



SPACE-BASED POSITIONING
NAVIGATION & TIMING
NATIONAL COORDINATION OFFICE

U.S. GPS Program and Policy Update

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26th SBAS International Working Group
New Delhi, India
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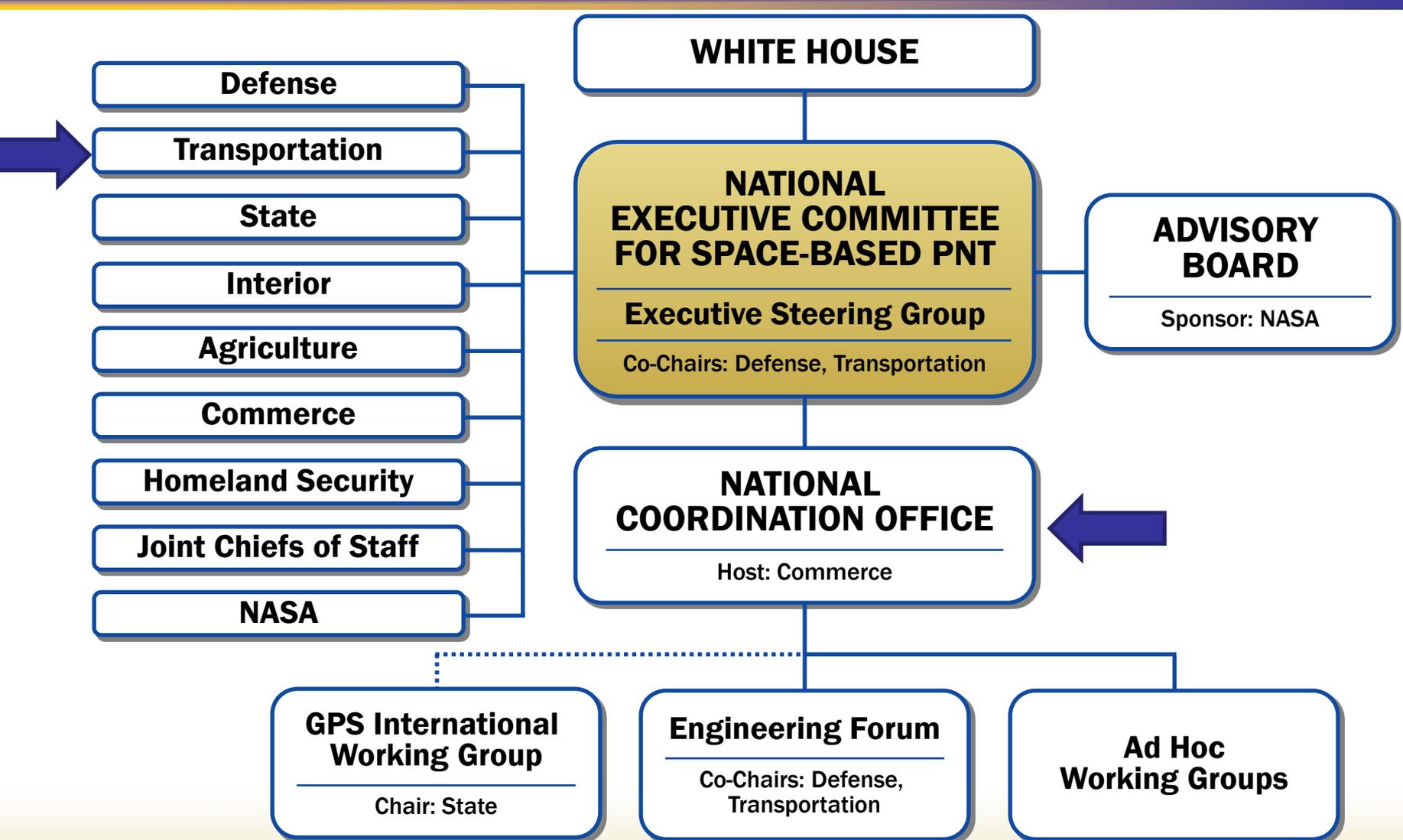
Overview



- **U.S. Space-Based PNT Policy**
- **Global Positioning System Status**
- **Space System Modernization**
- **Ground System Modernization**
- **International Interoperability**



