

Space and Missile Systems Center



Update on GPS Modernization Efforts

11 June 2015

Col Steve Whitney
GPS User Equipment Division

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 11 JUN 2015		2. REPORT TYPE		3. DATES COVERED 00-00-2015 to 00-00-2015	
4. TITLE AND SUBTITLE Update on GPS Modernization Efforts				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Space Command,Space and Missile Systems Center,GPS User Equipment Division ,Los Angeles AFB, El Segundo,CA,90245				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the Fifteenth Meeting, 11-12 June 2015, Annapolis, MD.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 15	19a. NAME OF RESPONSIBLE PERSON
a REPORT unclassified	b ABSTRACT unclassified	c THIS PAGE unclassified			

UNCLASSIFIED.

SMC SPACE OV-1



AEHF = Advanced Extremely High Frequency System, AFSCN = Air Force Satellite Control Network, CCAFS = Cape Canaveral Air Force Station, DMSP = Defense Meteorological Satellite Program, DSCS = Defense Satellite Communications, DSP = Defense Support Program System, EPS = Enhanced Polar System, GEODSS = Ground-based Electro-Optical Deep Space Surveillance System, GPS = Global Positioning System, GSSAP = Geosynchronous Space Situational Awareness Program, JSPOC = Joint Space Operations Center, ORS = Operationally Responsive Space, SBIRS = Space-Based Infrared System, SBSS = Space-Based Surveillance Telescope, SSA = Space Situational Awareness, SST = Space Situational Awareness Telescope, VAFB = Vandenberg Air Force Base, WGS = Wideband Global Satellite Communications

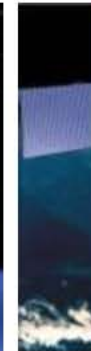


Global Positioning Systems Directorate

SPACE AND MISSILE SYSTEMS CENTER

Mission:

Acquire, deliver and sustain reliable GPS capabilities to America's warfighters, our allies, and civil users



From left to right, a GPS II



BGen Bill Cooley
Director



Master Control Station
(located at Schriever AFB, CO)

MGUE Components
A-Kit

Ground

(GB-GRAM-M)

Aviation &
Maritime

GRAM SEM-E-M
(GRAM S/M)

(GB-GRAM-M)

Moderni

PUBLICALLY RELEASABLE

Aviation &



GPS Overview

SPACE AND MISSILE SYSTEMS CENTER



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)



38 Satellites / 31 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	3	21.5	24.4
GPS IIR	12	13.3	17.7
GPS IIR-M	7	7.7	9.6
GPS IIF	9	1.8	4.9
Constellation	31	9.5	24.4

AS OF 20 APR 15

Spectrum

- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements
- Adjacent Band Interference
- International Committee On Global Navigation Satellite Systems (GNSS)



Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

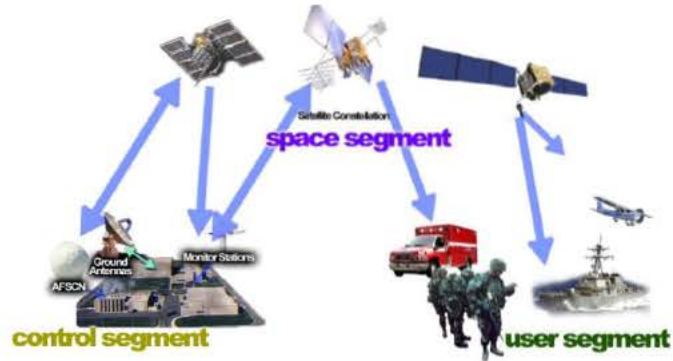
- U.S. Coast Guard

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 - COMPASS
 - Russia - GLONASS
 - Japan - QZSS
 - India - IRNSS

PUBLICALLY RELEASABLE



GPS Modernization Program

SPACE AND MISSILE SYSTEMS CENTER

Legacy GPS IIA/IIR

- Single Civil Frequency (L1 C/A)
- P(Y)-Code (L1 & L2)

GPS IIR-M

- 2nd Civil Signal (L2C)
- M-Code (L1M & L2M)

GPS IIF

- 3rd civil signal (L5)
- 2 Rb + 1 Cs Clocks
- 12 year design life

GPS III

- 4th civil signal (L1C)
- 4x better User Range Error than GPS IIF
- Increased availability
- Increased integrity
- 15 year design life



