Space and Missile Systems Center

Global Positioning Systems Directorate

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

18-19 May 2016

Lt Col Andrew Zinn
Global Positioning Systems Directorate

Global Positioning Systems Directorate

SPACE AND MISSILE SYSTEMS CENTER

"We are... the Green Monsters!"

Col Steve Whitney
Director

Mission:

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

GPS Overview

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

39 Satellites / 31 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIR	12	14.3	18.8
GPS IIR-M	7	8.8	10.6
GPS IIF	12	2.3	5.9
Constellation	31	8.4	18.8

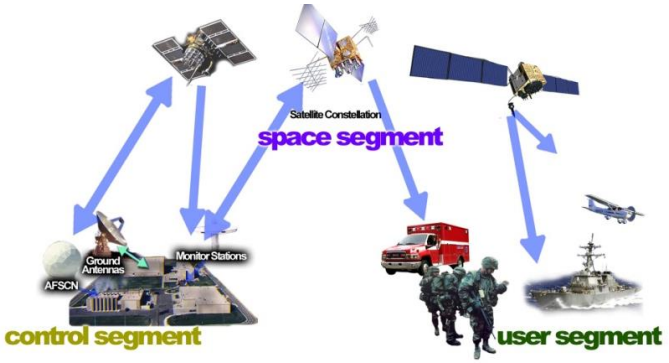
AS OF 4 MAY 16

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

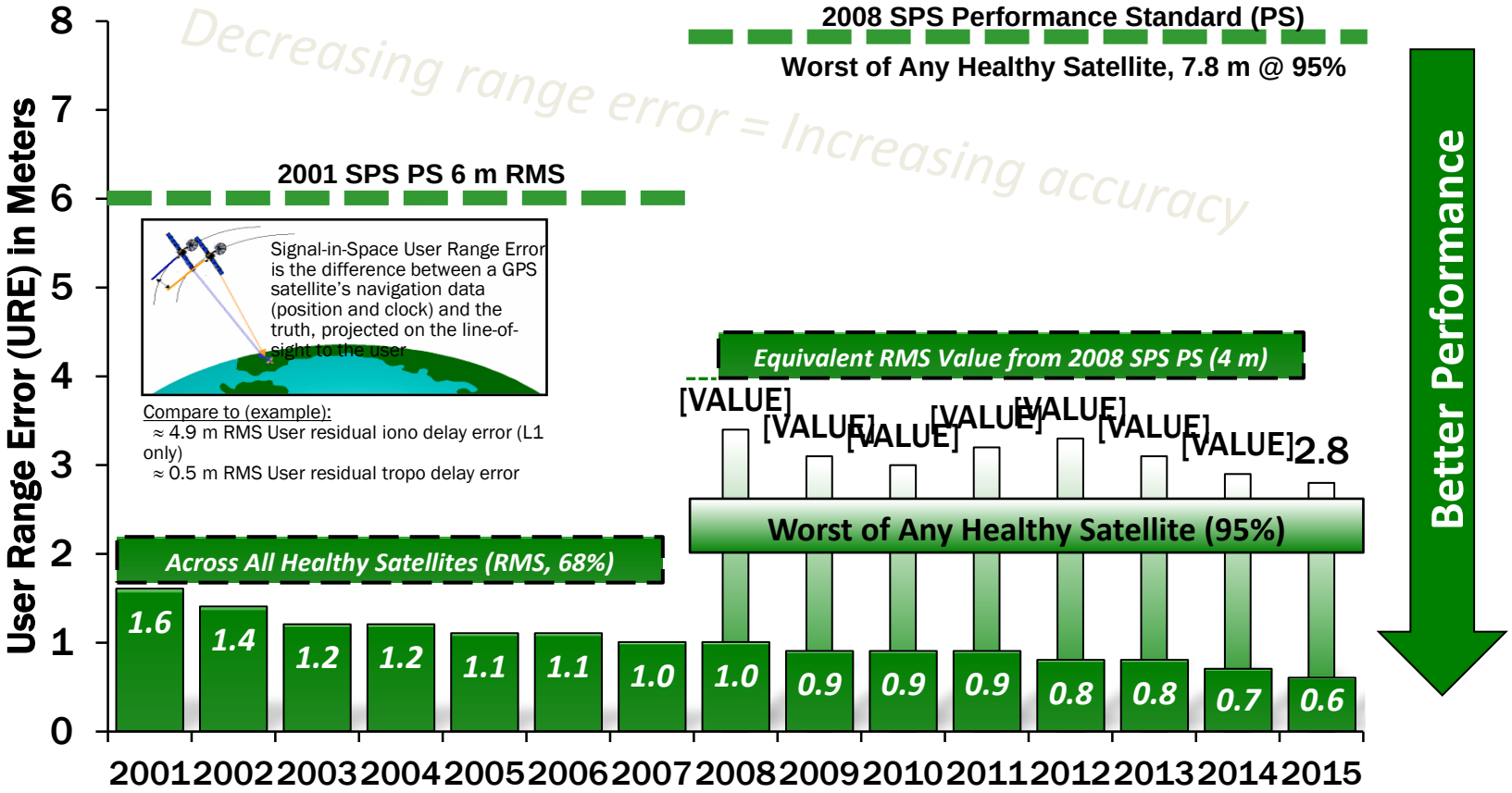
International Cooperation

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

Accuracy: Civil Commitments

Standard Positioning Service (SPS) Performance Standard