U.S. Space-Based PNT Organization Structure





U.S. National Space Policy 2010



- Provide continuous worldwide access to GPS for peaceful uses, free of direct user charges
- Encourage global compatibility and interoperability with other States' GNSS and promote transparency in the provision of civil services
- Operate and maintain constellation to satisfy civil and national security needs
- ***Other States' GNSS services may be used to complement GPS services***
- Invest in domestic capabilities and support international activities to detect, mitigate and increase resiliency to harmful interference

U.S. policy on civil GPS access has been stable and consistent for 30 years



U.S. Position on GNSS Intellectual Property



- **United States has a longstanding commitment to provide civil open service signals, and technical information necessary to develop and build equipment to use these signals, available worldwide to users at no direct cost (principle of transparency)**
- **All intellectual property for U.S. GPS civil signal designs and their broadcast from GPS are in the public domain**
- **Encourage other GNSS providers to make their signals available in same manner**
- **Those entities that wish to patent technologies or techniques that are specific to receiver design and application development are free to do so**
- **Approach maximizes private sector innovation and has promoted new applications and great economic benefits**



PNT Critical Infrastructure Resiliency



- **Critical Infrastructure sector dependencies on satellite navigation assessed 2010 - 2012**
 - Communications (e.g. cellular phone tower synchronization)
 - Energy (e.g. power grid synchronization)
 - Emergency Services (e.g. location)
 - Transportation Systems (NextGen)
- <http://www.gps.gov/news/2013/05/2013-05-NRE-public-summary.pdf>
- **February 2013 Presidential Policy Directive 21 and Executive Order 13636 address critical infrastructure**
- **Ongoing interagency activities are addressing critical infrastructure sectors' use of GPS/GNSS and needs for critical infrastructure resiliency**



GNSS Spectrum Challenges



- **2010 & 2013 Presidential Memorandums**
 - 500 MHz broadband initiative, with sharing
- **LightSquared, Dish, Globalstar**
 - Multiple broadband companies with filings near GPS
- **National Advanced Spectrum & Communications Test Network (NASCTN)**
 - Facilitate and Coordinate: testing and evaluation of spectrum sharing capabilities
- **GPS Adjacent Band Compatibility Assessment (DOT)**
 - Determining adjacent band power limits

Spectrum Protection Issues Continue for GPS/GNSS and Have National-Level Attention



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- **U.S. Space-Based PNT Policy**
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Fourth GPS IIF Satellite Launch



Satellite Vehicle Number 66 (PRN 27)

Launched May 15, 2013

Set healthy June 21, 2013



Next planned launch: February 20, 2014



GPS Constellation Status



31 Operational Satellites **Baseline Constellation: Expandable 24+3**

- 8 Block IIA
- 12 Block IIR
- 7 Block IIR-M
 - Transmitting L2C
- 4 Block IIF
 - Transmitting L2C and L5
- 4 Additional satellites in residual status, 1 in test status
- Continuously assessing constellation health to determine launch needs





