

Space and Missile Systems Center

Global Positioning Systems Directorate

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

CGSIC / ION GNSS+

25-29 Sep 2017

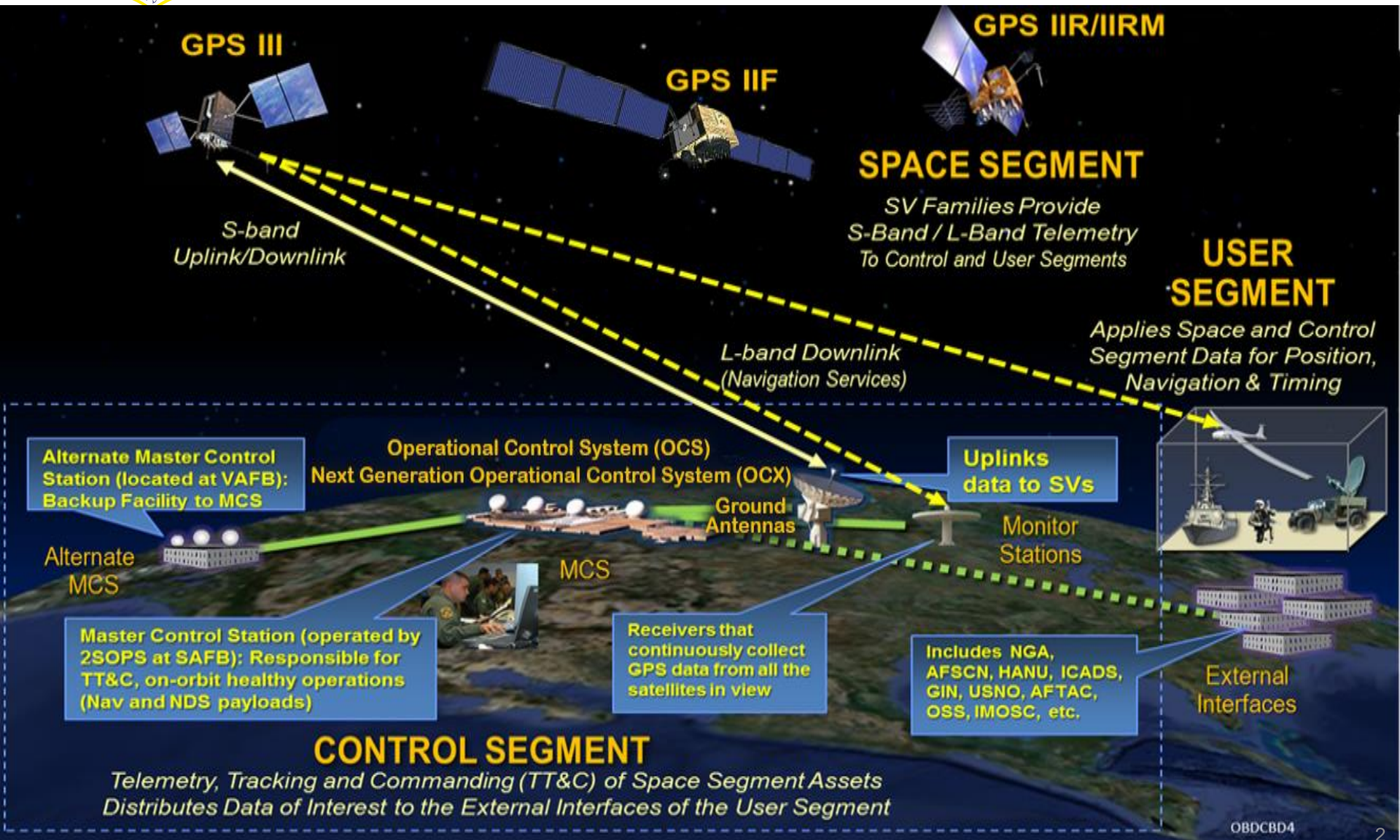
Col Steve Whitney, Director
Global Positioning Systems Directorate





