

Space and Missile Systems Center

Global Positioning Systems Directorate

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

PNT Advisory Board
7-8 Dec 2016

Col Gerry Gleckel, Deputy Director
Global Positioning Systems Directorate





Global Positioning Systems Directorate

SPACE AND MISSILE SYSTEMS CENTER



"We are... the Green Monsters!"

Mission:

Professionals acquiring, delivering and sustaining reliable GPS capabilities to America's warfighters, our allies, and civil users

Col Steve Whitney
Director



GPS Overview

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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

Maintenance/Security

- All Level I and Level II
 - Worldwide Infrastructure
 - NATO Repair Facility
- Develop & Publish ICDs Semi-Annually
 - ICWG: Worldwide Involvement
- Update GPS.gov Webpage
- Load Operational Software on over 970,000 SAASM Receivers
- Distribute PRNs for the World
 - 120 for US and 90 for GNSS



Spectrum

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

37 Satellites / 31 Set Healthy Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIR	12	14.9	19.4
GPS IIR-M	7	9.4	11.2
GPS IIF	12	2.9	6.5
Constellation	31	9.0	19.4

AS OF: 2 DEC16

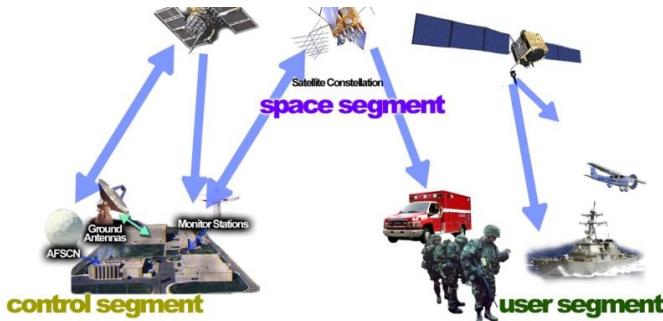


Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

- U.S. Coast Guard



International Cooperation

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



GPS SIS Performance Scoreboard

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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





GPS Performance Report Card

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- 2013 report now available on [gps.gov](http://www.gps.gov)
 - <http://www.gps.gov/systems/gps/performance/>
- This report measures GPS performance against GPS SPS PS assertions

Table 2.1: Summary of SPS PS Metrics Examined for 2013

SPSPS08 Section	SPS PS Metric	2013 Status
3.4.1 SIS URE Accuracy	≤ 7.8 m 95% Global average URE during normal operations over all AODs	✓+
	≤ 6.0 m 95% Global average URE during normal operations at zero AOD	✓+
	≤ 12.8 m 95% Global average URE during normal operations at any AOD	✓+
	≤ 30 m 99.94% Global average URE during normal operations	✓+
	≤ 30 m 99.79% Worst case single point average URE during normal operations	✓+
3.5.1 SIS Instantaneous URE Integrity	≤ 1×10^{-5} Probability over any hour of exceeding the NTE tolerance without a timely alert	✓+
3.6.1 SIS Continuity - Unscheduled Failure Interruptions	≥ 0.9998 Probability over any hour of not losing the SPS SIS availability from the slot due to unscheduled interruption	✓+
3.7.1 SIS Per-Slot Availability	≥ 0.957 Probability that (a.) a slot in the baseline 24-slot will be occupied by a satellite broadcasting a healthy SPS SIS, or (b.) a slot in the expanded configuration will be occupied by a pair of satellites each broadcasting a healthy SIS	✓+
3.7.2 SIS Constellation Availability	≥ 0.98 Probability that at least 21 slots out of the 24 slots will be occupied by a satellite (or pair of satellites for expanded slots) broadcasting a healthy SIS	✓+
	≥ 0.99999 Probability that at least 20 slots out of the 24 slots will be occupied by a satellite (or pair of satellites for expanded slots) broadcasting a healthy SIS	✓+
3.7.3 Operational Satellite Counts	≥ 0.95 Probability that the constellation will have at least 24 operational satellites regardless of whether those operational satellites are located in slots or not	✓+
3.8.1 PDOP Availability	≥ 98% Global PDOP of 6 or less	✓+
	≥ 88% Worst site PDOP of 6 or less	✓+
3.8.2 Position Service Availability	≥ 99% Horizontal, average location	✓+
	≥ 99% Vertical, average location	
	≥ 90% Horizontal, worst-case location	
3.8.3 Position Accuracy	≥ 90% Vertical, worst-case location	✓+
	≤ 9 m 95% Horizontal, global average	
	≤ 15 m 95% Vertical, global average	
	≤ 17 m 95% Horizontal, worst site	
	≤ 37 m 95% Vertical, worst site	

✓+ - Met or Exceeded

Official U.S. Government information about the Global Positioning System (GPS) and related topics

Home
What's New
Systems
Applications
Governance
Multimedia
Support

Home » Systems » GPS » Performance

SYSTEMS:

- GPS Overview
- Space Segment
- Control Segment
- Performance
- Accuracy
- Modernization
- Augmentation Systems
- Technical Documentation

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GPS Performance

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he U.S. government is committed to providing GPS to the civilian community at the performance levels specified in the GPS Standard Positioning Service (SPS) Performance Standard (PS). [VIEW DOCUMENT](#) →

The following study, commissioned by the Air Force, confirms that, "in 2013 all of the SPS PS assertions examined were met or exceeded." The assertions evaluated include those associated with the accuracy, integrity, continuity, and availability of the GPS signal-in-space and the position performance standards.