GPS Civil Commitment



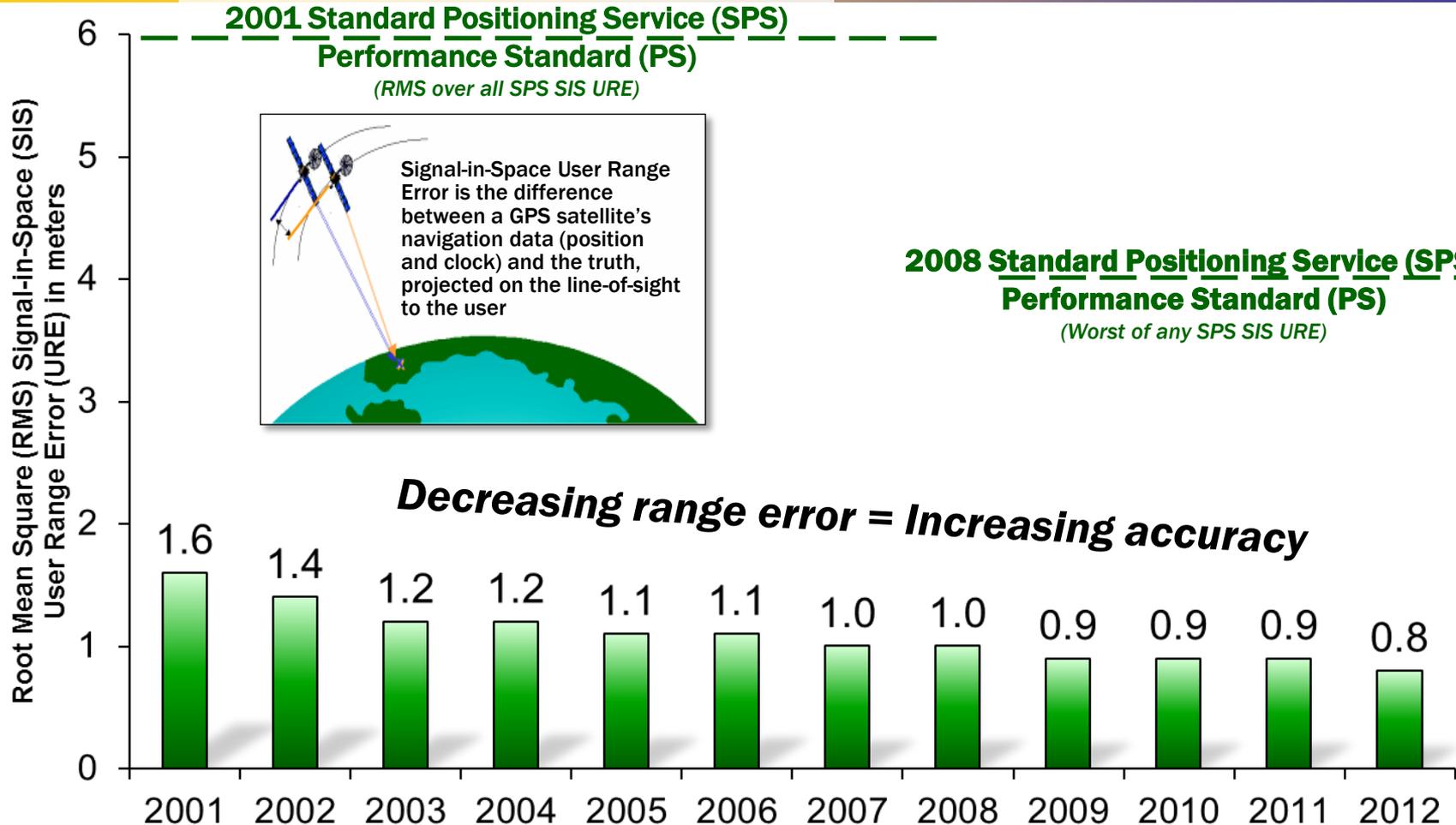
- Global GPS civil service performance commitments met continuously since Dec 1993
- Extensive International and Civil Cooperation
 - Agreements with international customers
 - Public Interface Working Group
 - Published Performance Standards
 - Over 1 billion civil/commercial users
- GPS embedded in all facets of life
 - Aviation, Emergency Services, Timing, Agriculture, Rescue, Automotive, Tracking, Science, Military, Robotics/Control Systems