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

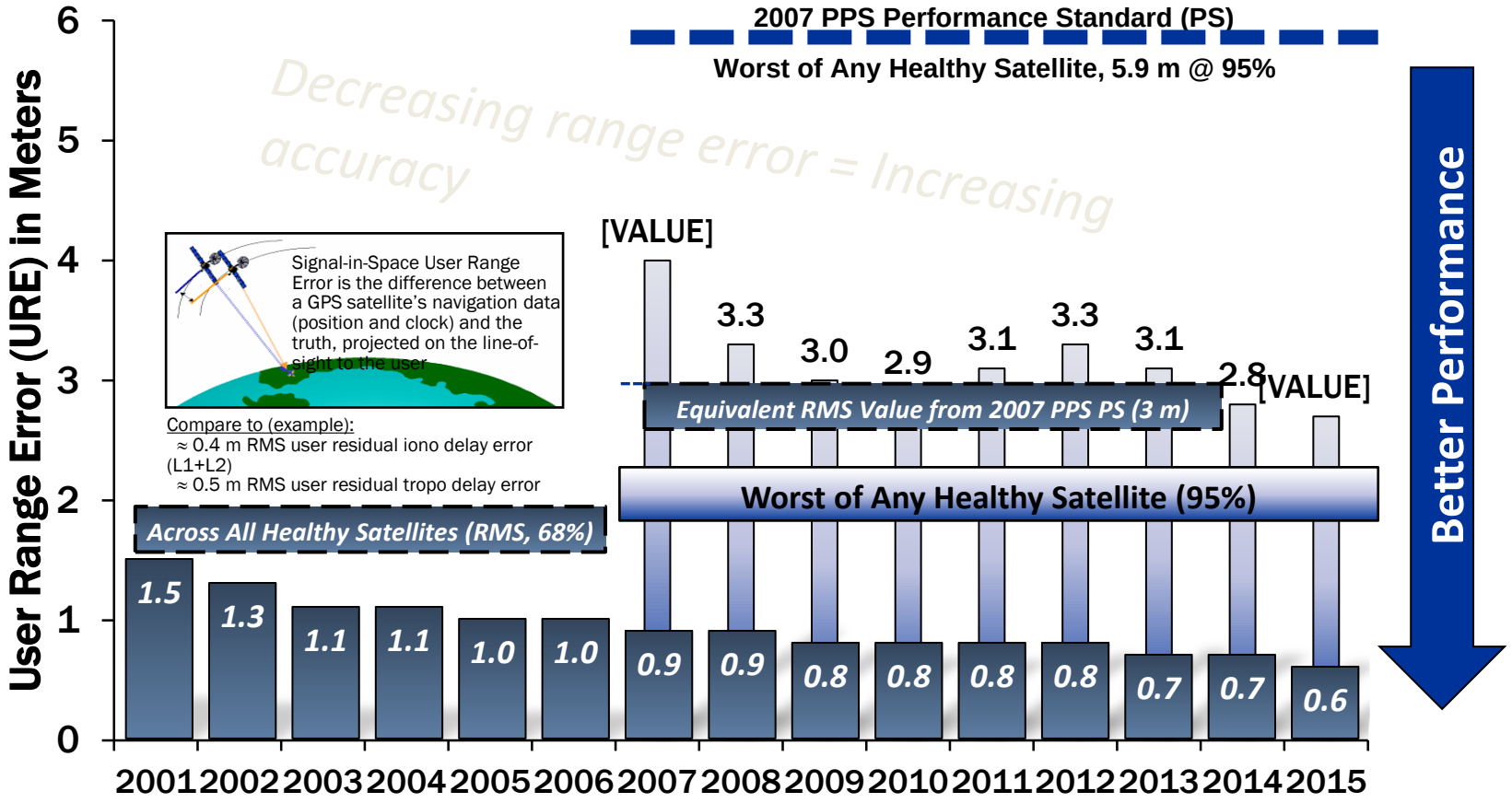


System accuracy better than published standard

Accuracy: Military Commitments

Precise Positioning Service (PPS) Performance Standard

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



System accuracy better than published standard

Current & Historical Statistics

	SIS vs JPL RMS URET (cm)						Mean AoD
	Period		Best Day		Worst Day		
	Ending	SIS	Date	SIS	Date	SIS	hours
Current Week	05/04/2016	51.0	04/29/2016	38.8	05/04/2016	60.6	11.38
Last Week	04/27/2016	51.7	04/25/2016	38.2	04/26/2016	60.9	11.67
Rolling Quarter	05/04/2016	51.9	04/25/2016	38.2	03/11/2016	64.0	11.55
Rolling 1/2 Year	05/04/2016	51.9	04/25/2016	38.2	12/19/2015	70.3	11.45
Rolling Year	05/04/2016	53.9	04/25/2016	38.2	05/23/2015	71.5	11.40
Best Day Ever			04/25/2016	38.2			11.81
Best Week Ever	04/14/2016	45.3					11.49
Worst Week Rolling Year	05/27/2015	64.4					11.32

Best day/week ever achieved this year!