Legacy Operational Control Segment (AEP / LADO)

- Mainframe system
- Command & Control
- Signal monitoring
- Launch and disposal

Next Generation Operational Control System (OCX)

OCX Block 0

- Launch & On-Orbit Checkout of GPS III

OCX Block 1

- Replaces AEP for constellation C2
- M-Code
- Robust cyber security
- New civil signals & monitoring
- Improved accuracy

Modernized GPS User Equipment (MGUE)

- Provides M-code access for military users
- Increased anti-jam/anti-spoof capabilities

PUBLICALLY RELEASABLE

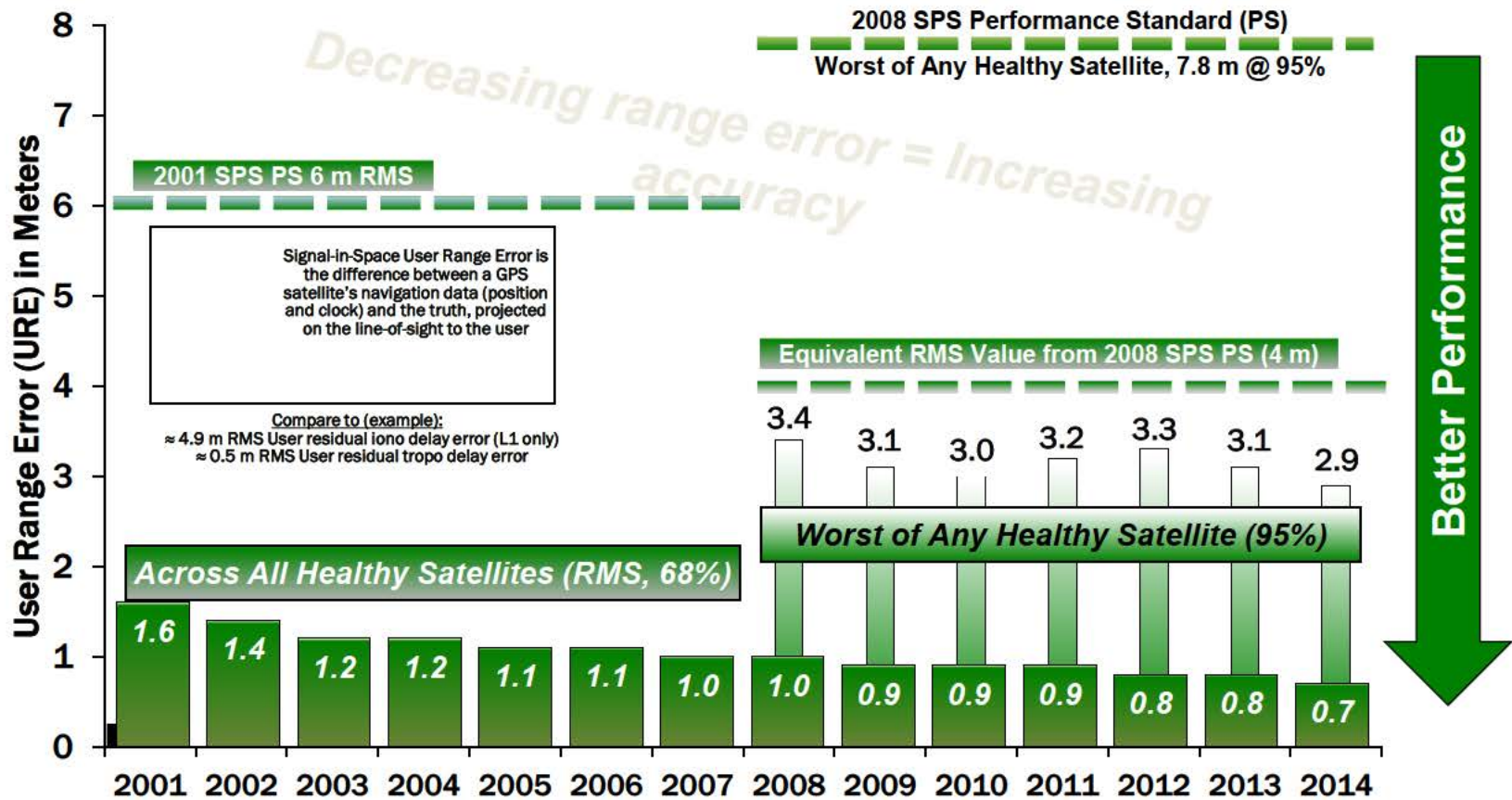


Accuracy: Civil Commitments

Standard Positioning Service (SPS) Performance Standard

SPACE AND MISSILE SYSTEMS CENTER

Standard Positioning Service (SPS) Signal-in-Space Performance



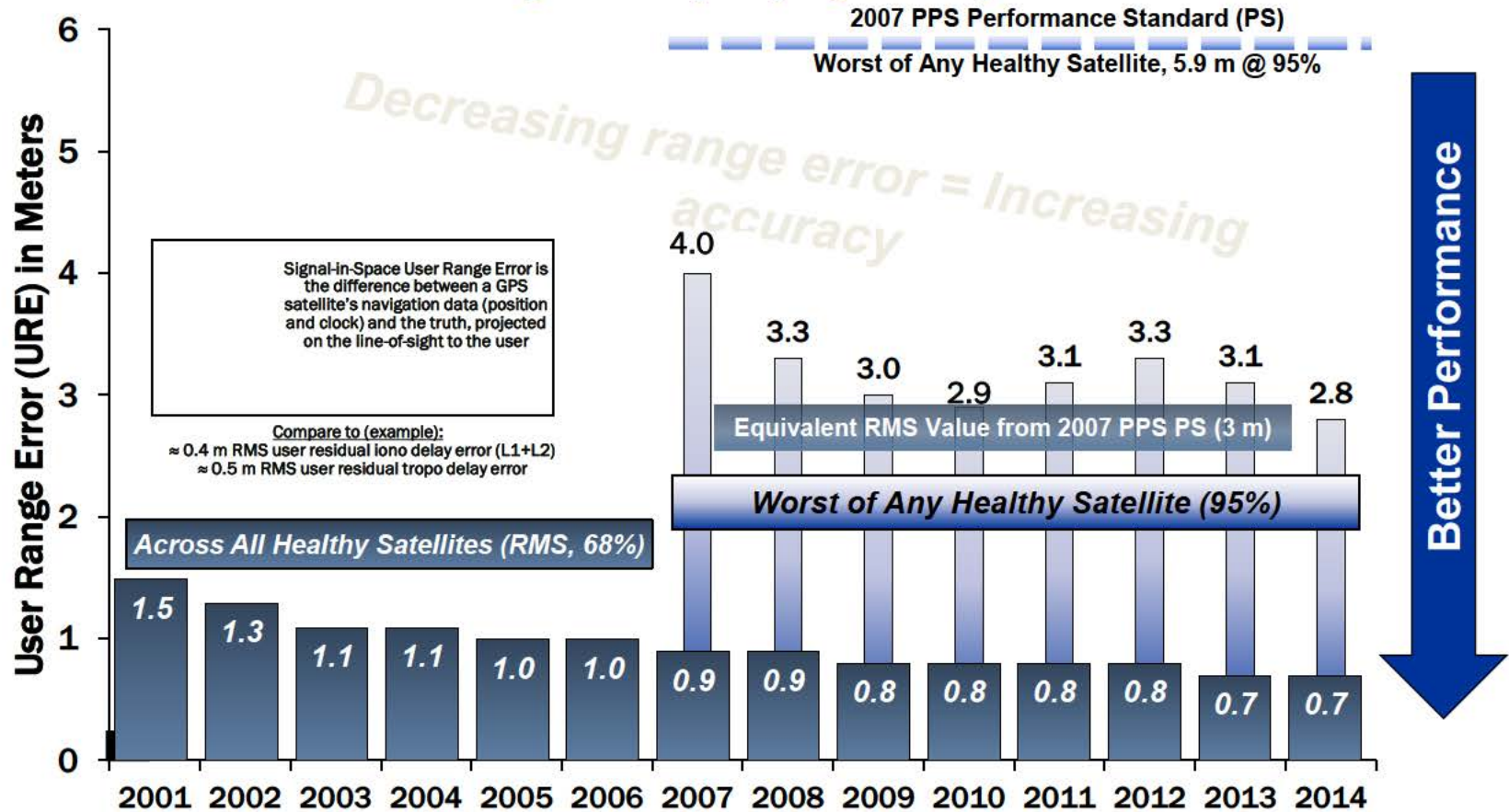


Accuracy: Military Commitments

Precise Positioning Service (PPS) Performance Standard

SPACE AND MISSILE SYSTEMS CENTER

Precise Positioning Service (PPS) Signal-in-Space Performance





Now on The Air: Modernized Civil Signals

SPACE AND MISSILE SYSTEMS CENTER