The GPS Triad Joint GPS User Support Service





Standard Positioning Service (SPS) Signal-in-Space Performance



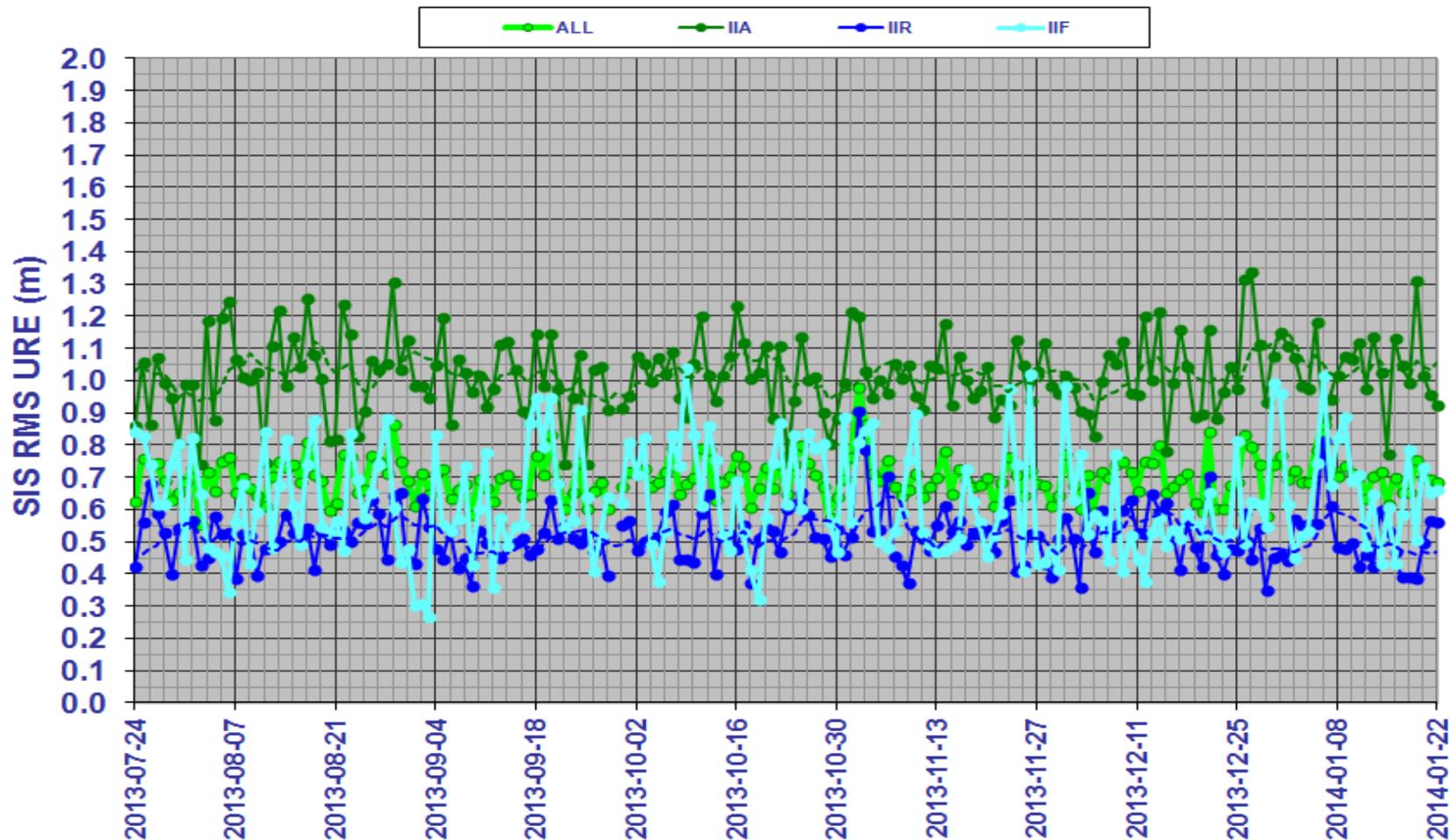
System accuracy exceeds published standard



GPS Performance – Past 6 Months



As-Broadcast SIS vs JPL Real Time





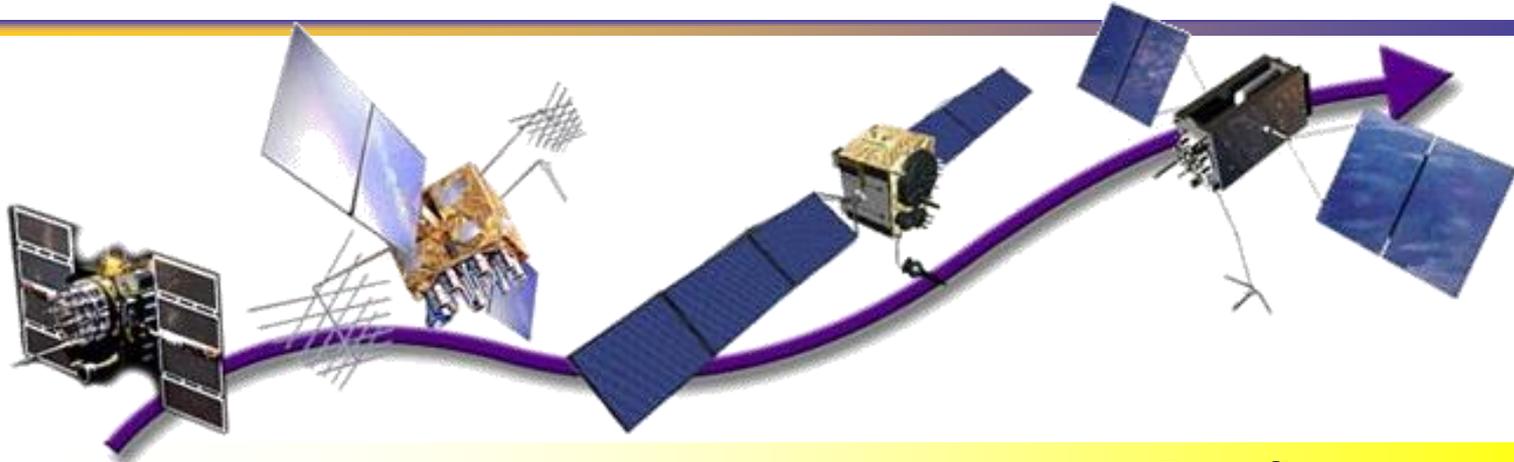
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GPS Modernization Program



