

Space and Missile Systems Center

Global Positioning Systems Directorate

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

National Space-Based Positioning,
Navigation, and Timing Advisory
Board Meeting

15 November 2017

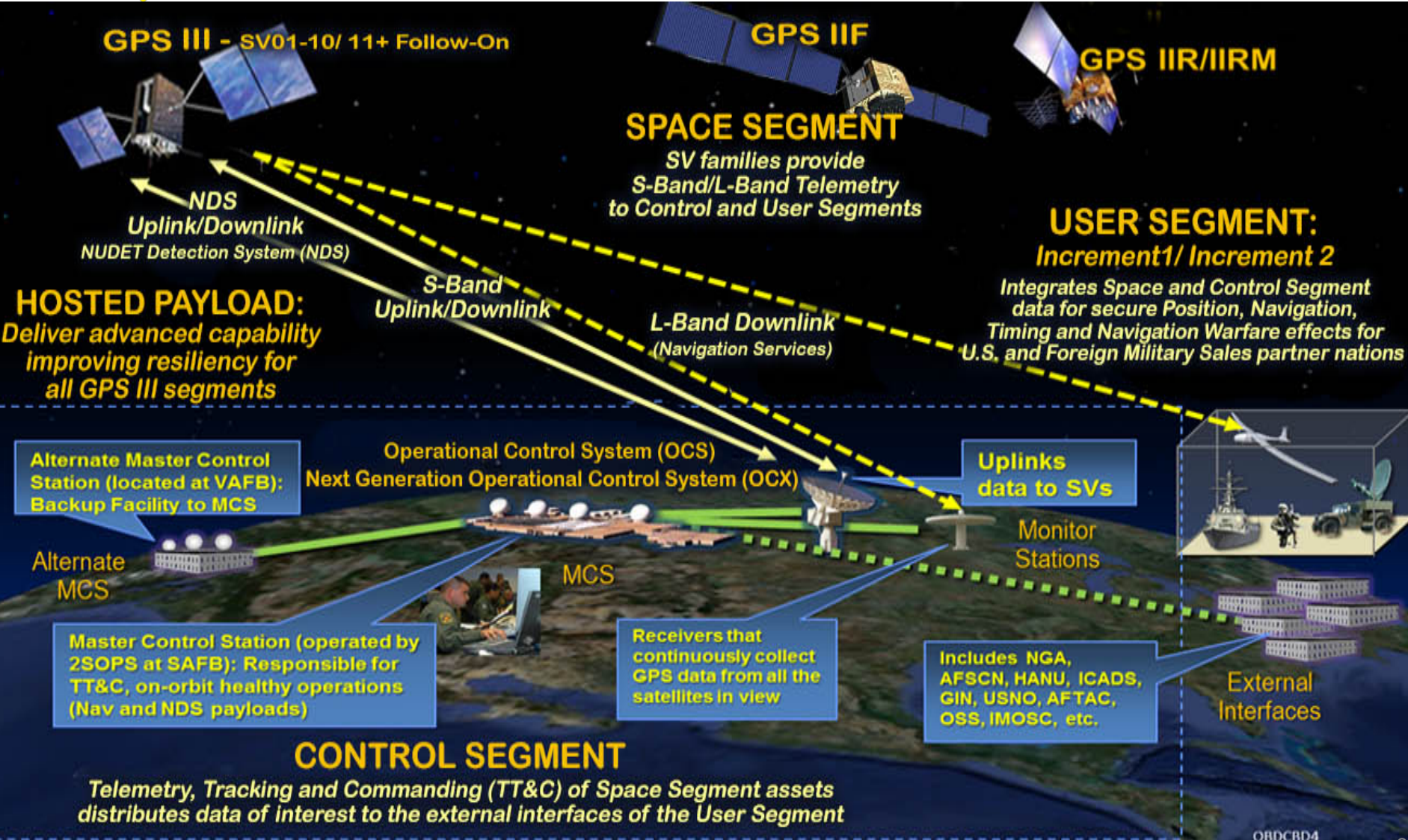
Col Gerry Gleckel, Deputy Director
Global Positioning Systems Directorate





GPS Enterprise Operational View

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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)



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	15.8	20.3
GPS IIR-M	7	10.3	12.1
GPS IIF	12	3.8	7.4
Constellation	31	9.9	20.3