Civil Navigation (CNAV)

CNAV message types currently being broadcast

Type	Title	Description/Function
10	Ephemeris 1	Keplerian orbital parameters
11	Ephemeris 2	Keplerian orbital parameters
30	Clock, IONO & Group Delay	SV Clock correction parameters, ionospheric and SV group delay correction parameters
33	Clock & UTC	SV Clock correction parameters, Coordinated Universal Time parameters
32	Clock & EOP	SV clock correction parameters, Earth Orientation Parameters (On hold until AEP 5.12.2 June 2016)

- **Current CNAV broadcast is "Pre-Operational" and intended to support modernized civil receiver development:**
  - L2C CNAV marked Healthy
  - L5 CNAV marked un-Healthy (supports test)
- Benefits:
  - Provides basic PNT service to CNAV developers

CNAV Broadcast is performing as expected.

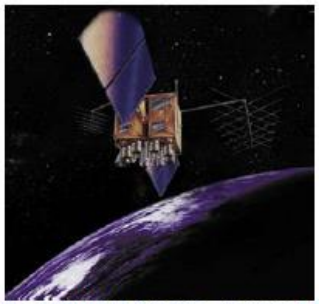
Constellation Snapshot

4 Generations of Operational Satellites

- **Block IIA - 8 Residual**
  - 7.5 year design life
  - Launched 1990-1997
- **Block IIR - 12 Operational**
  - 7.5 year design life (oldest operational satellite will be 19 yrs old in Jul)
  - Launched 1997-2004
- **Block IIR-M - 7 Operational, 1 Residual**
  - 7.5 year design life
  - Launched 2005-2009
  - Added 2nd civil navigation signal (L2C)
- **Block IIF - 12 Operational**
  - 12 year design life
  - Launched 2010-2016
  - Added 3rd civil navigation signal (L5)

*Current as of 5 May 16

Block IIA Satellite – Designed & Built by Rockwell International

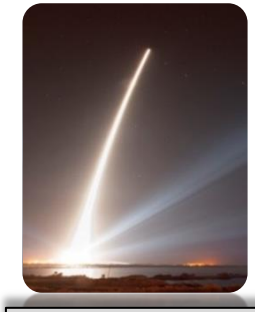


Block IIR/IIR-M Satellite – Designed & Built by Lockheed Martin

Block IIF Satellite – Designed & Built by Boeing

GPS IIF

- 12 total GPS IIFs on-orbit
- Final IIF launch complete!
  - GPS IIF-12 satellite successfully launched 5 Feb 16

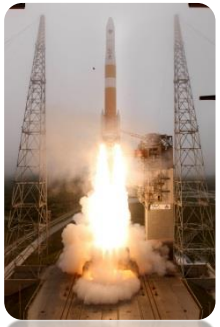


20 Feb 14: IIF-5

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

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

GPS III

- **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-SV08 on contract; SV09 & SV10 approved**
  - 2 year delay due to technical challenges w/ payload
  - SV09-10 same requirements baseline as SV01-08 but with no NDS payload
- **SV01 In Assembly Integration and Testing**
  - Baseline thermal vacuum testing completed 23 Dec 15
  - Electromagnetic Interference (EMI) test completed 14 May 16

GPS III SV11+ Acquisition

- Anticipate competing GPS III SV11-32 Production
  - Drive down SV costs & mitigate reliance on single nav payload vendor
  - Promote effective competition and reduce risk with production design phase

- Two-phase acquisition allows contractors time to mature designs
  - Phase 1: Production Readiness Feasibility Assessment
    - Awarded 5 May 16 to Boeing, Lockheed Martin, and Northrop Grumman
    - Determine if viable, low-risk, high confidence sources exist
    - Deliverables include nav payload design and brass board (hardware) test results, initial SV design, manufacturing/production process and facilities maturity
  - Phase 2: Full & open competition for GPS III SV11-32 production
    - FY18 projected award
    - First SV delivery in FY23 (SV11)