Increasing System Capabilities ♦ Increasing User Benefit

GPS IIA/IIR

Basic GPS

- Standard Service
 - Single frequency (L1)
 - Coarse acquisition (C/A) code navigation
- Precise Service
 - Y-Code (L1Y & L2Y)
 - Y-Code navigation

GPS IIR-M, IIF

GPS IIR-M – Basic GPS plus:

- 2nd civil signal (L2C)
- M-Code (L1M & L2M)

GPS IIF – GPS IIR-M capability plus:

- 3rd civil signal (L5)
- 2 Rb + 1 Cs Clocks
- 12 year design life

GPS III

- Backward compatibility
- 4th civil signal (L1C)
- 4x better User Range Error than GPS IIF
- Increased availability
- Increased integrity
- 15 year design life



Modernized Civil GPS Capabilities



2nd Civil Signal (L2C)

Provide dual-frequency civil navigation and extend GPS availability in challenged environments



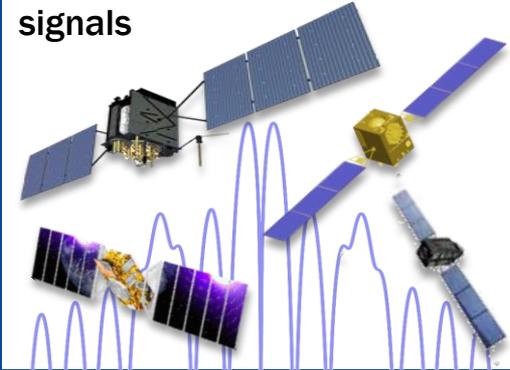
3rd Civil Signal (L5)

Provide dual-frequency and/or triple-frequency civil navigation and safety-of-life signals



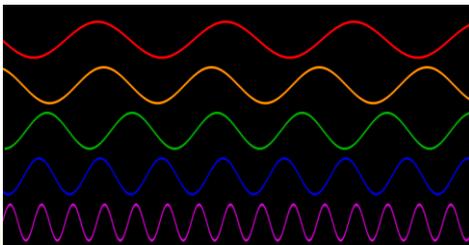
4th Civil Signal (L1C)

Provide internationally harmonized civil navigation signals



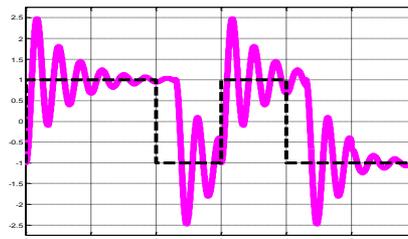
Precision Carrier-Phase Tracking

Dataless pilot channels for precision carrier phase lock loop tracking



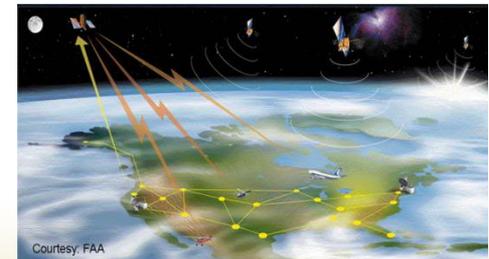
Monitored Integrity

On-board monitoring for clock anomalies, ground monitoring for signal malformation anomalies



External Augmentations

Extend GPS accuracy and integrity for safety-of-life applications





GPS III Status



- **Newest block of GPS satellites**
 - First U.S. satellite to broadcast common L1C signal
 - Multiple civil and military signals; L1 C/A, L1 P(Y), L1M, L1C, L2C, L2 P(Y), L2M, L5
 - Three Rubidium clocks
- **SV01 initial power turn-on 27 Feb 13**
- **GPS Satellite Simulator delivered to support OCX, 21 May 13**
- **GPS Non-Flight Satellite Testbed accomplished launch processing at Cape Canaveral; returned to factory**
- **Final elements of Navigation Payload are in acceptance test**





