



**SPACE-BASED POSITIONING  
NAVIGATION & TIMING**  
NATIONAL COORDINATION OFFICE

# **U.S. Space-Based Positioning, Navigation and Timing (PNT)**

**China Satellite Navigation Conference 2017  
Shanghai, China  
24 May 2017**

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Director**



# U.S. National Space Policy

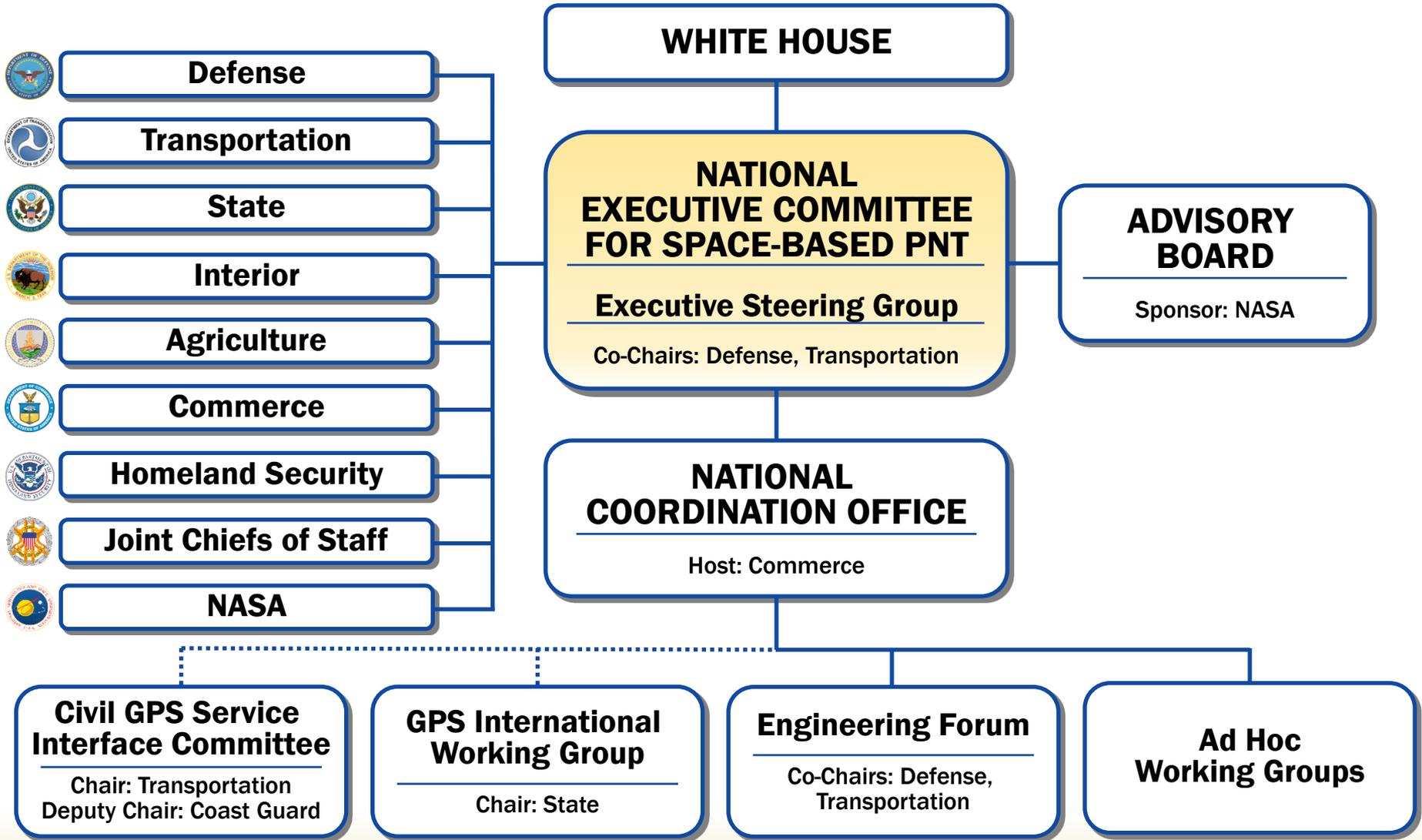


## *Space-Based PNT Guideline: Maintain leadership in the service, provision, and use of GNSS*

- **Provide continuous worldwide access to GPS for peaceful uses, free of direct user charges**
- **Engage with foreign GNSS providers on compatibility, interoperability, transparency, and market access**
- **Operate and maintain GPS constellation to satisfy civil and national security needs**
  - Foreign PNT may be used to strengthen resiliency
- **Invest in domestic capabilities and support international activities to detect, mitigate, and increase resiliency to harmful interference**