UTC Offset Anomaly

On January 25-26, 2016, GPS users experienced a rare anomaly in operations. For several hours, multiple satellites broadcast information regarding the offset between GPS time and UTC in a manner that did not conform to the GPS signal interface

2013 GPS SPS Performance Analysis Download 2.4 MB

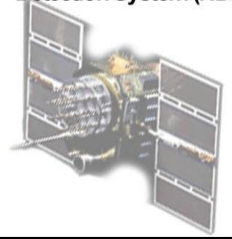


GPS Modernization

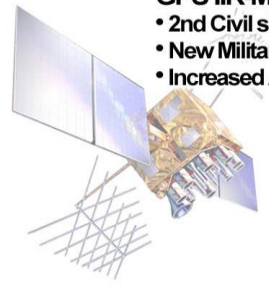
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Space System (Satellites)

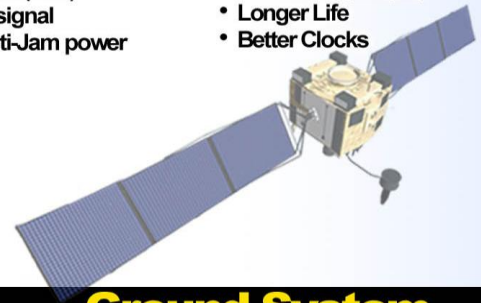
- Legacy (GPS IIA/IIR)**
- Basic GPS
 - NUDET (Nuclear Detonation) Detection System (NDS)



- 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

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



GPS III

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- 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
- SV01-SV10 on contract
 - SV09 & 10 awarded 21 Sep 16
 - Same requirements baseline as SV01-08
- Current Status
 - SV01 In Testing Flow
 - Baseline thermal vacuum testing completed 23 Dec 15
 - Electromagnetic Interference (EMI) test completed 14 May 16
 - SV02 NPE delivered 1 Jun 16
 - SV02/03 in assembly & integration
 - SV04-08 in box level assembly

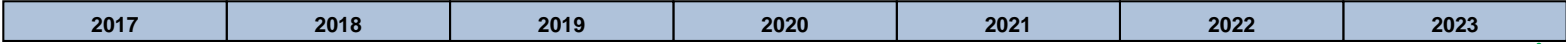




GPS III SV11+

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- Build on the legacy of the GPS IIF and GPS III programs
 - Drive down costs, maintain production readiness to achieve 2023 need date
- Plan to compete GPS III SV11+ Follow-on Production
 - Promote competition and reduce risk for production GPS space vehicles
- Two-phase approach
 - Phase 1: Production Readiness Feasibility Assessment
 - Gain insight into contractor SV & navigation payload production maturity & risk
 - The Boeing Company, Lockheed Martin Space Systems Company, and Northrop Grumman Aerospace Systems awarded contracts on 9 May 16
 - Phase 2: Production Competition
 - Full and open competition for up to 22 production ready GPS III SVs





GPS Next Generation Operational Control System (OCX)

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- 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: operate & manage GPS constellation, replaces AEP, adds modern features
 - OCX Block 2: operate advanced M-Code features and Civil Signal Performance Monitoring
- Current Status: Working through program challenges
 - Quarterly Reviews with OSD AT&L, SECAF, and Raytheon CEO
 - SECAF declared Nunn-McCurdy Breach on 30 Jun 16
 - Nunn-McCurdy process complete, program recertified on 12 Oct 16 by USD/AT&L

