Global Positioning Systems Directorate

GPS Status & Modernization Progress: Service, Satellites, Control Segment, and Military GPS User Equipment

CGSIC / ION GNSS+
25-29 Sep 2017

Col Steve Whitney, Director
Global Positioning Systems Directorate
GPS Enterprise Operational View

SPACE SEGMENT
- SV Families Provide S-Band / L-Band Telemetry To Control and User Segments
- Applies Space and Control Segment Data for Position, Navigation & Timing

USER SEGMENT
- S-band Uplink/Downlink
- L-band Downlink (Navigation Services)

CONTROL SEGMENT
- Telemetry, Tracking and Commanding (TT&C) of Space Segment Assets
- Distributes Data of Interest to the External Interfaces of the User Segment

Alternate Master Control Station (located at VAFB): Backup Facility to MCS
Alternate MCS

Master Control Station (operated by 25OPS at SAFB): Responsible for TT&C, on-orbit healthy operations (Nav and NDS payloads)

Operational Control System (OCS)
- Next Generation Operational Control System (OCX)

Ground Antennas
MCS

Uplinks data to SVs
Monitor Stations

Includes NGA, AFSCN, HANU, ICADS, GIN, USNO, AFTAC, OSS, IMOSC, etc.

Receivers that continuously collect GPS data from all the satellites in view

External Interfaces
GPS Overview

**Department of Defense**
- Services (Army, Navy, AF, USMC)
- Agencies (NGA & DISA)
- US Naval Observatory
- PNT EXCOM
- GPS Partnership Council

**International Cooperation**
- 57 Authorized Allied Users
- 25+ Years of Cooperation

**GNSS**
- Europe - Galileo
- China - Beidou
- Russia - GLONASS
- Japan - QZSS
- India - NAVIC

**Civil Cooperation**
- 3+ Billion civil & commercial users worldwide
- Search and Rescue
- Civil Signals
  - L1 C/A (Original Signal)
  - L2C (2nd Civil Signal)
  - L5 (Aviation Safety of Life)
  - L1C (International)

**Department of Transportation**
- Federal Aviation Administration

**Department of Homeland Security**
- U.S. Coast Guard

**Spectrum**
- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements
- Adjacent Band Interference

**35 Satellites / 31 Set Healthy**
**Baseline Constellation: 24 Satellites**

<table>
<thead>
<tr>
<th>Satellite Block</th>
<th>Quantity</th>
<th>Average Age</th>
<th>Oldest</th>
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<tr>
<td>GPS IIR</td>
<td>12</td>
<td>15.7</td>
<td>20.1</td>
</tr>
<tr>
<td>GPS IIR-M</td>
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<td>10.1</td>
<td>11.9</td>
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<tr>
<td>GPS IIF</td>
<td>12</td>
<td>3.6</td>
<td>7.3</td>
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<tr>
<td>Constellation</td>
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<td>20.1</td>
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</table>

AS OF 1 SEP 17
2013-2016 performance reports now available on gps.gov

These reports measure GPS performance against GPS SPS commitments

Reports generated by Applied Research Laboratories at the University of Texas at Austin

### GPS Performance Report Cards

<table>
<thead>
<tr>
<th></th>
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<td>✓</td>
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<tr>
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<tr>
<td>SIS Continuity</td>
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</table>
GPS SIS Performance Scoreboard

GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM)

**BEST WEEK**
- Ending SIS: 29 Nov 16 - 44.1

**BEST DAY**
- Ending SIS: 26 Jan 17 - 35.0

**WORST DAY**
- Ending SIS: 15 Jun 17 - 69.7

**BEST WEEK EVER**
- 29 Nov 16 - 44.1

*ROLLING YEAR*
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 (SV01-10)**
- Accuracy & Power
- Increased Anti-Jam power
- Inherent Signal Integrity
- Common L1C Signal
- Longer Life

**GPS III (SV11+)**
- Unified S-Band Telemetry, Tracking & Commanding
- Search & Rescue (SAR) Payload
- Laser Retroreflector Array
- Redesigned NDS Payload
- Regional Military Protect (RMP)

**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 0**
- GPS III Launch & Checkout

**GPS III Contingency Ops (COps)**
- GPS III Mission on AEP

**M-Code Early Use (MCEU)**
- Operational M-Code on AEP

**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

**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
<table>
<thead>
<tr>
<th>GPS III Space Vehicles in Full Production Flow</th>
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<tbody>
<tr>
<td><strong>State of the GPS III Space Vehicles</strong></td>
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<tr>
<td><strong>SV01</strong></td>
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<tr>
<td>L-ASSY</td>
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- **SV01 placed into storage on 28 Feb 17**
  - Factory Mission Readiness Test in Oct 2017; ECD Nov 2017
- **SV02 has begun TVAC**
  - Thermal Vacuum began Mid Sep 2017; ECD Mid Dec 2017
  - PIM/EMI/EMC in Jan 2018
- **SV03 is currently completing Post Mate Activities**
  - SPT starting late Oct 2017; ECD Nov 2017
  - Acoustics Test & Alignments scheduled for Feb 2018
- **SV04 is currently in System Module buildup stage**
  - System Module Performance Test starting in Oct 2017; ECD Nov 2017
  - Core Mate scheduled for Dec 2017
- **SV05 is currently in L-Assembly buildup stage; SV06 begins production in Dec 2017**
### GPS III Acquisition Strategy

