

Space and Missile Systems Center

Global Positioning Systems Directorate

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

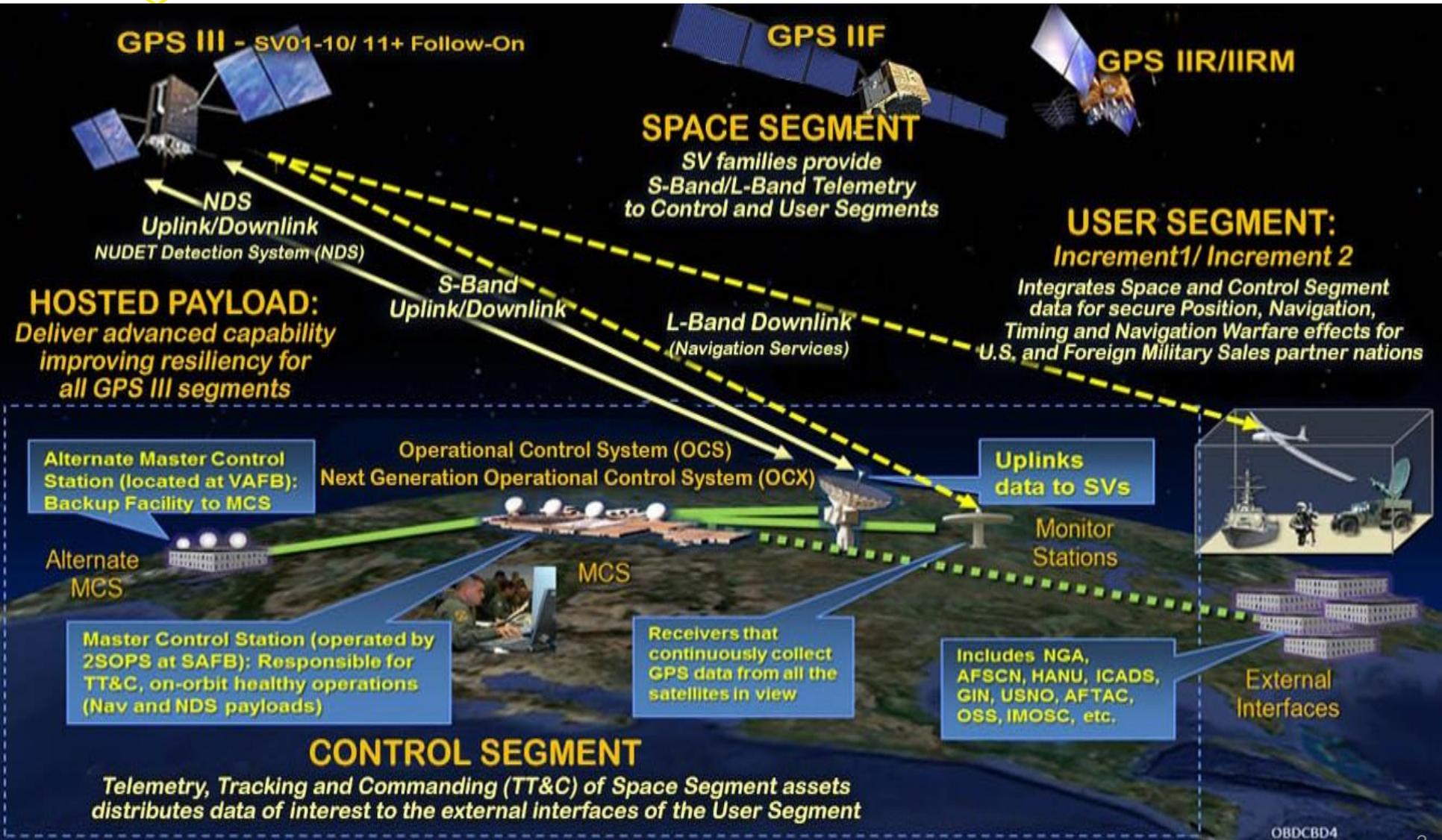
58th CGSIC Meeting (25 Sep) &
ION GNSS+ 2018 Conference (26 Sep)