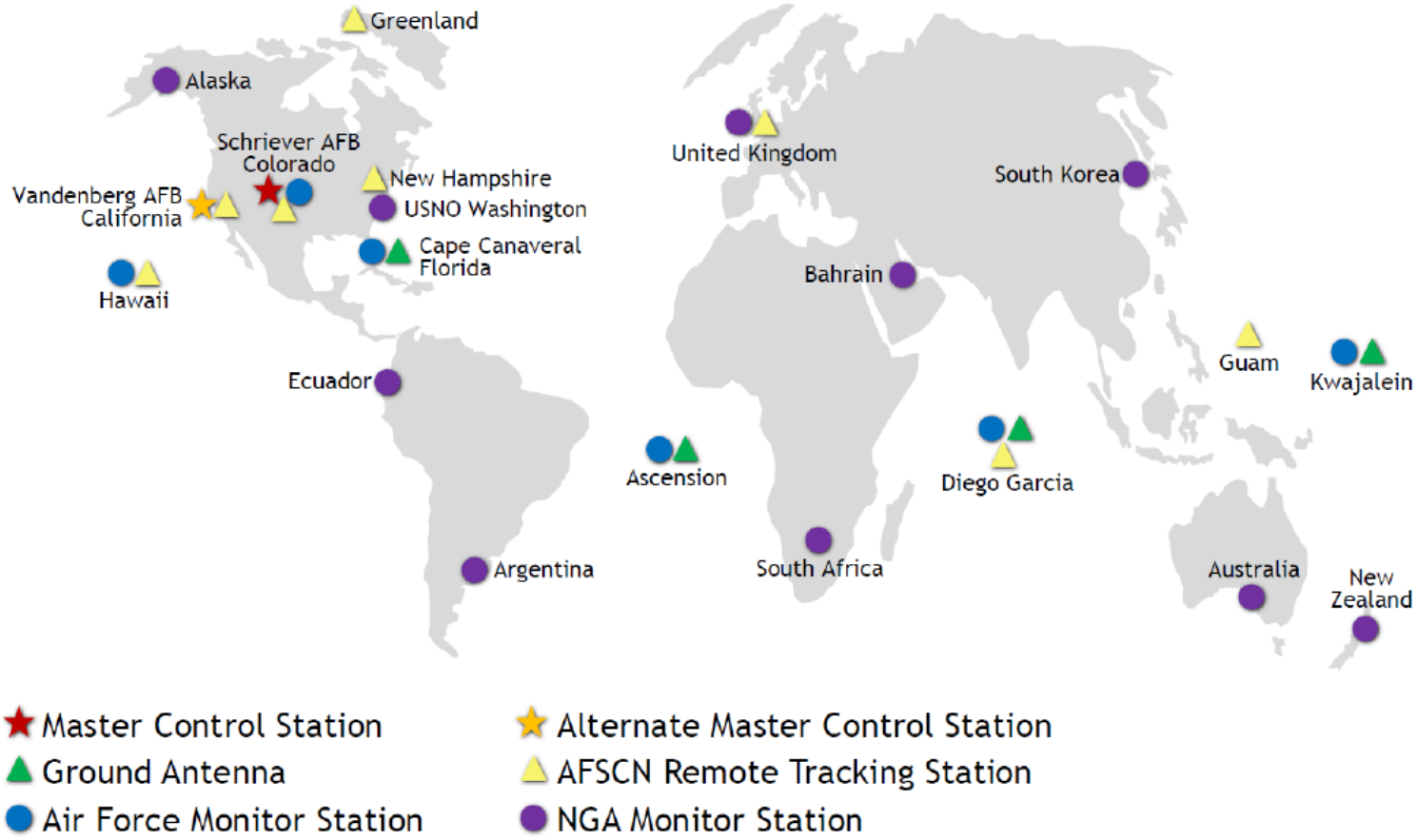
GPS III SV11+ Technical Baseline

- Current Enterprise technical baseline being updated to reflect AFROC-approved GPS III Follow-On Production CDD
  - SV01-10 baseline plus additional requirements:

Requirements (SV01-10 Baseline)	Additional Requirements
Backward Compatibility	Redesigned Nuclear Detonation Detection System (NDS) (KSA)
Availability of Position Accuracy	Laser Retro-reflector Array (KSA)
Position and Time Transfer Integrity (10^{-4})	Search and Rescue/GPS (KSA)
Availability of Time Transfer Accuracy	Unified S-Band Interface Compliance
Net Ready	Regional Military Protection – M-Code Power (TBD-KPP)
Sustainment – Materiel Availability	

- Capability Development Document (CDD) update will seek JROC approval to add Regional Military Protection – M-Code Power
  - Provides up to -140dBW M-Code Regional Power
  - Currently unfunded
- Synchronization of the tech baseline underway

Ground Segment



Ground Segment

- **Architecture Evolution Plan (AEP)**
  - Day-to-day command and control of up to 31 satellites
  - 4 dedicated Ground Antennas and AFSCN capability
  - 6 dedicated and 10 NGA Monitor Stations

- **Launch, Anomaly Resolution, and Disposal Operations (LADO)**
  - Day-to-day command and control residual satellites using AFSCN
  - State-of-health monitoring
  - Leverage for some vehicle emergencies
  - Launch prep and initial post-launch operations
  - Satellite end of life disposal operations

GPS Next Generation Operational Control System (OCX)