L2C and L5 CNAV Messages



- **June 2013 GPS CNAV testing publicized in advance through Federal Register notice**
- **First CNAV live-sky test broadcast with civil input**
 - Demonstrated CNAV messaging on GPS IIR-M & GPS IIF SVs (L2C, L5)
 - Focused on basic PNT functionality
- **Broadcast populated messages for two weeks**
 - Contents included: CNAV ephemeris, clock, almanac, and non-navigation message types
- **Opportunity to identify or explore any CNAV message issues in order to implement fixes before operations**
- **Interagency team now focused on operational availability of L2C and L5 CNAV messages prior to OCX implementation**



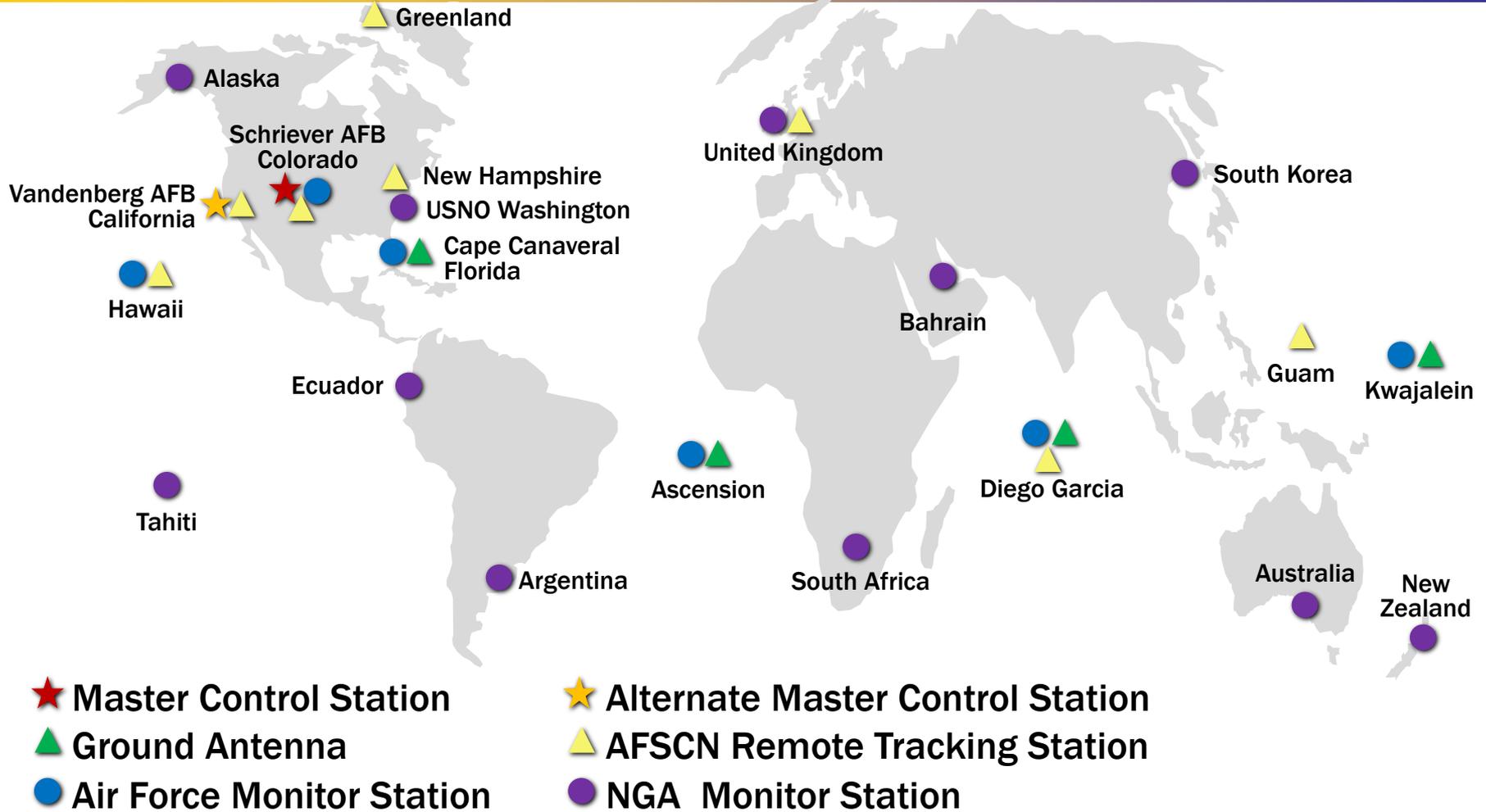
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GPS Operational Control Segment