Mr. Luke Schaub, Control Division Chief
Global Positioning Systems Directorate





GPS Enterprise Operational View

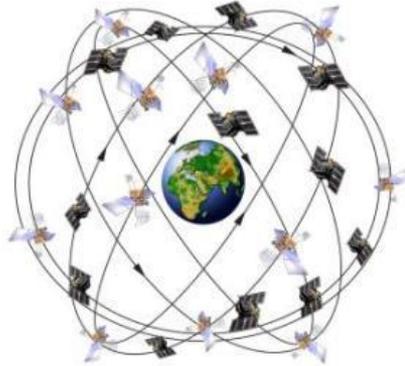


GPS Overview



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 Defense

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

Maintenance/Security

- All Level I and Level II
 - Worldwide Infrastructure
 - NATO Repair Facility
- Develop & Publish ICDs Annually
 - Public ICWG: Worldwide Involvement
 - Materials Available at: gps.gov/technical/icwg
- 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

34 Satellites / 31 Set Healthy Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	1	24.8	24.8
GPS IIR	11	16.6	21.1
GPS IIR-M	7	11.1	12.9
GPS IIF	12	4.6	8.2
Constellation	31	11.0	24.8

AS OF 24 AUG 18

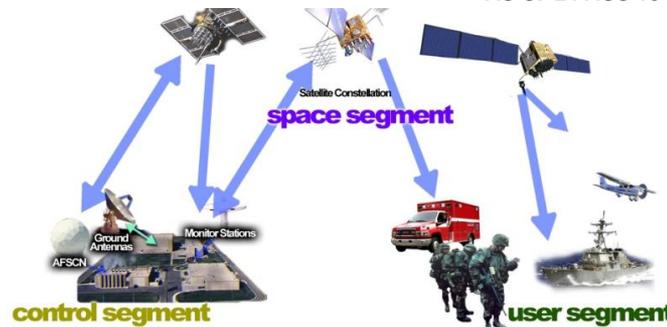


Department of Transportation

- 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 - NAVIC



GPS Performance Report Cards

- 2013-2017 performance reports now available on gps.gov
- These reports measure GPS performance against GPS Standard Positioning Service (SPS) Performance Standard commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

Performance Standard Metric		2013	2014	2015	2016	2017
SIS Accuracy	URE Accuracy	✓	✓	✓	✓	✓
	UTC OE Accuracy	N/A	N/A	✓	✓	✓
SIS Integrity	Instantaneous URE Integrity	✓	✓	✓	✓	✓
	Instantaneous UTC OE Integrity	N/A	N/A	✓	✓	✓
SIS Continuity	Unscheduled Failure Interruptions	✓	✓	✓	✓	✓
	Status and Problem Reporting	N/A	✗	✓	✗	✗
SIS Availability	Per-Slot Availability	✓	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓	✓



GPS SIS Performance Scoreboard

GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM)

	● BEST WEEK *		● BEST DAY *		● WORST DAY *	
	ENDING	SIS	ENDING	SIS	ENDING	SIS
ROLLING YEAR	20 SEP 17	48.9	14 MAR 18	37.5	1 DEC 17	77.7
	● ● ● BEST WEEK EVER		29 NOV 16	44.1		

*ROLLING YEAR



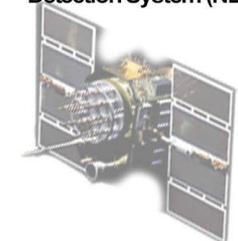


GPS Modernization

Space System (Satellites)

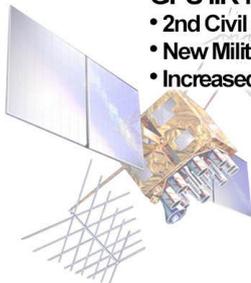
Legacy (GPS IIA/IIR)