**Modernization, Recapitalization, and Resiliency**

#### On Orbit Reprogrammable Digital Payload (ORDWG)
- **High Power Amplifiers (SSPAs)**
- **Regional Military Protection (RMP)**

#### Notional Capability Additions
- **M-Code Space Service Volume**
- **Near Real-Time Commanding/Adv Clocks**
- **Future Enhancements**

#### Future Enhancements
- **AFRL Effort**
- **Space Modernization Initiative**

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- **Targeting 2017 RFP release for competitive production contract for 22 GPS III satellites**

- **Partnerships with AFRL for technology insertion & path to flight**
  - Digital Payloads
  - High Power Amplifiers
  - Advanced Clocks
  - Near Real-Time Commanding/Crosslinks

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**Ensuring the Gold Standard Today and into the future**

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<table>
<thead>
<tr>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>FY22</th>
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<th>FY31</th>
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<th>FY33</th>
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<tbody>
<tr>
<td>SV01 LEC</td>
<td>SV02 LEC</td>
<td>SV03 LEC</td>
<td>SV04 LEC</td>
<td>SV05 LEC</td>
<td>SV06 LEC</td>
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<td>SV12 LEC</td>
<td>SV13 LEC</td>
<td>SV14 LEC</td>
<td>SV15 LEC</td>
</tr>
</tbody>
</table>

- AFSPC/CC SV11 Need Date
- Design Turn NRE & SV11-12 Build - 3600
- Production (6-yr ATP to AFL for SV13) - 3021

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GPS Next Generation Operational Control System (OCX)

- Next-generation C2 and cyber-defense for GPS
  - Worldwide, 24 hr/day, all weather, position, velocity and time source for military & civilian users
  - Improved PNT performance
  - Robust information assurance and cyber security
  - Modern civil signals & monitoring
  - Support to Military Code (M-Code) navigation warfare

- Incremental Development
  - OCX Block 0: launch & checkout for GPS III
  - OCX Block 1 & 2: operate & manage modernized GPS constellation, adds modern features and signals, provide Civil Signal Performance Monitoring

- Current Status: Working through program challenges
  - Nunn-McCurdy Breach declared on 30 Jun 16; OCX recertified in Oct 2016
  - Program focused on improving systems engineering and implementing DevOps/automation
  - First integrated launch rehearsal between GPS III and OCX Block 0 completed Aug 2017 exercising key mission events and establishing crew proficiency
  - AF Satellite Control Network (AFSCN) Ranging Demo in Aug 2017 validated ability to utilize operational AFSCN sites, process live ranging data, compute orbit determination solutions
GPS III Contingency Operations (COps)

- Limited operations for GPS III Space Vehicles until OCX Block 1 delivery
  - Provides legacy and modernized civil signal operations
  - Relies on OCX Block 0 for GPS III launch, major anomaly, and disposal capabilities
  - Available for operations projected in Apr 2019

- Software Development
  - Risk reduction modification to current Operational Control System (OCS)
  - Four incremental software builds planned

- Current Status: on track
  - Build 3 complete and in testing
  - Build 4 preparation underway, planned completion by Dec 2017

COps is a critical bridge, enabling sustainment of legacy signals for GPS III
GPS III SV01 Road To Launch

Mission Rehearsals

Transport

Launch Integration

Readyiness Tests

Launch 2018

GPS Directorate

The Gold Standard

GPS III SV01 Enterprise road to launch – A series of firsts!
Military GPS User Equipment (MGUE)

- Commercial market-driven acquisition approach
- Three vendors developing modernized receiver cards
  - Ground form factor
  - Aviation/Maritime form factor
- Current Status
  - L-3 Technologies first to receive security certification Oct 2016
  - Developmental testing ongoing
  - Conducting early integration activities to support Service-nominated Lead Platforms
MGUE Precision Guided Munitions Test

MGUE Increment 1
First Ever Guide-to-Hit
B-2 MGUE Flight Test
Adjacent Band Compatibility (ABC)

Ensuring GNSS spectrum use for GPS and its multi-GNSS partners

• Publicly-available test reports confirm unacceptable impacts to GPS receivers
  – Air Force tested DoD receivers to assess the impact of adjacent band interference
  – Results support U.S. Department of Transportation conclusions

Help needed: Communicate operational impacts to spectrum regulators
GPS Director’s Perspectives

• GPS is the Global Utility
  – Committed to maintaining uninterrupted service
  – “The Gold Standard”

• Continue to enhance GPS resiliency by:
  – Addressing near-term needs with current efforts
  – Identifying opportunities for resiliency improvements
  – Maturing technical needs for future use

• Appreciate the need for alternative PNT sources, and challenge the community (labs, industry, others) to propose & explore solutions

• Exploring & expanding multi-GNSS potential

Deliver capabilities, execute with excellence, lead with transparency
Acquisition professionals delivering the Gold Standard in Space-Based PNT & NDS Services