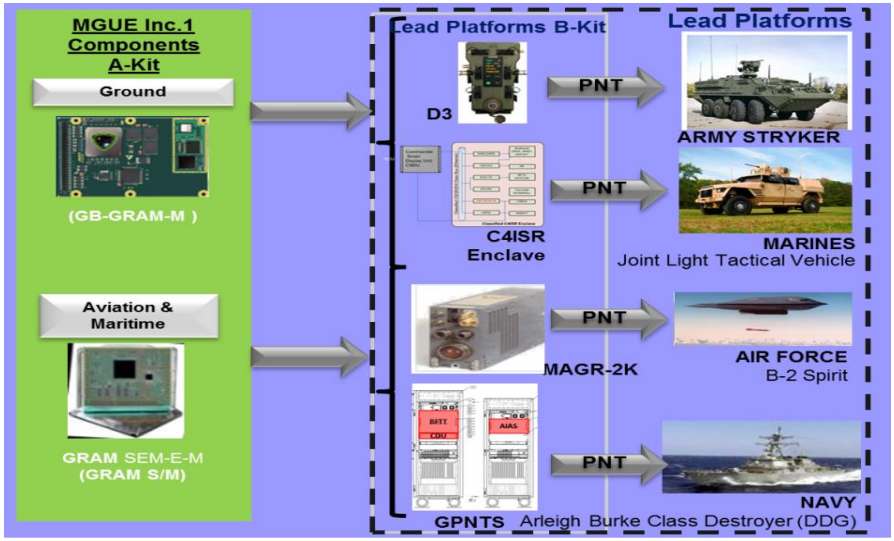
- **Modernized command & control system**
  - GPS III command & control
  - M-Code
  - Robust cyber security infrastructure
  - Modern civil signals & monitoring
  - Improved PNT performance
- **Prime: Raytheon (Aurora, CO)**
- **OCX Block 0: launch & checkout for GPS III**
  - Currently in test
  - Successfully completed seven launch exercises/simulations
- **OCX Block 1: replaces AEP, adds modern features**
  - Currently in design and risk reduction testing prior to restart of coding
- **OCX Block 2: adds advanced NAVWAR and Civil Signal Performance Monitoring capabilities**

OCX Status

- **Root cause of OCX problems:**
  - **Schedule was unrealistic at contract award in 2010**
  - **Appropriate systems engineering and system integration was not implemented in early phases**
  - **Initial cybersecurity requirements not well understood**
- **Holding quarterly reviews with Mr. Kendall, SecAF, and Raytheon CEO**
  - **Detailed reviews to measure progress and schedule ahead**
  - **Mobilizing resources across government and industry to enable system fielding**
- **Contingencies and "off ramps" are in place to meet GPS commitments in-case of further OCX issues**

Military GPS User Equipment (MGUE)

- **Commercial market-driven acquisition approach**
  - Three vendors developing modernized receiver cards
  - Feedback from initial testing flowing back to vendor developments
- **Conducting early integration activities with platform program offices**
  - Agreements in place to support integration and test of service nominated lead platforms
  - Progress integrating MGUE into B-2 software integration lab and prototype MAGR-2k box



- **MGUE program is in process of finalizing the Increment 1 Acquisition Program Baseline (APB) per OUSD(AT&L) direction to support a Milestone B decision**
- **Draft MGUE Increment 2 Capability Development Document (CDD) in coordination; includes space receiver, hand-held, and Precision Guided Munitions (PGM)**

GPS Director's Perspectives

- **Recognize the global utility of GPS**
  - **Committed to maintaining uninterrupted service – "the Gold Standard"**
- **Embracing Gen Hyten's 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 delivery**