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



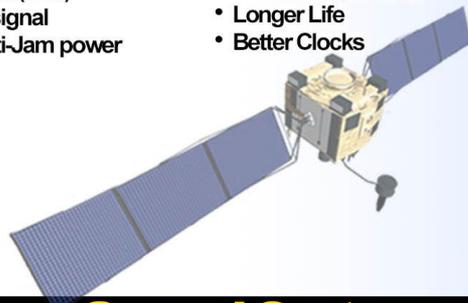
GPS IIR-M

- 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

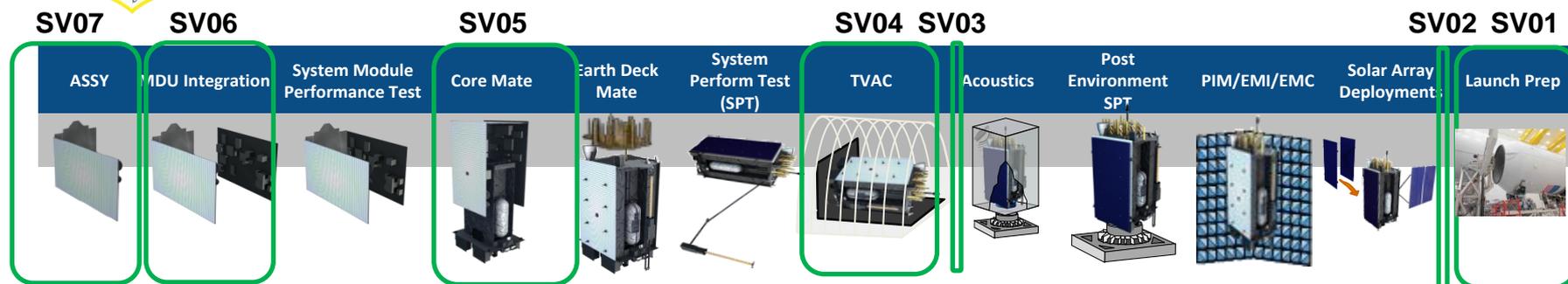


Modernized

- 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



State of the GPS III Space Vehicles (SVs)



- SV01 successfully completed post-ship functional testing
- SV02 declared Available For Launch (AFL) on 10 Aug 18. Spacecraft is in short-term storage
- SV03 acoustics testing prep is ongoing
 - Solar array testing in work
 - Shipped to Reverberant Acoustic Laboratory (RAL) on 7 Sep 18
 - Completed Thermal Vacuum (TVAC) on Jun 2018
- SV04 in TVAC Chamber on 30 Aug 18
 - Open door testing to begin on 4 Sep 18
- SV05 core mating is in progress
- SV06 is currently integrating harnesses
- SV07 is currently in Assembly buildup stage