GPS Enterprise Operational View

SPACE AND MISSILE SYSTEMS CENTER





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

35 Satellites / 31 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIR	12	15.7	20.1
GPS IIR-M	7	10.1	11.9
GPS IIF	12	3.6	7.3
Constellation	31	9.7	20.1

AS OF 1 SEP 17

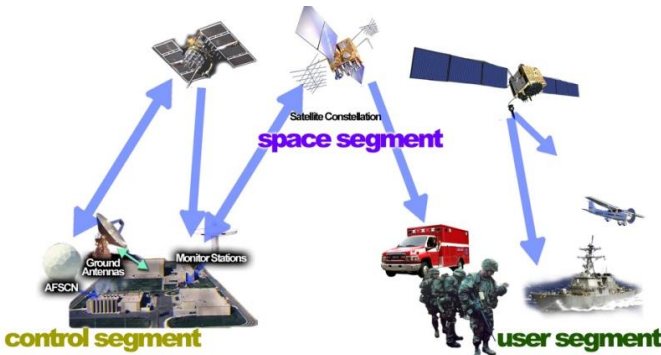


Department of Transportation

- 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

Performance Standard Metric		2013	2014	2015	2016
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	x	✓	x
SIS Availability	Per-Slot Availability	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓

- 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



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

29 NOV 16

44.1

26 JAN 17

35.0

15 JUN 17

69.7



BEST WEEK EVER

29 NOV 16

44.1

**ROLLING YEAR*





GPS Modernization

Space System (Satellites)

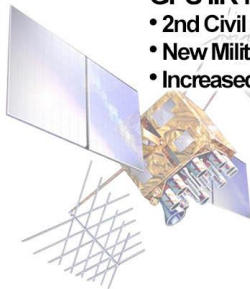
Legacy (GPS IIA/IIR)