AS OF 1 NOV 17

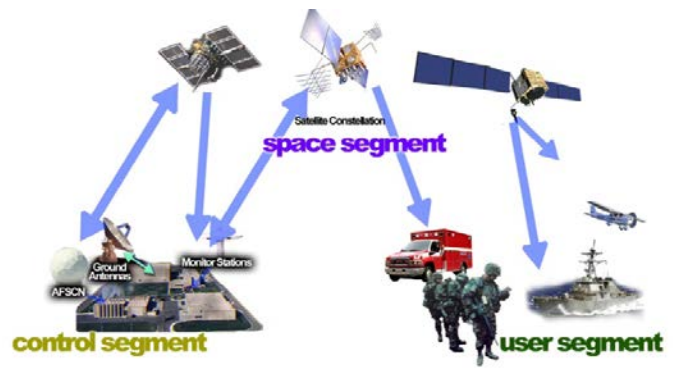


Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

- U.S. Coast Guard



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

International Cooperation

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



GPS Performance Report Cards

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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	✗	✓	✗
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

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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*





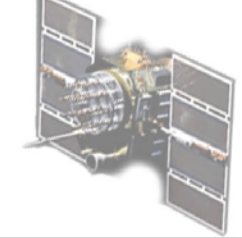
GPS Modernization

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Space System (Satellites)

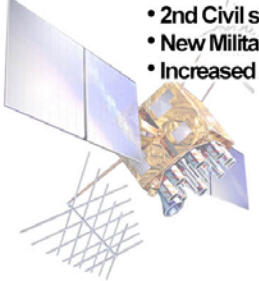
Legacy (GPS IIA/IIR)

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



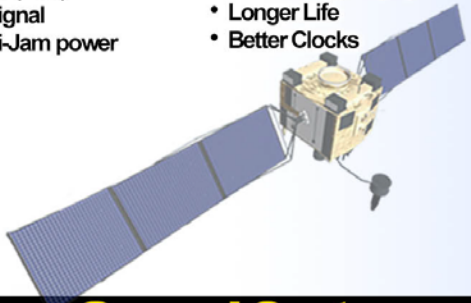
GPS IIR-M

- 2nd Civil signal (L2C)
- New Military signal
- Increased Anti-Jam power



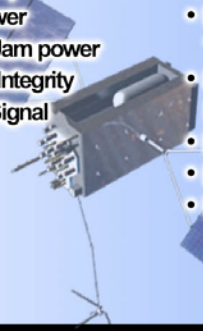
GPS IIF

- 3rd Civil Signal (L5)
- Longer Life
- Better Clocks



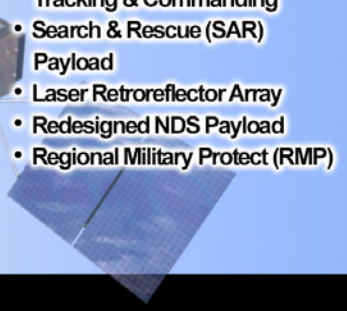
GPS III (SV01-10)

- 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
- 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

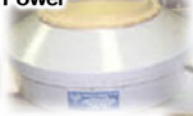
User Equipment

- Improved Anti-Jam & Systems
- Reduced Size, Weight & Power



Upgraded Antennas

- Improved Anti-Jam Antennas



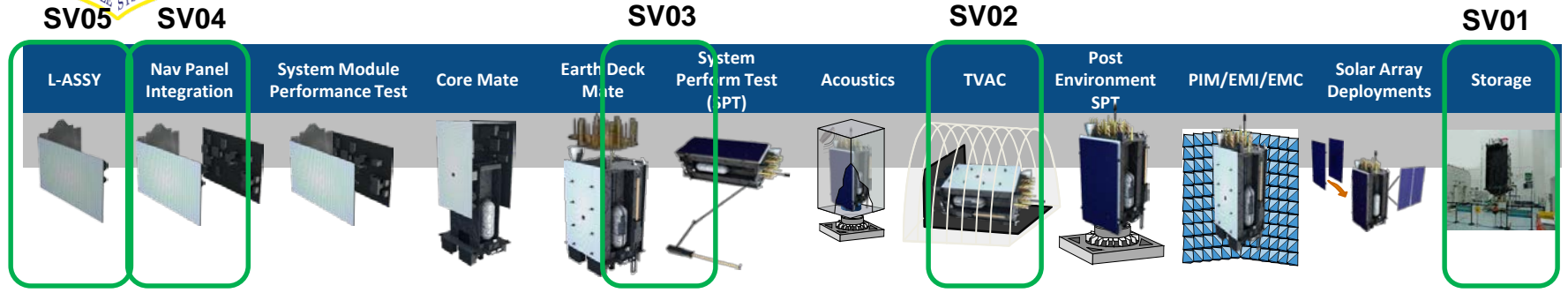
Modernized

- 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

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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