# National Space-Based PNT Organization





# GPS Signal in Space Performance Scoreboard



## GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM)

**BEST WEEK**

**BEST DAY**

**WORST DAY**

**ENDING SIS**

**DATE SIS**

**DATE SIS**

**ROLLING YEAR**

**14 APR 16 45.3**

**11 MAY 16 36.5**

**19 DEC 15 70.3**

**BEST WEEK EVER**

**14 APR 16**

**45.3**

RMS across all healthy satellites





# Constellation Snapshot



**36 Total Satellites / 31 Operational**  
(Baseline Constellation: 24)

## Four Generations of Operational Satellites

- **Block IIA - 4 Residual**
  - 7.5 year design life
  - Launched 1990 to 1997
- **Block IIR - 12 Operational**
  - 7.5 year design life (oldest operational satellite is 19 years old)
  - Launched 1997 to 2004
- **Block IIR-M - 7 Operational, 1 Residual**
  - 7.5 year design life
  - Launched 2005 to 2009
  - Added 2nd civil navigation signal (L2C)
- **Block IIF - 12 Operational**
  - 12 year design life
  - Launched 2010 to 2016
  - Added 3rd civil navigation signal (L5)



Block IIA Satellite – Designed & Built by Rockwell International



Block IIR/IIR-M Satellite – Designed & Built by Lockheed Martin



Block IIF Satellite – Designed & Built by Boeing



# GPS III



- **GPS III is the newest block of GPS satellites**
  - 4 civil signals: L1 C/A, L1C, L2C, L5
    - First satellites to broadcast common L1C signal
  - 4 military signals: L1/L2 P(Y), L1/L2M
  - 3 improved Rubidium atomic clocks
- **SV01-SV10 on contract**
  - Resolved technical challenges with payload
  - SV9-10 same requirements baseline as SV01-08
- **Current Status**
  - SV01 Placed into storage Feb 17
  - SV02/03 In Assembly and Integration
  - SV04 thru 08 in box level assembly



***First GPS III Launch No Earlier Than Mar 2018***

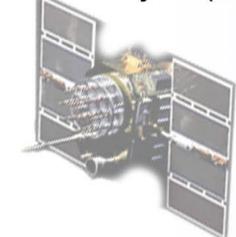


# GPS Modernization

## Space System (Satellites)

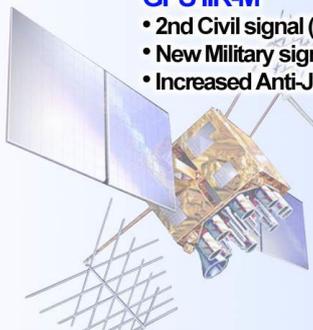
### Legacy (GPS IIA/IIR)

- Basic GPS
- NUDET (Nuclear Detonation) Detection System (NDS)



### GPS IIR-M

- 2nd Civil signal (L2C)
- New Military signal
- Increased Anti-Jam power



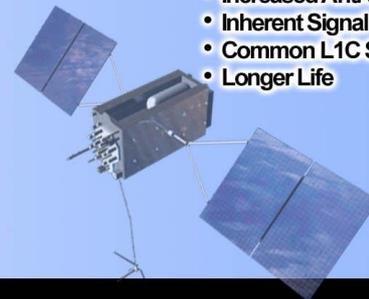
### GPS IIF

- 3rd Civil Signal (L5)
- Longer Life
- Better Clocks



### GPS III

- Accuracy & Power
- Increased Anti-Jam power
- Inherent Signal Integrity
- Common L1C Signal
- Longer Life



## Ground System

### Legacy (OCS)

- Mainframe System
- Command & Control
- Signal Monitoring

### AEP

- Distributed Architecture
- Increased Signal Monitoring Coverage
- Security
- Accuracy
- Launch And Disposal Operations



### OCX Block 1

- Fly Constellation & GPS III
- Begin New Signal Control
- Upgraded Information Assurance