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



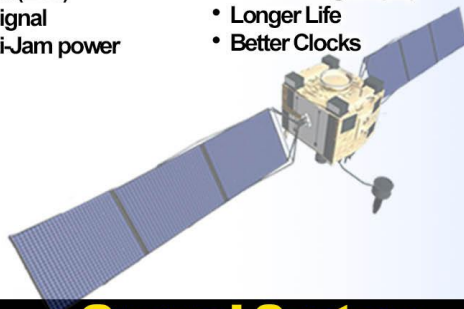
GPS IIR-M

- 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

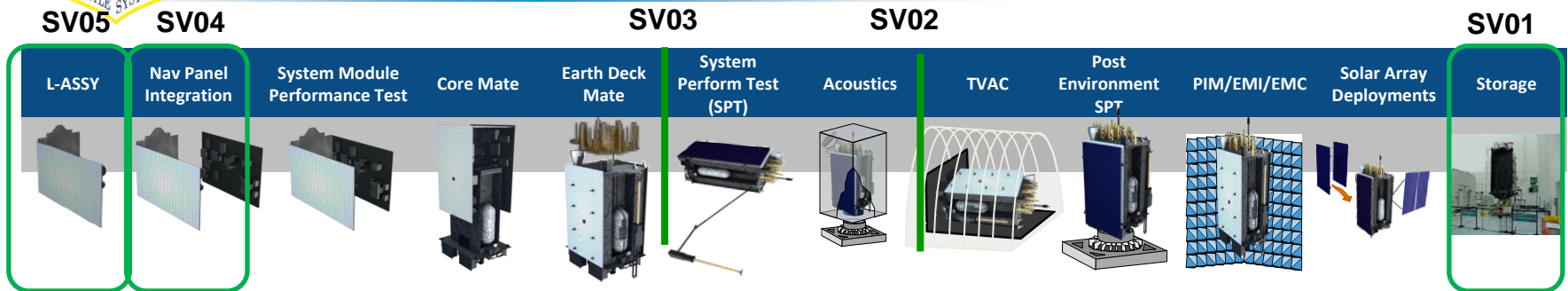


Modernized

- 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



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

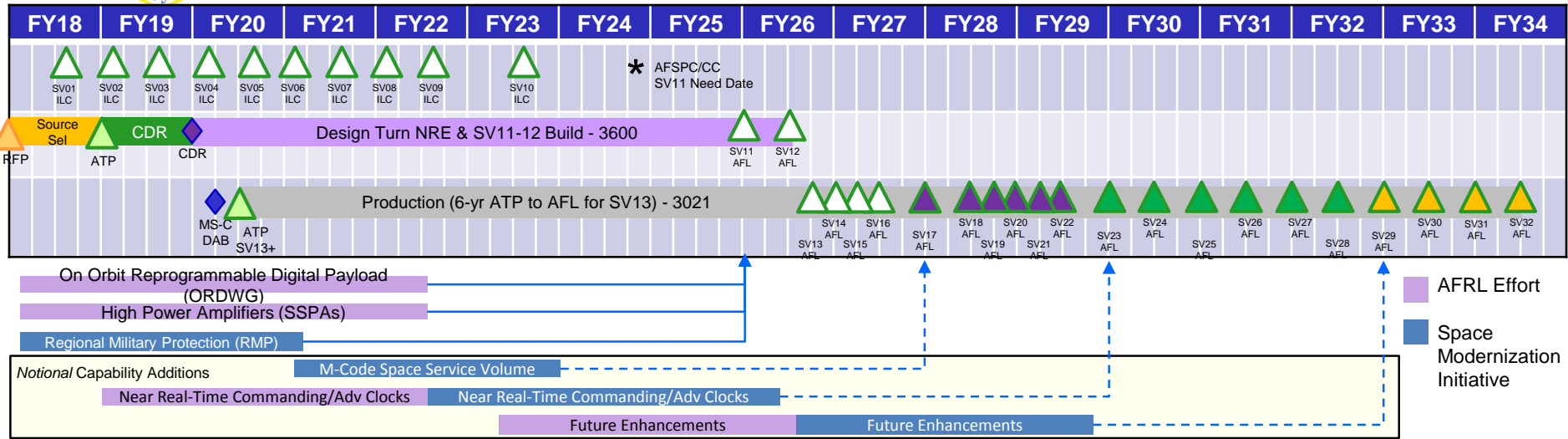


GPS III Space Vehicles in Full Production Flow

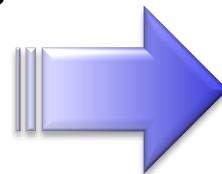


GPS III Acquisition Strategy

Modernization, Recapitalization, and Resiliency



- 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



Ensuring the Gold Standard Today and into the future



GPS Next Generation Operational Control System (OCX)

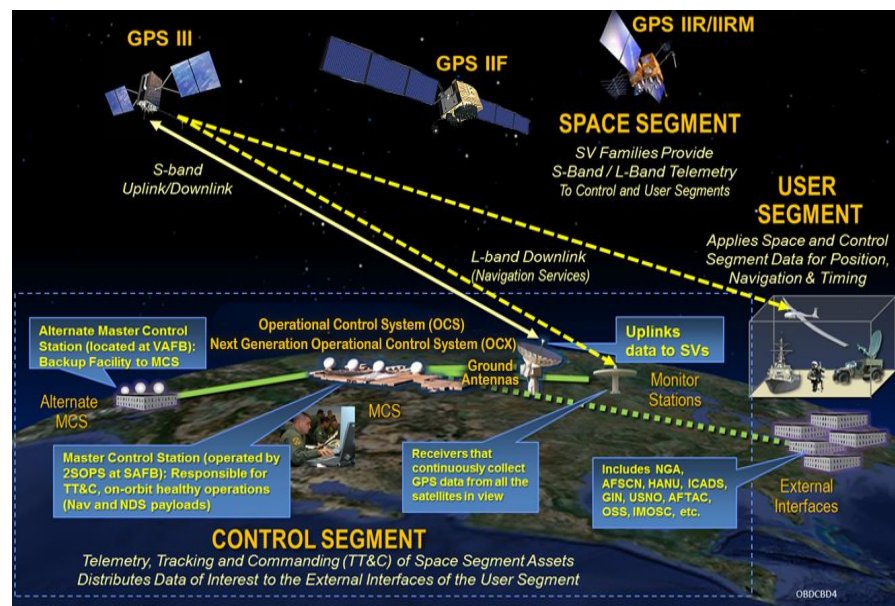
- **Next-generation C2 and cyber-defense for GPS**
 - Worldwide, 24 hr/day, all weather, position, velocity and time source for military & civilian users
 - Improved PNT performance
 - Robust information assurance and cyber security
 - Modern civil signals & monitoring
 - Support to Military Code (M-Code)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