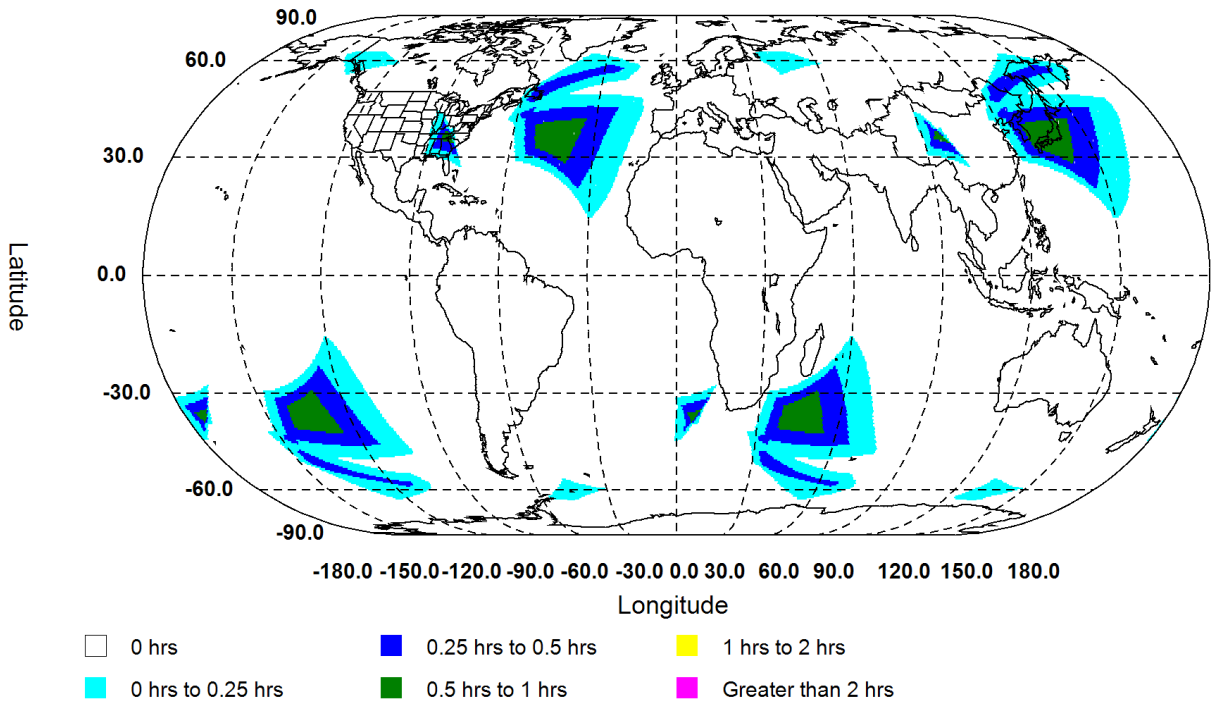

The men and women of the GPS Directorate
GLOBAL POSITIONING SYSTEMS
DIRECTORATE
NAVSTAR
Any Time, Any Place
Right Time, Right Place
GPS
GREEN MONSTERS
Transportation
Congratulations on the
Successful Completion
of
SV-6
RIGEL

Back-Up

Civil Signal Coverage

Current Constellation - L2C - 4-Fold Visibility Gaps

1 May 2016 - No Failures



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AEROSPACE

Civil Signal Coverage

Current Constellation - L2C - 1-Fold Visibility Gaps

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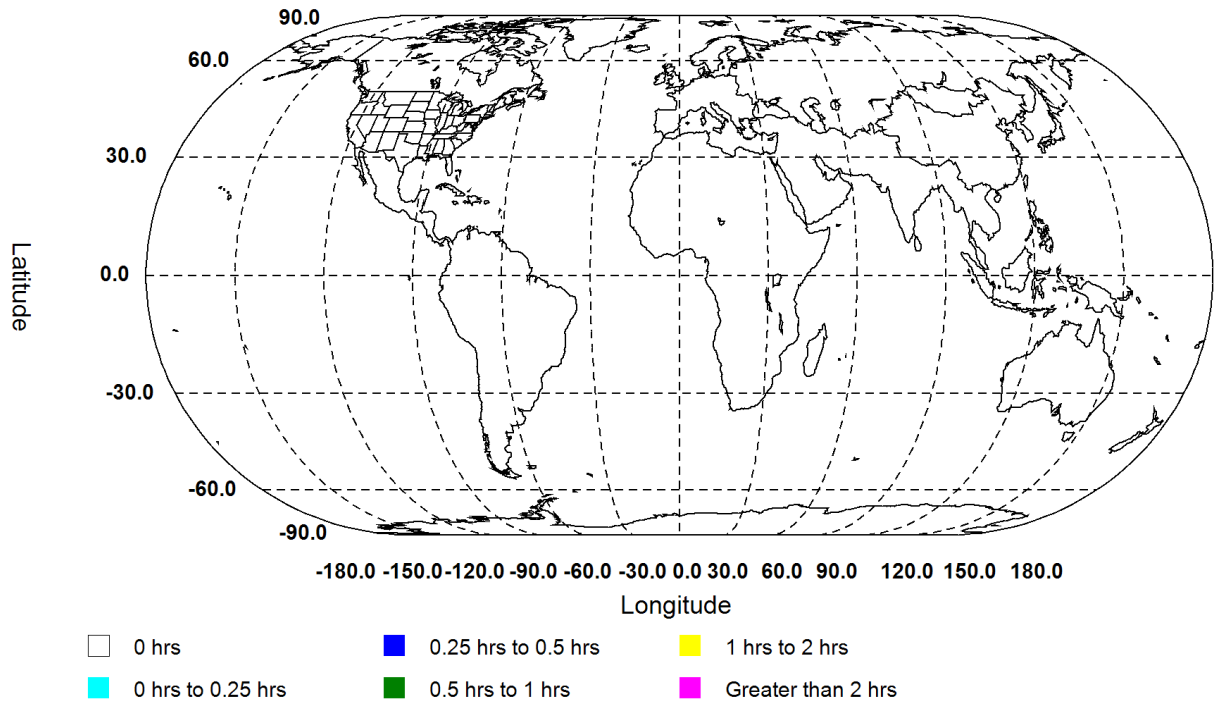

