promote U.S. technological leadership in applications involving space-based PNT services

2006 U.S. National Space Policy Provides Guidance for Spectrum Management

- 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)

Congress

US Federal Government

President

Civil Sector Spectrum

Federal Spectrum

FCC
- Chair (Pres appointee)

Coordination

NTIA
- Asst Sec'y of Commerce

DoD

Dept of State

Federal Dept/ Agency

Commercial

Liaison

IRAC
- 20 Federal agencies

JCS

Non-Allied Countries

MILDEPs

Combatant Commands

Allied Countries

*** IRAC Members:**

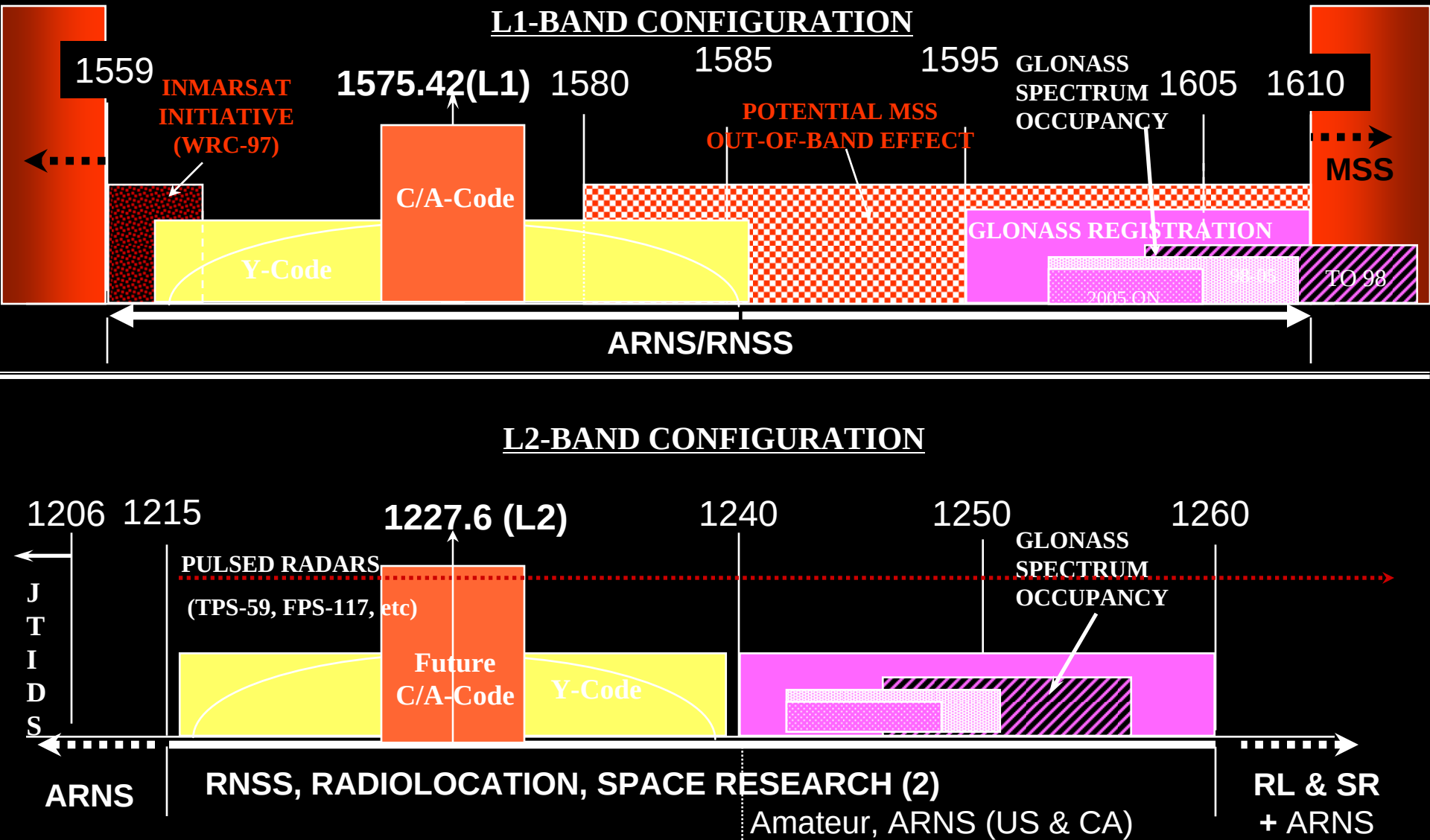
Dept of Army	Dept of Health and Human Services
Dept of Navy	Dept of Justice
Dept of Air Force	Dept of Veteran Affairs
Dept of Agriculture	Federal Aviation Administration
Dept of Commerce	Federal Emergency Management Agency
Dept of Energy	General Services Administration
Dept of State	National Aeronautics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

FCC: Federal Communications Commission
NTIA: National Telecommunications and Information Administration
IRAC: Interdepartmental Radio Advisory Committee