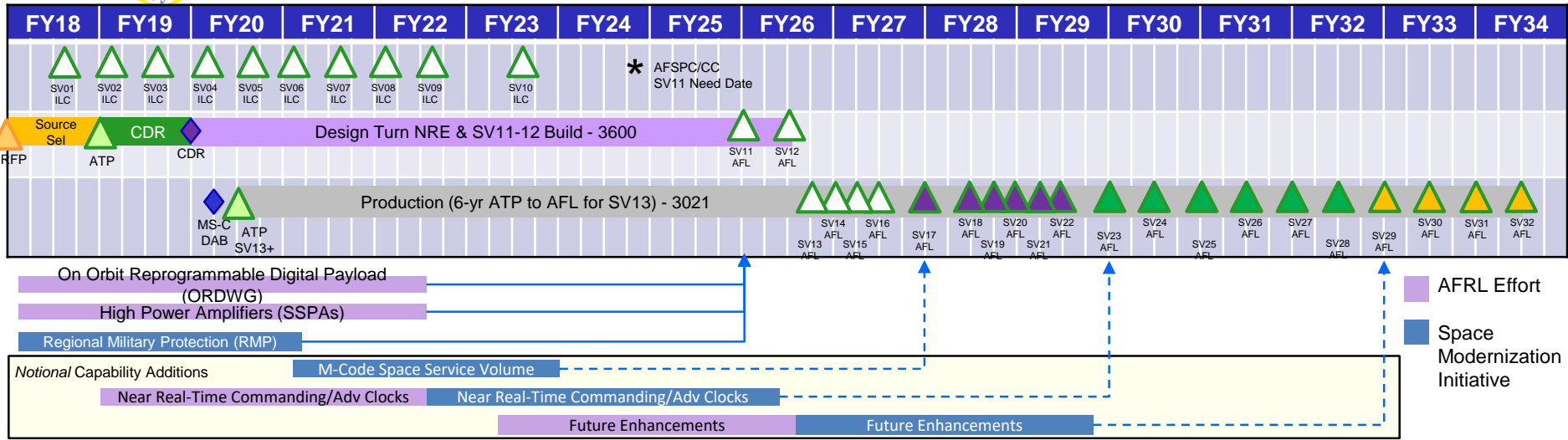
GPS III Space Vehicles in full production flow



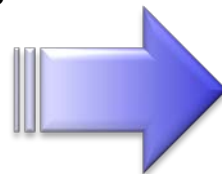
GPS III Acquisition Strategy

Modernization, Recapitalization, and Resiliency

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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



Ensuring the Gold Standard Today and into the future



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 & 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

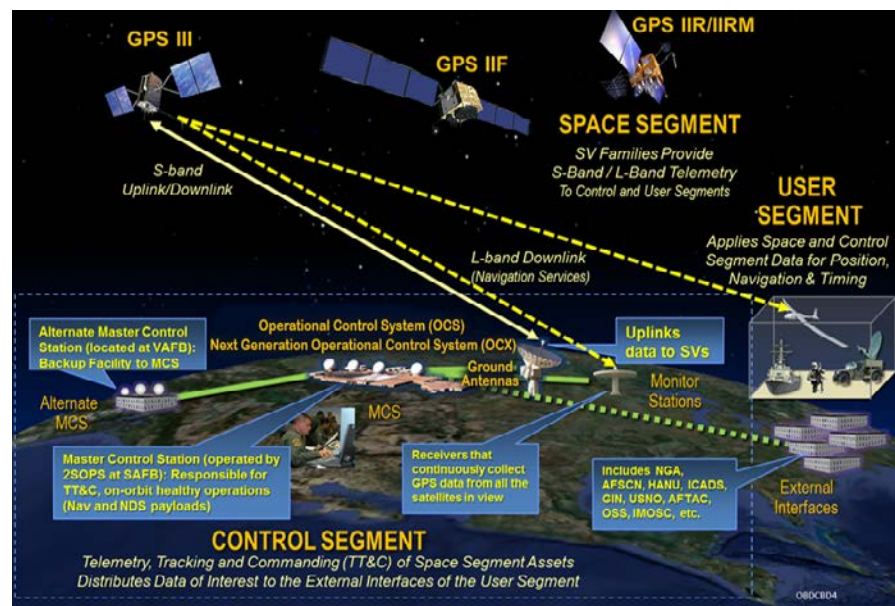




GPS III Contingency Operations (COps)