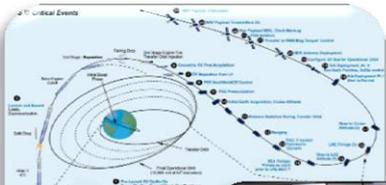


7 SVs in various phases within the single line flow



GPS III SV01 Road To Launch

GPS Directorate



Mission Rehearsals



Launch 2018

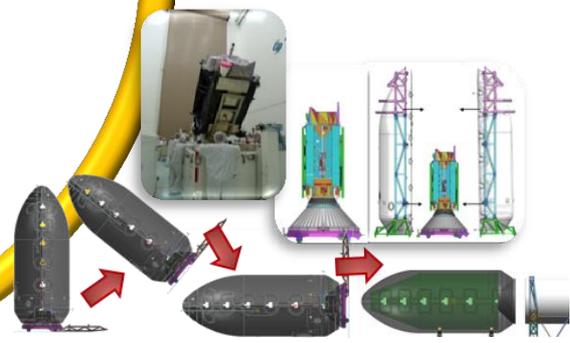
The Gold Standard



Readiness Tests



Transport



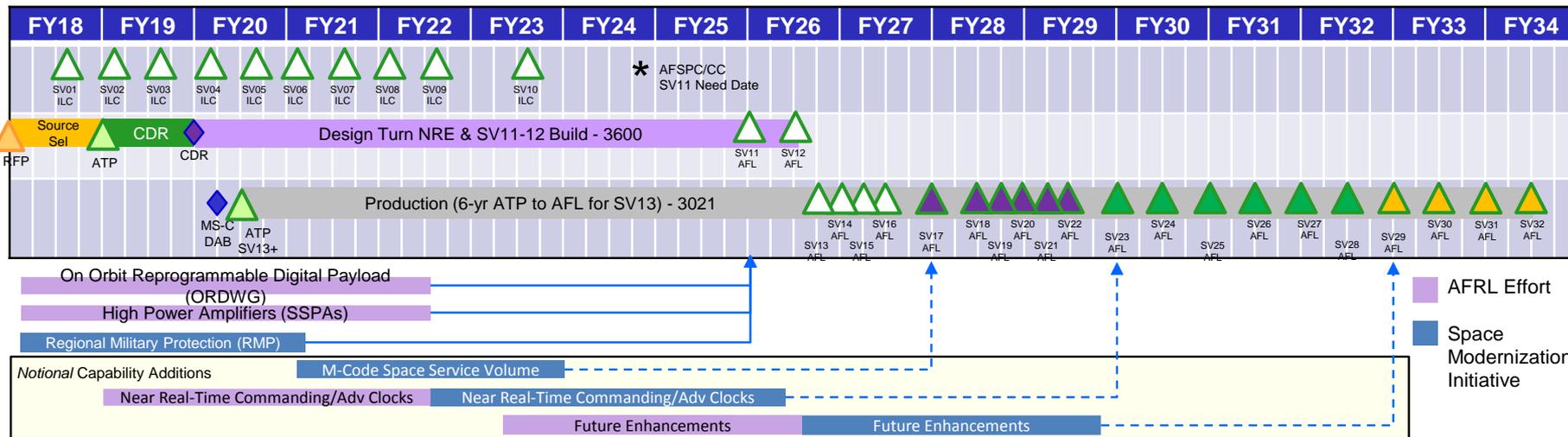
Launch Integration

GPS III SV01 enterprise road to launch – A series of firsts!

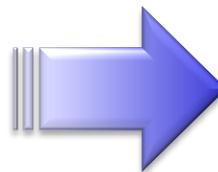


GPS III Acquisition Strategy

Modernization, Recapitalization, and Resiliency



- Contract award pending 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



Ensuring the Gold Standard Today and into the future

Lockheed Martin selected as vendor for GPS III F on 14 Sep 18



GPS Next Generation Operational Control System (OCX)

- Next-generation C2 and cyber-defense for GPS
 - Worldwide, 24 hr/day, all weather, Positioning, Navigation, and Timing (PNT) source for military and civilian users
 - Robust information assurance and cyber security
 - Modern civil signals and monitoring
 - Support to Military Code (M-Code) navigation warfare
- Incremental Development
 - OCX Block 0: Launch and Checkout System (LCS) for GPS III
 - OCX Blocks 1 and 2: Operate and manage modernized GPS constellation, add modern features and signals, and provide Civil Signal Performance Monitoring
- Current Status
 - LCS is ready to support GPS III SV01 launch in Dec 2018
 - Third successful integrated launch rehearsal between GPS III and OCX Block 0 completed Jun 2018
 - Cybersecurity testing events in Apr 2018 and May 2018 validated GPS III LCS cybersecurity requirements and identified no new vulnerabilities
 - Block 1 development continues to meet milestones
 - Final iteration Critical Design Review (iCDR) completed 7 Sep 18
 - Final iteration of coding scheduled to complete second quarter 2019; next step is 2.5 years of system testing