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

NB: As of c. 2000

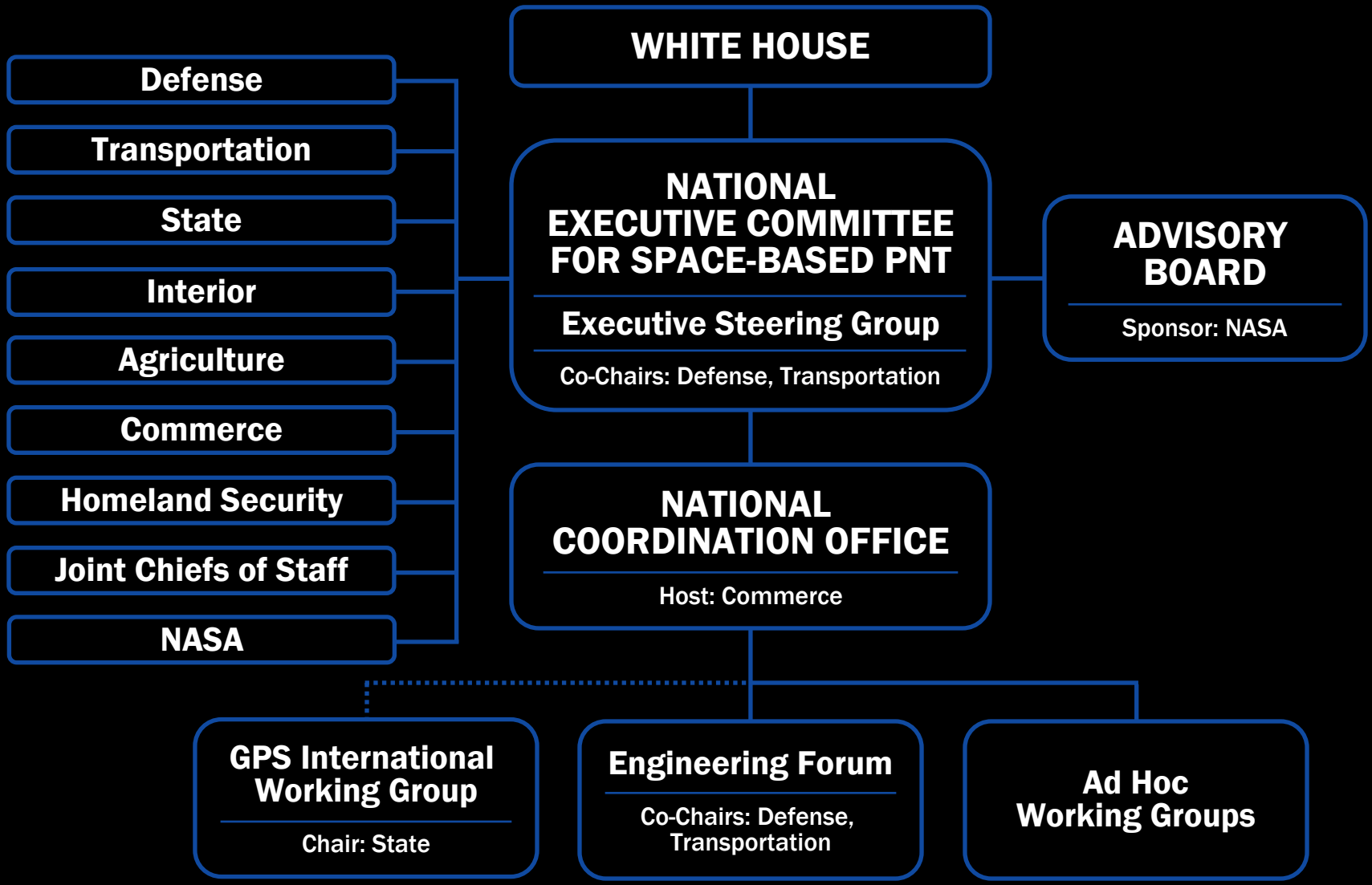
Current RNSS Allocations and Threats to GPS