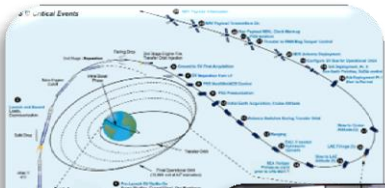


COps is a critical bridge, enabling sustainment of legacy signals for GPS III



GPS III SV01 Road To Launch

GPS Directorate



Mission Rehearsals



Launch 2018

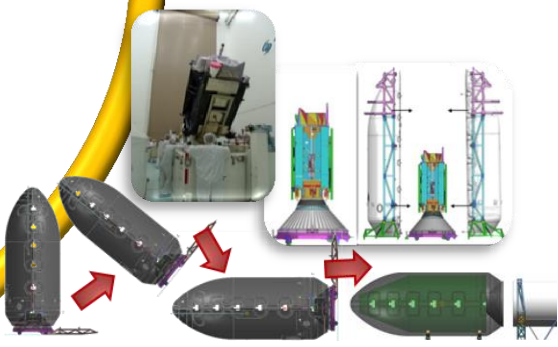
The Gold Standard



Readiness Tests



Transport



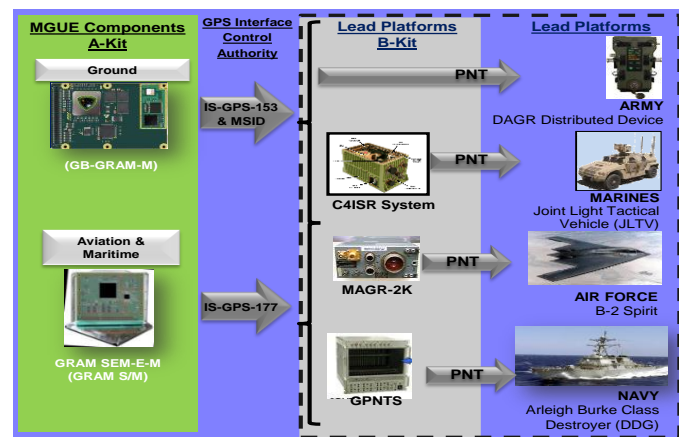
Launch Integration

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

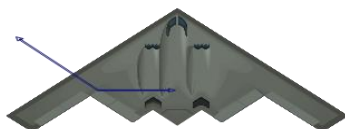


Military GPS User Equipment (MGUE)