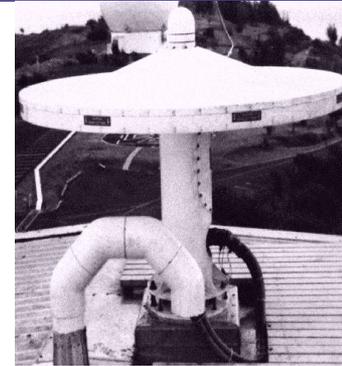




GPS Modernized Ground System



- Current system Operational Control Segment (OCS) now flying GPS IIA/IIR/IIR-M/IIF constellation to provide L1 C/A
- Next Generation Operational Control System (OCX) on track
 - OCX Block 0 (2014) Supports GPS III launch and checkout
 - OCX Block I (Operational capability projected in 2016)
 - Provides operational CNAV for L2C and L5
 - Command & control for GPS IIR/IIR-M/IIF/III
 - OCX Block II (Operational capability projected in 2017)
 - Delivers new international signal (L1C) and M-Code
- OCX to GPS III Integration Status
 - Initiated Hardware in the Loop (HWIL) testing using OCX
 - Communicated with Ground Non-flight Satellite Testbed at Cape Canaveral
 - System Integration demonstrations underway for key system interactions



Monitor Station



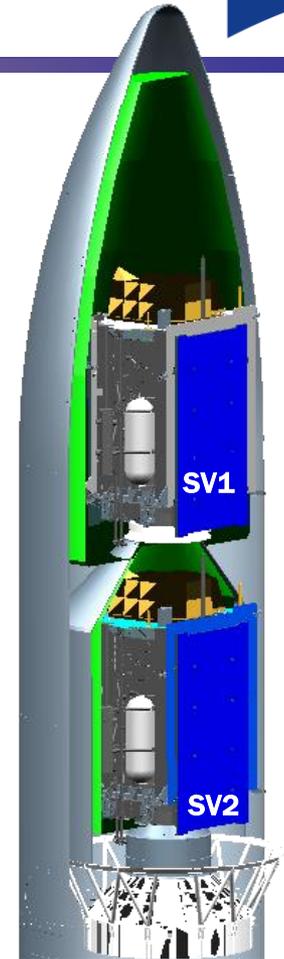
Ground Antenna



Enabling Affordability & Capability



- **Dual Launch significantly reduces launch costs**
 - Studies indicate capability can be provided with minor changes in GPS III SV09+ production line
 - Reduces launch vehicle needs
 - Developing final requirements for dual payload adapter
- **Future Size, Weight, Power (SWAP) considerations**
 - Battery & Solar Array Efficiency, Star Tracker/IMU, More Efficient Amplifiers, etc...
 - Allows SV09+ payload considerations
- **New capability SV9+**
 - Search and Rescue (SAR-GPS) – formerly DASS
 - Laser retroreflectors



Notional
Dual Launch
Configuration on
Atlas V



GPS Augmentation Satellite Study



- **Smaller GPS Navigation Satellites (NavSats)**

- Augments GPS III capabilities

- No secondary payloads
- PNT-only reduces size, weight and power (SWAP)