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



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

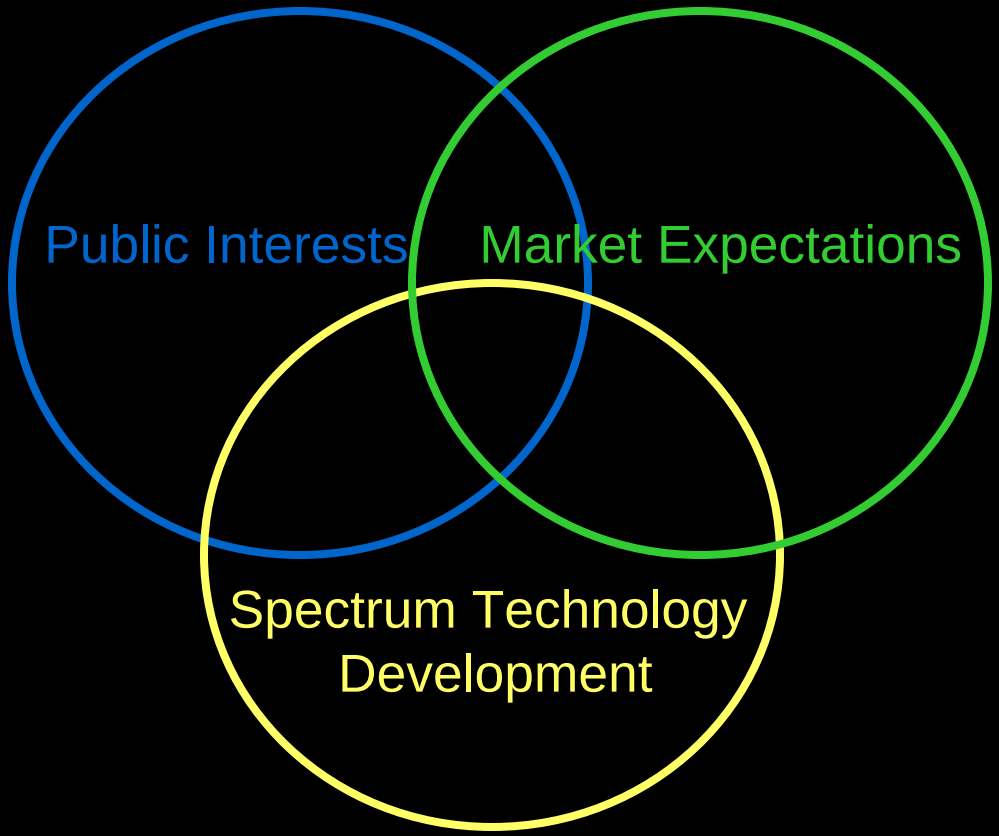
- U.S.-Japan Joint statement on GPS cooperation in 1998
  - Established foundation for stable policy leading to Japan as a global leader in commercial GPS/GNSS markets
  - Japan's Quasi Zenith Satellite System (QZSS) designed to be fully compatible and highly interoperable with GPS
  - U.S. working with 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

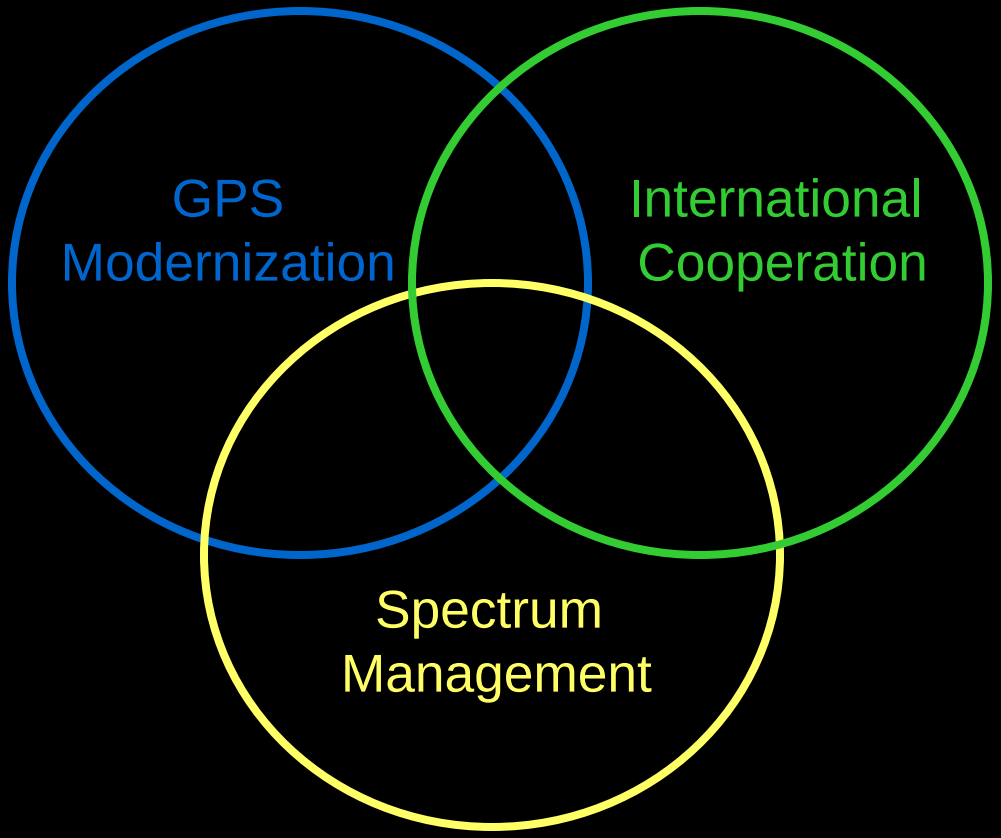
- Promotes GNSS use and integration into infrastructures, particularly in developing countries
- Encourages system compatibility, interoperability
- Membership: GNSS providers, international organizations and associations
- Providers Forum
  - United States, Europe, Russia, China, India, Japan
  - Focused 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)


Public Interests
Market Expectations
Spectrum Technology Development

The Way Forward



DISCUSSION