### OCX Block 2+

- Control all signals
- Capability On-Ramps
- GPS III Evolution

### OCX Block 0

- GPS III Launch & Checkout

### GPS III Contingency Ops (COPs)

- GPS III Mission

## User Equipment System (Receivers)

### Legacy (PLGR/GAS-1/MAGR)

- First Generation System



### User Equipment

- Improved Anti-Jam & Systems
- Reduced Size, Weight & Power

### Upgraded Antennas

- Improved Anti-Jam Antennas



### Modernized

- M-Code Receivers
- Common GPS Modules
- Increased Access/ Power with M-Code
- Increased Accuracy
- Increased Availability
- Increased Anti-Tamper/ Anti-Spoof
- Increased Acquisition in Jamming



# 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
- Promote fair competition in the global marketplace

*Pursue through Bilateral and Multilateral Cooperation*



# Bilateral GNSS Cooperation



- **Europe: GPS-Galileo Cooperation Agreement signed 2004**
  - Working Group on Next Generation GPS/Galileo Civil Services meets twice per year – most recent meeting Oct. 2016
  - Working Group on Trade & Civil Applications met Mar. 2016
  - PRS access negotiations are under way
- **China: Most recent civil GNSS Plenary – Jun. 2015**
  - Sub-group on compatibility and interoperability met Sep. 2016 in Portland
  - GNSS discussed at U.S.-China Civil Space Dialogue – Oct. 2016
- **Japan: Civil Space Dialogue held in Washington, D.C. – May 15, 2017**
  - U.S. hosts QZSS monitoring stations in Hawaii and Guam
- **India: Civil Space Joint Working Group Meeting in Bangalore – Sep. 2015**
  - ITU compatibility coordination completed



# ICG-11: Significant Accomplishments and Recommendations



- **Interference Detection and Mitigation (IDM) & Spectrum Protection**
  - Recommendation for Providers to promote the implementation of protection measures of GNSS operations around the world
- **International Multi-GNSS monitoring (IGMA)**
  - Recommendation for an ICG workshop to be held in May 2017 to discuss the multi-GNSS monitoring trial project established in 2016 between the ICG and IGS, and discuss the need for GNSS signal quality monitoring
- **Interoperability – Timing**
  - Recommendation for ICG expert level workshop to be held in 2017 to further discuss GNSS system time offsets among the systems
- **Space Weather**
  - Discussion about ionospheric models – will be further discussed at future ICG meetings
- **Space Service Volume (SSV)**
  - SSV Booklet to be released in early 2017 – results of completed simulations used to develop definitions and assumptions for an interoperable SSV



# Summary



- **U.S. policy encourages the worldwide use of civil GPS services and cooperation with other GNSS providers**
  - **Compatibility, interoperability, and transparency in civil service provision are priorities**
- **GPS performance continues to improve beyond published commitments**
- **Ongoing GPS modernization is adding new capabilities for user benefits**
- **The ICG, with strong U.S. participation, continues to pursue a Global Navigation Satellite System-of-Systems to provide civil GNSS services that benefit users worldwide**



# Thank You

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**GPS BULLETIN**  
*Information for Policymakers from the National Coordination Office for Space-Based Positioning, Navigation, and Timing (PNT)*  
 March 29, 2017

**Update on Fiscal Year 2017 GPS Appropriations**

On March 9, the House passed H.R. 1301, the revised Department of Defense appropriations bill. The measure would increase overall FY 2017 funding for the GPS program above President Obama's request.

Program Line Item	President's Request	H.R. 1301
Space Procurement: GPS III Satellites	\$34.059M	\$34.059M
Development: GPS III Satellites	\$141.888M	\$171.888M
Development: Next Generation Operational Control System (OCX)	\$393.268M	\$393.268M
Development: Military GPS User Equipment (MGUE)	\$278.147M	\$309.047M
<b>TOTAL</b>	<b>\$847.362M</b>	<b>\$908.032M</b>

[View full details at GPS.gov](#)

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**GPS Backup Discussed at Senate Hearing**

At a March 22 hearing held by the Senate Subcommittee on Oceans, Atmosphere, Fisheries, & Coast Guard (OAFRCG) on the State of the Coast Guard, the Coast Guard Commandant responded to questions regarding a GPS backup.

[View hearing information at senate.gov](#)  
 (The discussion on GPS backup begins at 1:22:09 in the video)

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**GPS Act Reintroduced**

In February, Sen. Ron Wyden (D-OR) and Rep. Jason Chaffetz (R-UT) reintroduced the Geolocation Privacy and Surveillance Act ("GPS Act," S. 395 and H.R. 1062). The legislation seeks to provide clarity for government agencies, commercial service providers, and the public regarding the legal procedures and protections that apply to electronic devices that can be used to

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