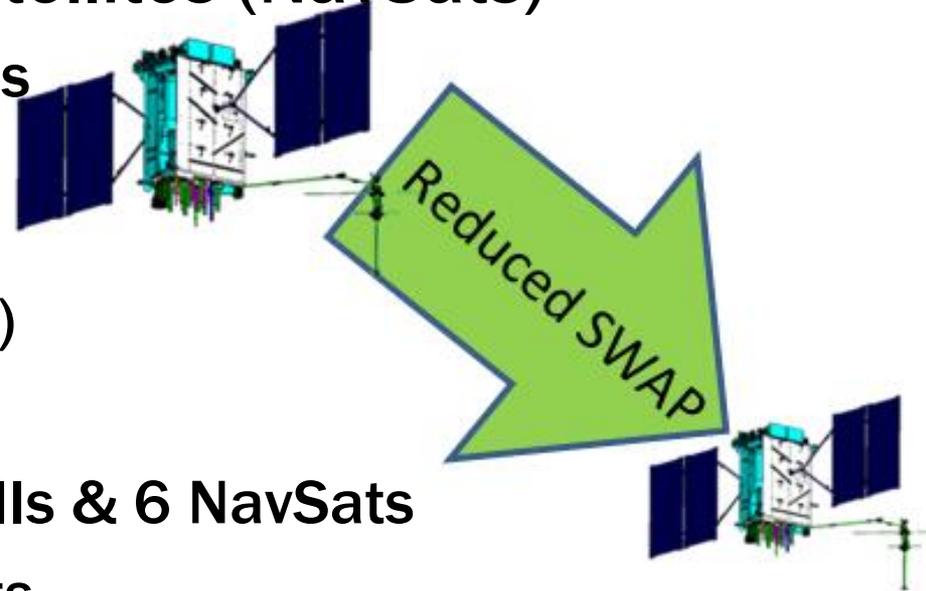
- Increased resiliency

- Constellation of 24 GPS IIIs & 6 NavSats

- Enables reduced launch costs

- Multiple launch capability
- Commercial launch capability

- **Congressionally mandated report submitted**



Demonstration Phase Not funded



Overview



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- **International Interoperability**



- **Established under the umbrella of the United Nations, promotes cooperation on matters of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services**
- **Members include: GNSS Providers (U.S., EU, Russia, China, India, Japan), Other Member States of the United Nations, International organizations/associations**
- **Multi-GNSS Monitoring Subgroup approved Jun 2012**
 - **Identifying service parameters that should be monitored**
 - **identifying monitoring methods and level of monitoring**
 - **Potential mechanism to support APNT**
- **8th ICG met in Dubai, UAE Nov 9-14, 2013**
- **9th ICG Nov 10-14, 2014 in Prague, Czech Republic**

<http://www.oosa.unvienna.org/oosa/SAP/gnss/icg.html>



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



- Ensure **compatibility** — ability to use multiple States' GNSS services separately or together without interfering with each individual service or signal to achieve radio frequency compatibility
- Achieve **interoperability** — ability to use multiple States' GNSS services together to provide the user better capabilities than would be achieved by relying solely on one service or signal
 - Primary focus is on common L1C and L5 signals
- Principle of **transparency**: every GNSS provider should publish documentation that describes: signal and system information, the policies of provision and the minimum levels of performance offered for its open services
- Consider the perspective of various user applications and equipment manufacturers
- Ensure a level playing field in the global marketplace

***Pursue through Bilateral
and Multilateral Cooperation***



Avionics Modernization and International Harmonization



- **Air Traffic Management operations based upon Performance-Based Navigation (PBN) maximize interoperability**
 - Recognition of aircrafts' certified performance capabilities precludes operational need for Mandates
- **Cooperation on development of Dual-Frequency/Multi-Constellation (DFMC) avionics:**
 - Enables enhanced GNSS performance to optimize aviation capabilities
 - Accelerates aviation use of other States' GNSS in conjunction with GPS
 - Essential for implementation:
 - GNSS Provider Performance commitments
 - Thorough signal interface control documents
 - Internationally accepted avionics minimum operational performance standards (MOPS)
- **U.S. desires to continue an open dialogue in support of aircraft and avionics manufacturers**



Summary



- **GPS constellation is robust with 31 usable satellites**
- **Continuously increasing accuracy and capabilities**
- **Modernization of all GPS segments is on track**
 - Pursuing innovative, cost-effective improvements
- **Striving to improve international GNSS cooperation**
- **Next generation dual-frequency, multi-constellation avionics can facilitate and optimize global PBN implementation**
 - GNSS provider and manufacturer commitments are essential for progressing development of next generation avionics



For Additional Information and copy of this brief...



The screenshot shows the GPS.gov website with the following elements:

- Browser address bar: www.gps.gov/internationals/
- Language selection menu: English, Español, Français, 中文, عربي (circled in red)
- Header: GPS.gov Official U.S. Government information about the Global Positioning System (GPS) and related topics
- Navigation menu: HOME, WHAT'S NEW, SYSTEMS, APPLICATIONS, GOVERNANCE, MULTIMEDIA, SUPPORT
- Left sidebar menu: For General Public, For News Media, For Congress, For Internationals (circled in red), For Professionals, For Students
- Main content area: "U.S. and UK Reach Understanding on GPS Patents" with a "LEARN MORE..." link
- Section: "Multilingual Content" with links for Español and 中文
- Section: "GPS Cooperation with Other Nations" with a list of countries: Australia, China, Europe, India, Japan, Russia, United Kingdom, International Committee on GNSS, Other International

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Dhanyavaad



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