- 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



MAGR2K-M



JLTV



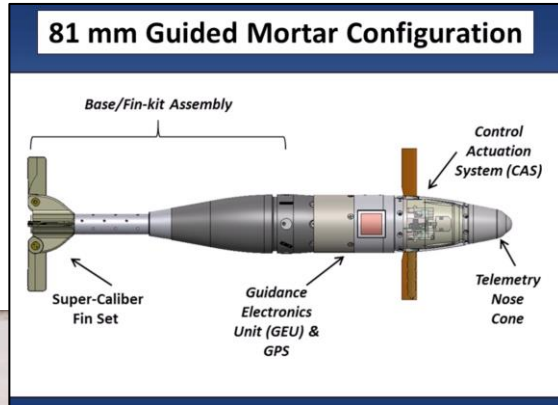
D3



PGM



MGUE Precision Guided Munitions Test

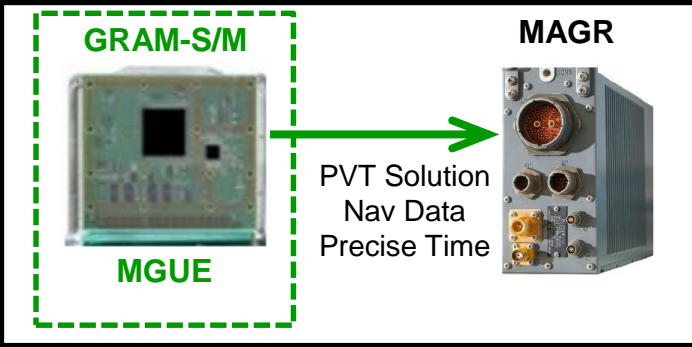


MGUE Increment 1 First Ever Guide-to-Hit





B-2 MGUE Flight Test





Adjacent Band Compatibility (ABC)

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

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

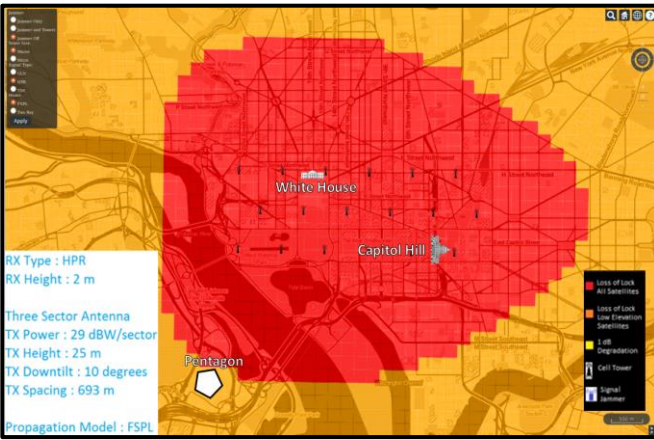
Demand for commercial spectrum to support broadband wireless communications has led the government to consider repurposing various radio frequencies, including the satellite communications bands next to GPS.

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



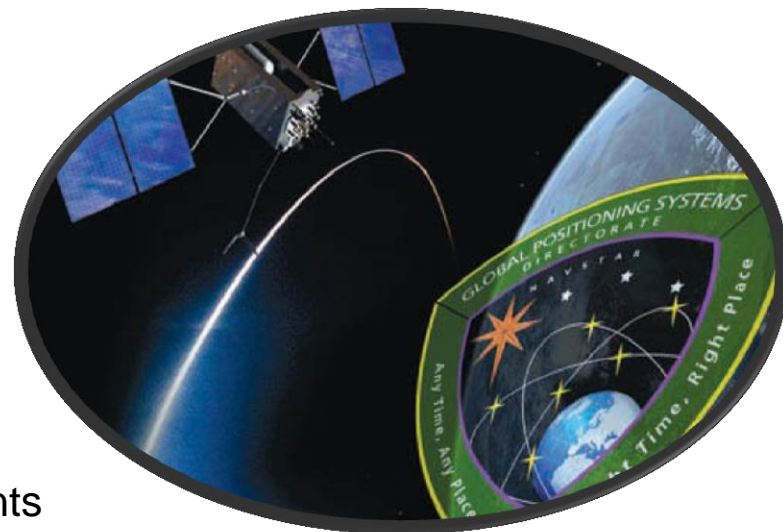
- Publicly-available test reports confirm unacceptable impacts to GPS receivers
 - Air Force tested DoD receivers to assess the impact of adjacent band interference
 - Results support U.S. Department of Transportation conclusions

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



the men and women of the
GLOBAL POSITIONING SYSTEMS DIRECTORATE



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