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- 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



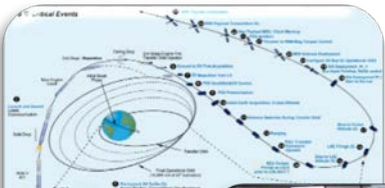
COps is a critical bridge, enabling sustainment of legacy signals for GPS III



GPS III SV01 Road To Launch

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GPS Directorate



Mission Rehearsals



**Launch
2018**

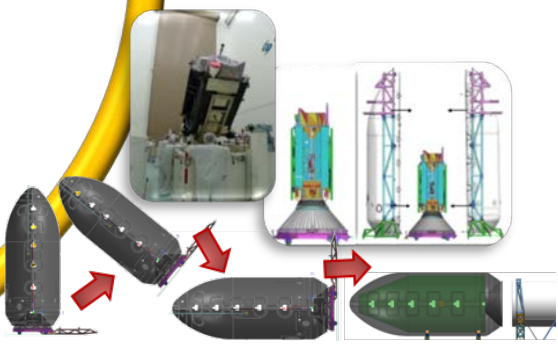
The Gold Standard



Readiness Tests



Transport



Launch Integration

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



Military GPS User Equipment (MGUE)

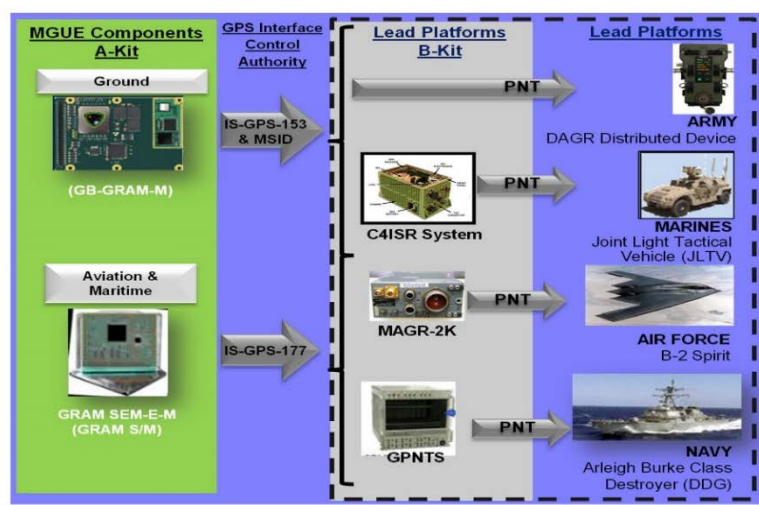
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- Commercial market-driven acquisition approach
- Three vendors developing modernized receiver cards

- 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

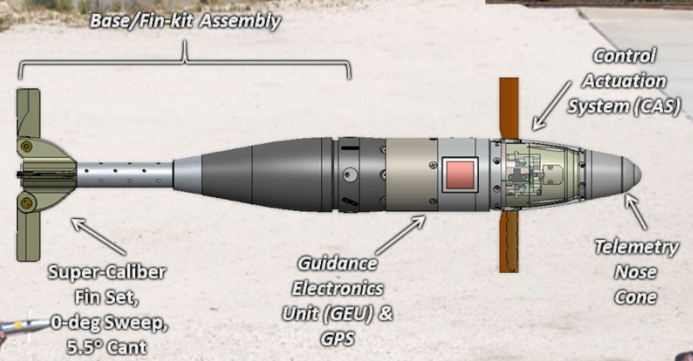




MGUE Precision Guided Munitions Test

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MGUE INCREMENT 1 FIRST EVER GUIDE-TO-HIT





Military GPS User Equipment *Prototype GPS Receiver Flight Tested on B-2*

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*Prototype
Military GPS
User
Equipment
Receiver Card*



*Prototype
Miniaturized
Airborne GPS
Receiver*



*4 Successful
B-2 Test Flights*



Military GPS User Equipment demonstrated in B-2



GPS Director's Perspectives

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- 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