Space and Missile Systems Center

Global Positioning Systems Directorate

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

Stanford University Center for Position, Navigation, and Time Symposium

8 November 2017

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

GPS III - SV01-10/11+ Follow-On

HOSTED PAYLOAD:
Deliver advanced capability improving resiliency for all GPS III segments

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

Master Control Station (operated by 2SOPS at SAFB): Responsible for TT&C, on-orbit healthy operations (Nav and NDS payloads)

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

SPACE SEGMENT
SV families provide S-Band/L-Band Telemetry to Control and User Segments

S-Band Uplink/Downlink
L-Band Downlink (Navigation Services)

USER SEGMENT:
Increment 1/Increment 2
Integrates Space and Control Segment data for secure Position, Navigation, Timing and Navigation Warfare effects for U.S. and Foreign Military Sales partner nations

Uplinks data to SVs
External Interfaces

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

MCS

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

Monitor Stations

GPS IIIF

GPS IIR/IIRM

NDS
Uplink/Downlink
NUDET Detection System (NDS)

External Interfaces
GPS Overview

Civil Cooperation
- 1+ 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 Defense
- Services (Army, Navy, AF, USMC)
- Agencies (NGA & DISA)
- US Naval Observatory
- PNT EXCOMS
- GPS Partnership Council

International Cooperation
- 57 Authorized Allied Users
  - 25+ Years of Cooperation
- GNSS
  - Europe - Galileo
  - China - Beidou
  - Russia - GLONASS
  - Japan - QZSS
  - India - IRNSS

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

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As of 1 Nov 17
2013-2016 performance reports now available on gps.gov

These reports measure GPS performance against GPS SPS PS commitments

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

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GPS SIGNAL IN SPACE (SIS) PERFORMANCE

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

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

- **WORST DAY**:
  - **ENDING**: 15 Jun 17
  - **SIS**: 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

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

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

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

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
State of the GPS III Space Vehicles

• 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**

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- **Source Selection**
  - ATP
  - CDR

- **Design Turn NRE & SV11-12 Build** - 3600

- **Production (6-yr ATP to AFL for SV) - 3021**

- **AFSPC/CC SV11 Need Date**

- **AFRL Effort**

- **Space Modernization Initiative**

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

### Key Points

- **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*
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

Readiness Tests

Launch 2018

Launch Integration

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
Military GPS User Equipment

Prototype GPS Receiver Flight Tested on B-2

Prototype Miniaturized Airborne GPS Receiver

4 Successful B-2 Test Flights

Military GPS User Equipment demonstrated in B-2
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
the men and women of the
GLOBAL POSITIONING SYSTEMS DIRECTORATE

Acquisition professionals delivering the Gold Standard in Space-Based PNT & NDS Services