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Civil Signal Coverage

Current Constellation - L2C - PDOP < 6 Gaps

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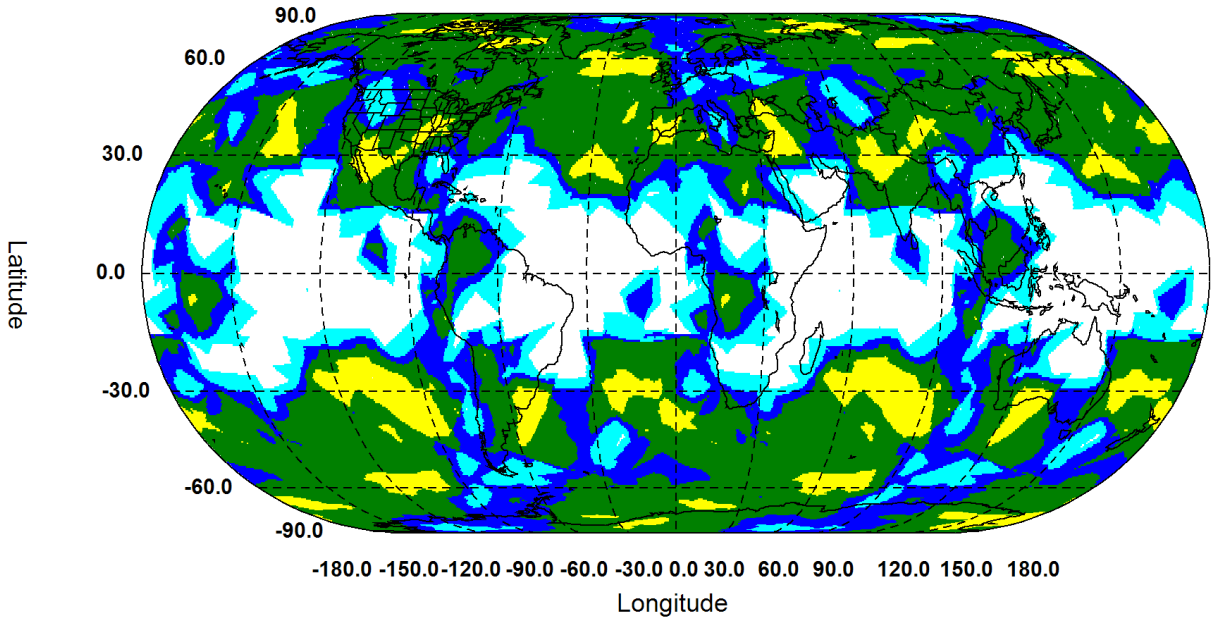

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Civil Signal Coverage

Current Constellation - L5 - 4-Fold Visibility Gaps

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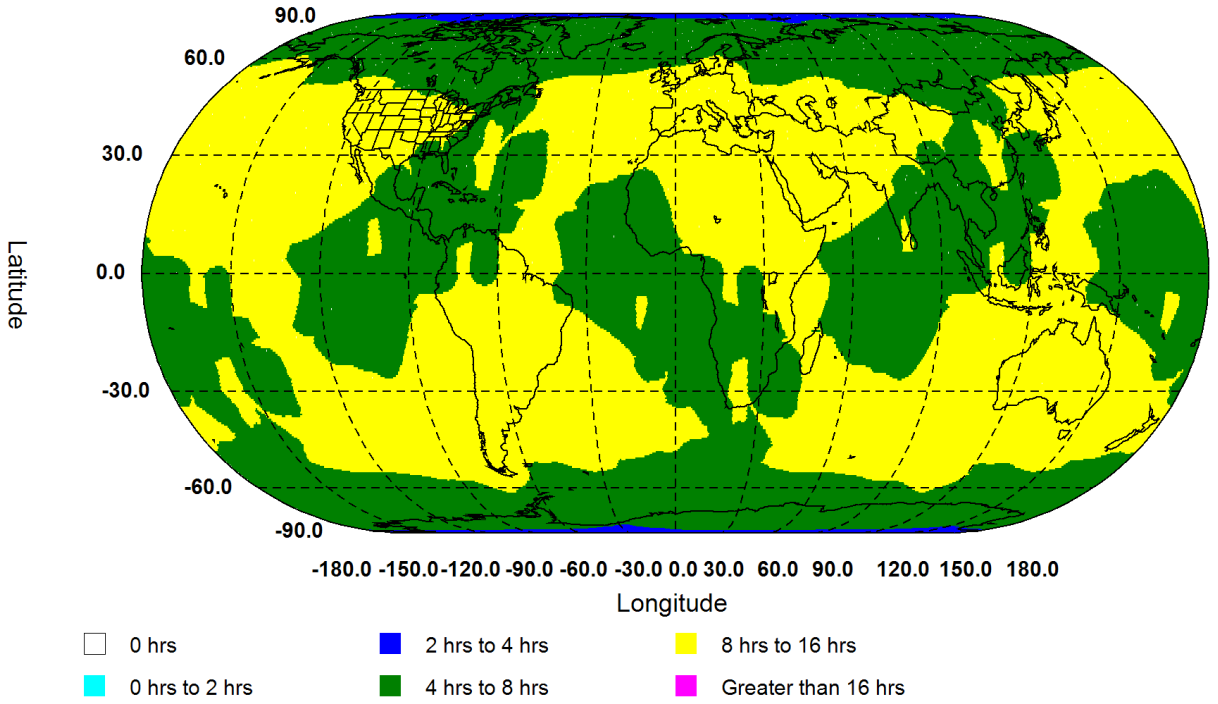