- The U.S. initiated CNAV message broadcast (L2C & L5) on 28 Apr 14
 - Daily uploads (nominal procedure for satellite operations) began on 31 Dec 14
 - L2C message currently set “healthy”
 - L5 message set “unhealthy” until sufficient monitoring capability established
 - Position accuracy not guaranteed during pre-operational deployment
- User Range Error (URE) CNAV Performance Post
 - Daily uploads consistent with or exceed legacy navigation performance*
 - Inter-signal corrections enable single point positioning competitive with P(Y) receivers
- Full potential of signals require receiver manufactures’ adoption
 - Challenge: Industry taking advantage of these signals moves capabilities forward!



* Data from “Performance Evaluation of the Early CNAV Navigation Message”, Pstreigenberger, O. Montenbruck, U. Hessels; Study conducted in Europe.

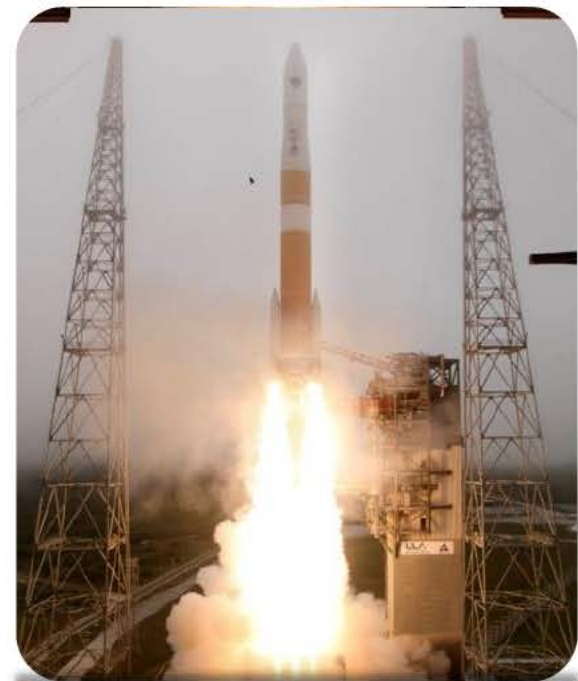
PUBLICALLY RELEASABLE



Modernized Space System: GPS IIF

SPACE AND MISSILE SYSTEMS CENTER

- Nine total GPS IIFs on-orbit
- Four GPS IIF launches in 2014!
- Three additional GPS IIFs in the pipeline
 - SV-9 & 12 are in storage; SV-11 at Cape
- Prime: The Boeing Company
- Upcoming launch dates:
 - GPS IIF-10 (SV-11) : 15 Jul 15
 - GPS IIF-11 (SV-12): 30 Oct 15
 - GPS IIF-12 (SV-9): NET 3 Feb 16



25 Mar 15: IIF-9



Modernized Space System: GPS III

SPACE AND MISSILE SYSTEMS CENTER

- 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
- SV-1 – SV-8 on contract; SV-9 & 10 approved
- Navigation payload panel delivered 1 Nov 14
- Updated Mission Data Unit delivered 9 Mar 15
- SV-1 System Module Core Mate completed 9 Apr 15
- SV level thermal vacuum scheduled for Fall 2015
- SV-1 available for launch Aug 2016



Lockheed Martin (Waterton, CO) – Prime



Current Control Segment: OCS

SPACE AND MISSILE SYSTEMS CENTER

- Current system Operational Control Segment (OCS)
 - Flying the GPS constellation with both the Architecture Evolution Plan (AEP) and the Launch & Early Orbit, Anomaly Resolution, and Disposal Operations (LADO) software systems
 - Cyber security / information assurance enhancements in progress
 - Prime: Lockheed Martin