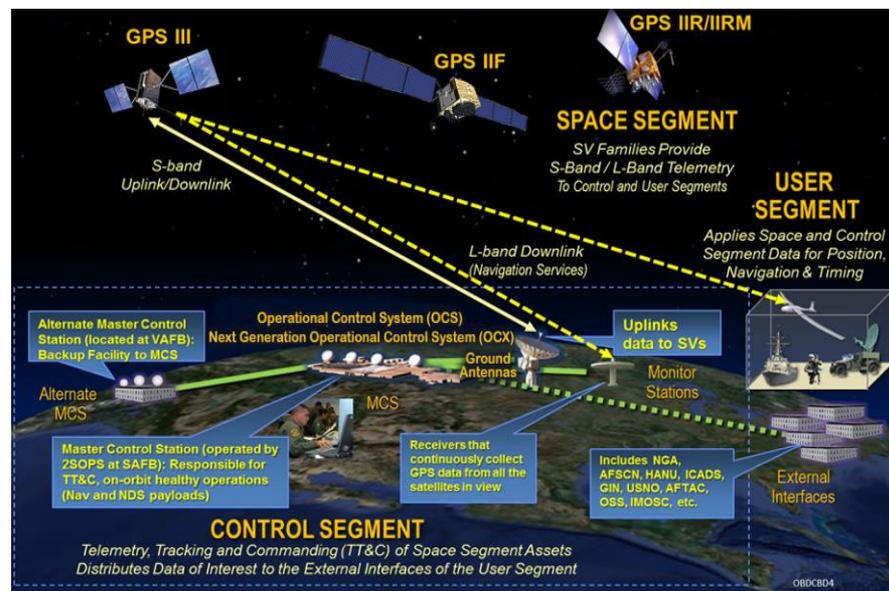


OCX program continues to execute and meet schedule



GPS III Contingency Operations (COps)

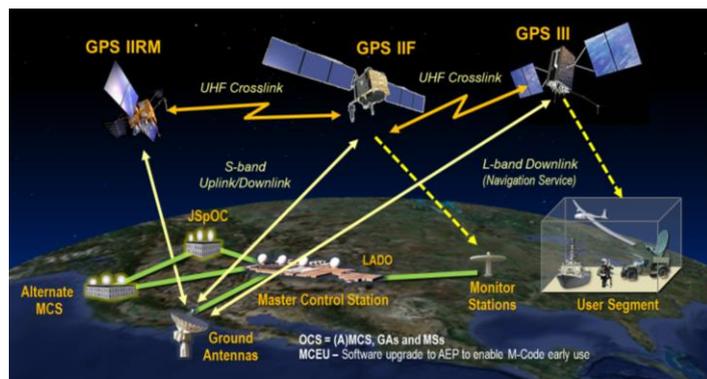
- Limited operations for GPS III Space Vehicles until OCX Block 1 delivery
 - Provides legacy and modernized civil signal operations
 - Relies on OCX Block 0 for GPS III launch, major anomaly, and disposal capabilities
- Software Development
 - Risk reduction modification to current Operational Control System (OCS)
 - Four incremental software builds
- Current Status:
 - Software development is complete
 - Component Integration Test (CIT) finishes Oct 2018
 - Operational Acceptance: Jan 2020



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



GPS Military Code Early Use (MCEU)

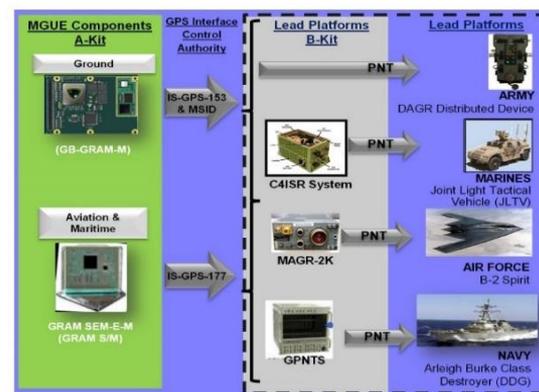


- Description
 - Provide early use of GPS M-Code signal from 2020 until OCX Block 1 Ready for Transition to Operations
 - Enable and operate M-Code messaging on capable satellites, including GPS IIR-M, GPS IIF, and GPS III (at a GPS IIF performance level)
 - Process Joint Space Operations Center M-Code directives and monitor M-Code message sets
- Software Development
 - Updates to Operational Control System (OCS)
 - Integration of M-Code Keying and Modernized Monitoring Stations
- Current Status
 - Critical Design Review Complete – Apr 2018
 - Currently in Software Development phase
 - Operational Acceptance: Sep 2020



Military GPS User Equipment (MGUE)

- Competitive market-driven acquisition approach
- MGUE Increment 1 is post-Milestone B with three vendors developing modernized receiver cards
 - Ground form factor
 - Aviation/maritime form factor
- Increment 2 addresses GPS receiver card obsolescence issue, and extends M-Code to space receivers, Precision-Guided Munitions, and a joint, common modernized Handheld receiver
- Current Status:
 - Increment 1 on track to support Core M-Code Operations in 2020
 - Modified contracts to enable legacy weapons initialization
 - All contractors have delivered Final Test Article hardware
 - One vendor completed hardware testing with software in final testing
 - Remaining vendors delivering incremental software builds for risk reduction testing
 - Increment 2 acquisition is in the materiel solutions analysis phase
 - Increment 2 Capability Development Document was approved in Apr 2018
 - Acquisition strategy projected approval by Dec 2018