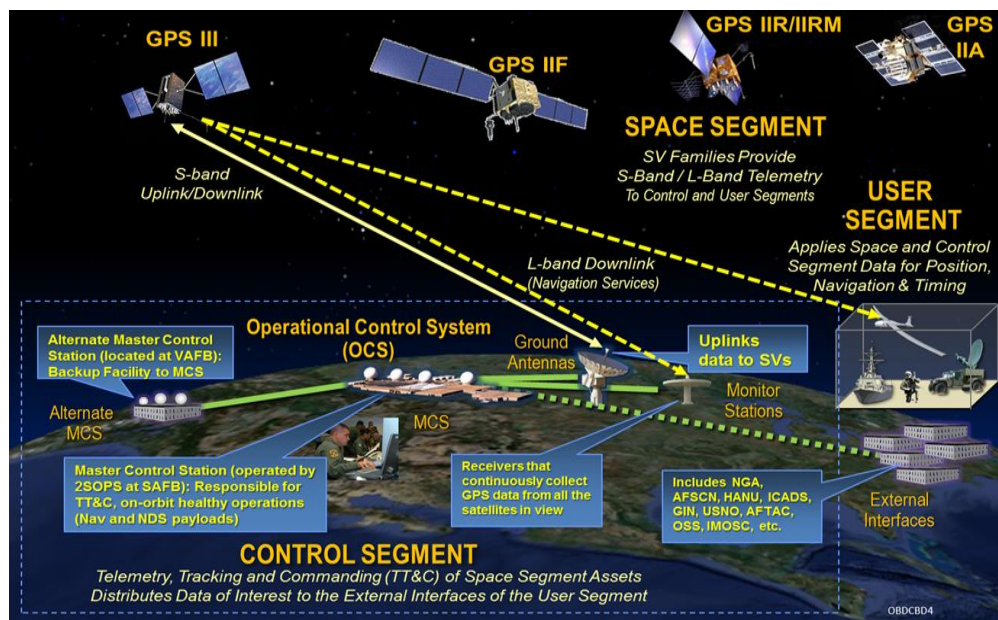




Contingency Operations (COps)

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- Contingency Operations (COps) provides limited operations of GPS IIIs until OCX Block 1 delivery
 - Legacy signal operations
 - Test-only support for modernized signals
 - RTO projected Apr 2019
- Schedule supports current mission need date of Sep 2019 to sustain on-orbit legacy signal capability
- COPS relies on OCX Block 0 for GPS III launch, major anomaly, and disposal capabilities
- Completed CDR in Nov 2016



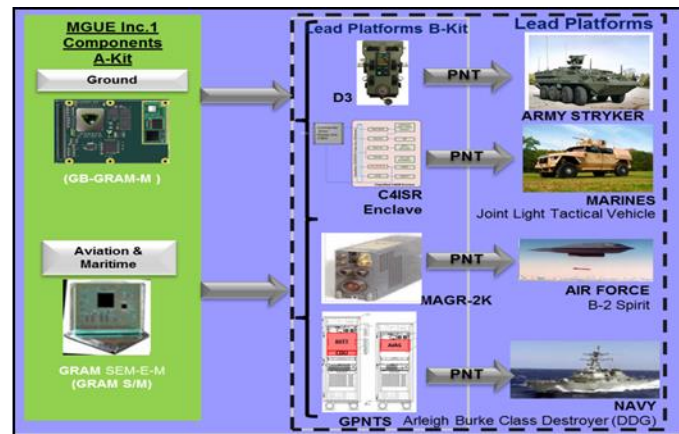
COps is a critical bridge enabling sustainment of Legacy signals for GPS III



Military GPS User Equipment (MGUE)

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- Commercial market-driven acquisition approach
 - Three vendors developing modernized receiver cards
- Conducting early integration activities to support Service-nominated Lead Platforms
 - Nov 2015: Delivered first prototype MAGR2K-M to support B-2 integration & test
 - Dec 2015: Successful tracking of Y-Code by prototype MAGR2K-M in B-2 Software Integration Lab (SIL)
 - Apr 2016: Successful integration and M-Code track: modernized Embedded GPS Inertial System (EGI)
 - Jun 2016: MGUE Final Test Articles (FTAs) provided to Navy DDG Destroyer Lead Platform program
 - Aug 2016: B-2 Integration with new antenna in the B-2 SIL; tracking M-Code
- Draft MGUE Increment 2 Capability Development Document (CDD) in coordination: Space Receiver, Handheld, Precision Guided Munitions
- L-3 Interstate Electronics Corporation first DoD contractor to receive user equipment security certification, Oct 16



MAGR2K-M



JLTV



D3



PGM



GPS Director's Perspectives

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- GPS is the Global Utility
 - Committed to maintaining uninterrupted service – “the Gold Standard”
- Embracing Space Enterprise Vision by continuing to enhance PNT resiliency
 - Includes examination of multi-GNSS receivers
- Appreciate the need for alternative PNT sources, and challenge the community (labs, industry, others) to propose & explore solutions
- Next-Generation Operational Control System (OCX) addressing cost and schedule challenges
 - Looking at opportunities to provide operational modernized signal capabilities prior to OCX

The men and women of the GPS Directorate



ACQUISITION PROFESSIONALS DELIVERING THE GOLD STANDARD IN SPACE-BASED PNT AND NDS SERVICES



GPS IIF

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20 Feb 14: IIF-5



16 May 14: IIF-6



1 Aug 14: IIF-7



29 Oct 14: IIF-8



25 Mar 15: IIF-9



15 Jul 15: IIF-10



31 Oct 15: IIF-11



5 Feb 16: IIF-12

8 Launches in 24 Months -- Most aggressive GPS launch schedule since 1993