Monitor
Station



Ground
Antenna



2SOPS Ground Control
(Schriever AFB)



Modernized Control Segment: OCX

SPACE AND MISSILE SYSTEMS CENTER

- Next Generation Operational Control System
 - Modernized command & control system
 - GPS III command & control
 - M-Code
 - Robust cyber security infrastructure
 - Modern civil signals & monitoring
 - Improved PNT performance
 - Prime: Raytheon (Aurora, CO)
 - OCX Block 0: launch & checkout for GPS III
 - Currently in test; delivery expected May 2016
 - Successfully completed four launch exercises
 - OCX Block 1: replaces AEP, adds modern features
 - Currently in design, delivery expected 2019
 - OCX Block 2: adds advanced NAVWAR and Civil Signal Performance Monitoring capabilities
 - Delivery expected in 2020

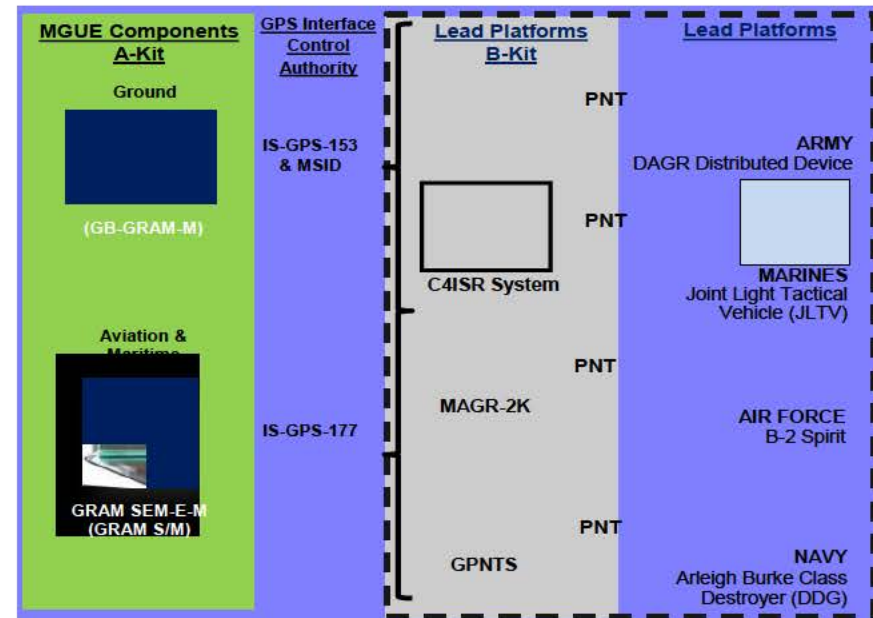




Modernized User Equipment: MGUE

SPACE AND MISSILE SYSTEMS CENTER

- Military GPS User Equipment (MGUE) is using a commercial market driven acquisition approach
- Accelerated from TD phase into testing and lead platform integration
- Increment 1 program's 2366b certification is pending
- Successful Preliminary Design Reviews (PDRs) for all 3 MGUE Inc 1 contractors
 - Rockwell Collins (Cedar Rapids IA): 06 Aug 14
 - L-3 Communications (Anaheim, CA): 04 Sep 14
 - Raytheon (El Segundo, CA): 17 Sep 14
- Security Certification Underway
- Integrating Service Lead Platforms
 - Air Force: B-2 Spirit (B-2)
 - Army: DAGR Distributed Device (D3) / Stryker
 - Marines: Joint Light Tactical Vehicle (JLTV)
 - Navy: Arleigh Burke Class Guided Missile Destroyer (DDG)





GPS Director's Focus

SPACE AND MISSILE SYSTEMS CENTER

- Delivering new signals to military and civilian users (M-Code, L2C, L5)
- Accelerating Military GPS User Equipment (MGUE)
- GPS III production, following 2-year delay, due to Navigation Panel issues
 - Thermal Vacuum test (Fall '15) final development hurdle
- Next Generation Ground (OCX) program challenges continue
 - Cybersecurity & systems engineering issues drove schedule and cost overruns
 - Contractor working closely with Gov't to deliver, but challenges remain



SPACE AND MISSILE SYSTEMS CENTER



Team GPS thanks you for your support!