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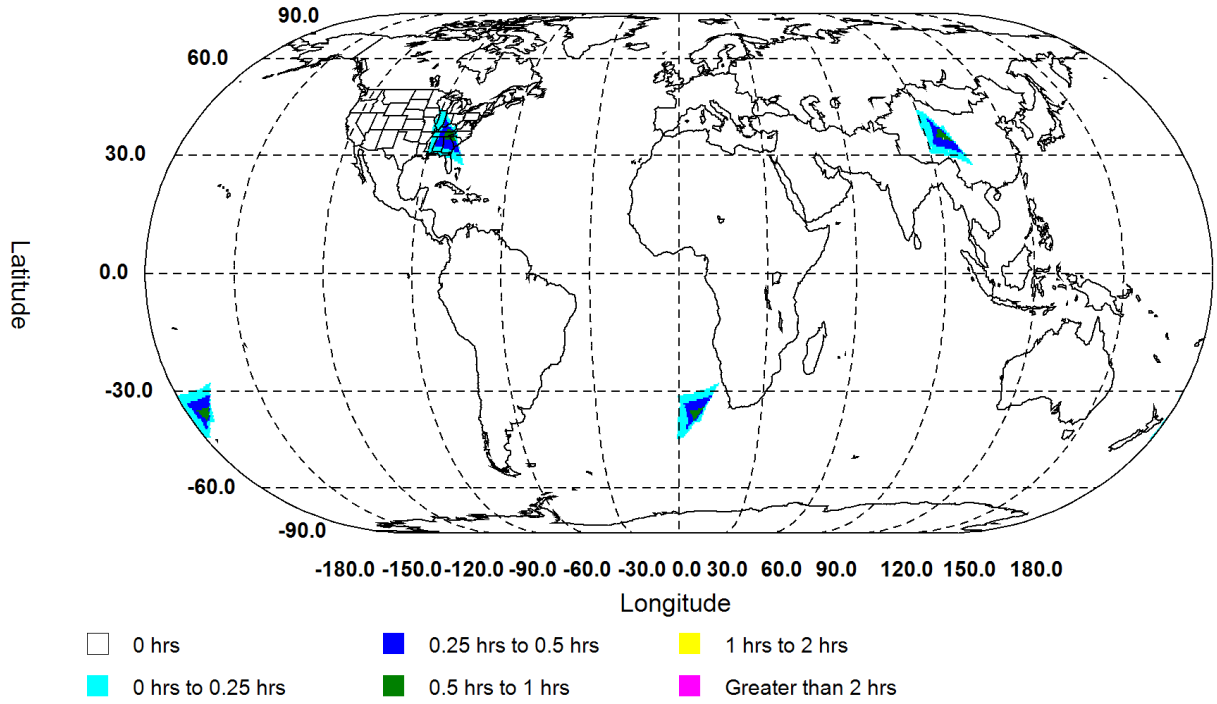
Civil Signal Coverage

Current Constellation - L5 - 1-Fold Visibility Gaps

1 May 2016 - No Failures



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Civil Signal Coverage

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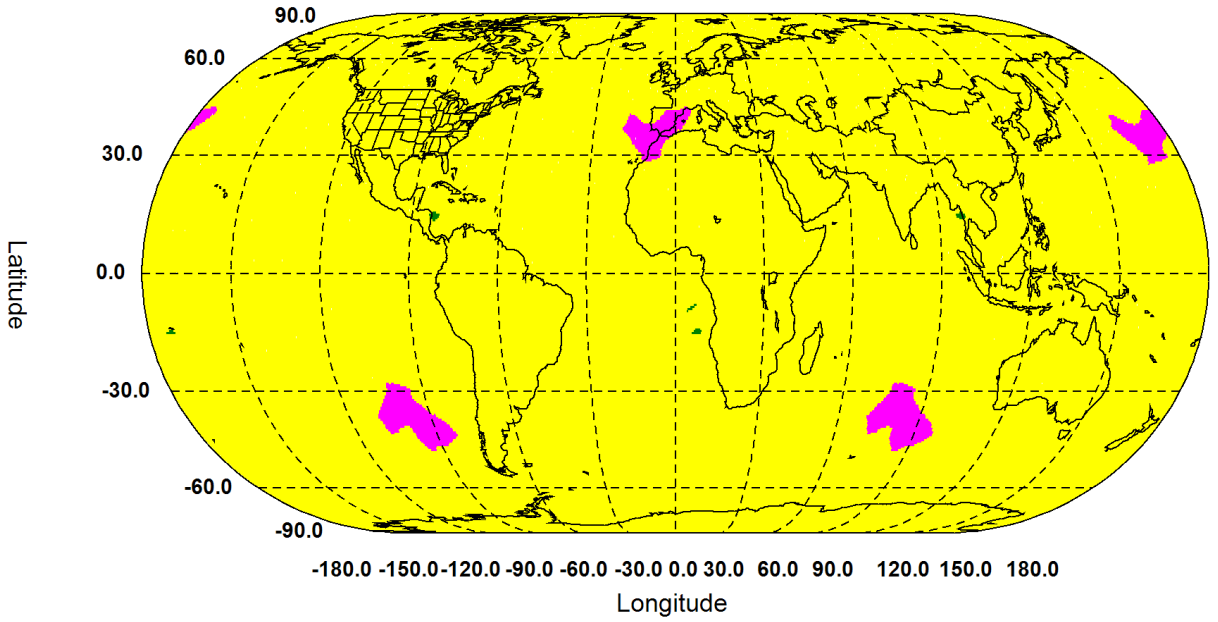
1 May 2016 - No Failures



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