Adjacent Band Compatibility (ABC)

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

Developing Interference Standards

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

Home What's New Systems Applications **Governance** Multimedia Support

Home > Governance > Spectrum & Interference > Adjacent-Band Compatibility Assessment

GOVERNANCE:

- Policy & Law
- Organization
- Program Funding
- Congress
- International Cooperation
- Spectrum & Interference
- GPS Jamming
- Frequency Coordination
- Use of Facilities

GPS Adjacent-Band Compatibility Assessment

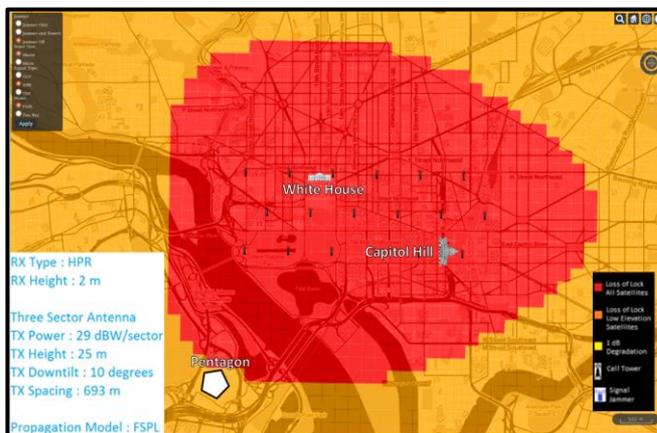
Demand for commercial spectrum to support broadband wireless communications has led the government to consider repurposing various radio frequencies, including the satellite communications bands next to GPS.

In 2012, the National Executive Committee for Space-Based Positioning, Navigation, and Timing proposed to draft new GPS spectrum interference standards to inform future proposals for non-space, commercial use of the bands adjacent to the GPS signals. [LEARN MORE](#)

On this page:

- Assessment Plan
- Device Testing
- March 2017 Workshop
- Previous Workshops

Analyzing Operational Impacts



Testing Receiver Impacts



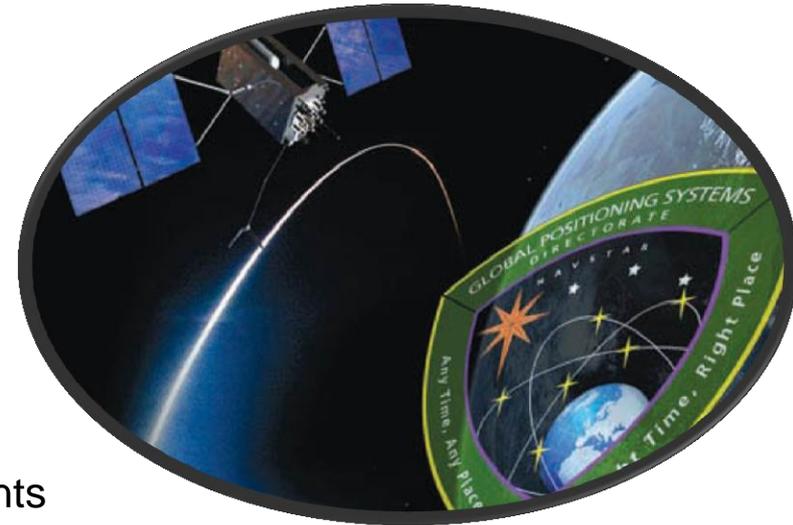
- Publicly-available test reports confirm unacceptable impacts to GPS receivers
 - Air Force tested DoD receivers to assess the impact of adjacent band interference
 - Results support [U.S. Department of Transportation conclusions](#) and [PNT Advisory Board Recommendation](#)

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



GREEN MONSTER
10TH BIRTHDAY

BEST FLAVOR SAVER AWARD
COMUSTACHE
RESEARCH
AWARDS
ADDRESS

the men and women of the
GLOBAL POSITIONING SYSTEMS DIRECTORATE

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