

# Space and Missile Systems Center



## GPS Update for PNT Advisory Board

10 December 2014

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Director

Global Positioning Systems Directorate

# GPS Constellation Status

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## 30 Operational Satellites (Baseline Constellation: 24+3)

- **Robust operational constellation**
  - 4 GPS IIA – L1 C/A, L1 P(Y), L2 P(Y) signals
  - 12 GPS IIR – same signals as IIA
  - 7 GPS IIR-M – adds L2C, L1M, L2M signals
  - 7 GPS IIF – adds L5 signal
- **8 additional satellites in residual/test status, and 1 in early orbit test (IIF-8)**
- **Global GPS civil service performance commitment met continuously since Dec 1993 (IOC)**
  - Best performance **46.2 cm** User Range Error (URE) 17 Nov 2014; best weekly average **55.2 cm** URE 17 Nov 2014
  - Performance improving as new satellites replace older satellites



39 Satellites / 30 Set Healthy  
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	4	21.5	24.0
GPS IIR	12	12.9	17.4
GPS IIR-M	7	7.3	9.2
GPS IIF	7	1.9	4.5
<b>Constellation</b>	<b>30</b>	<b>10.2</b>	<b>24.0</b>

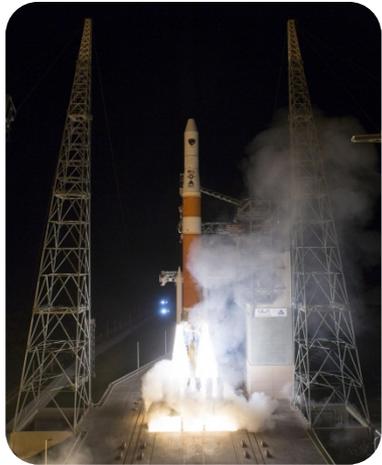
AS OF 19 NOV 2014

# 2014 Banner Year for GPS IIF

## 4 Successful Launches!

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- 8 total GPS IIFs on-orbit
- 4 more GPS IIFs in the pipeline
  - SVs 10, 11, and 12 are in storage
  - SV-9 is in production testing



**20 Feb: IIF-5**



**16 May: IIF-6**

**SVN 66 thru 69**



**1 Aug: IIF-7**



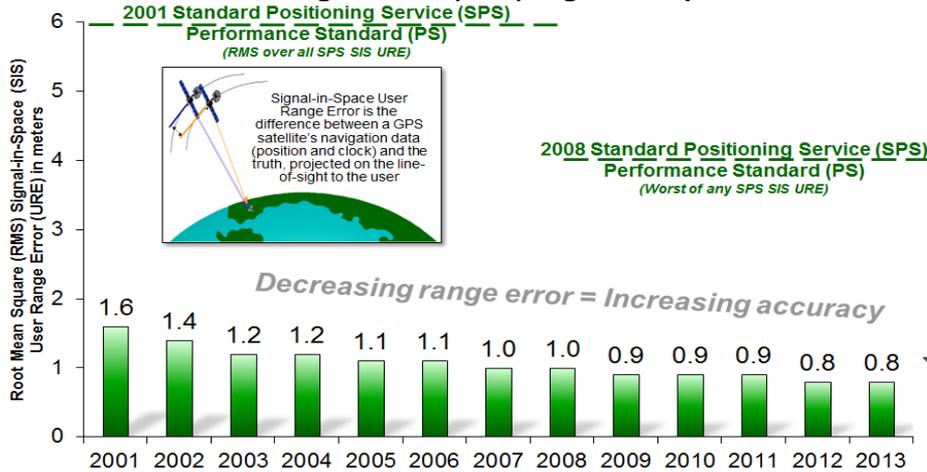
**29 Oct: IIF-8**

**Most GPS launches in a single year since 1993**

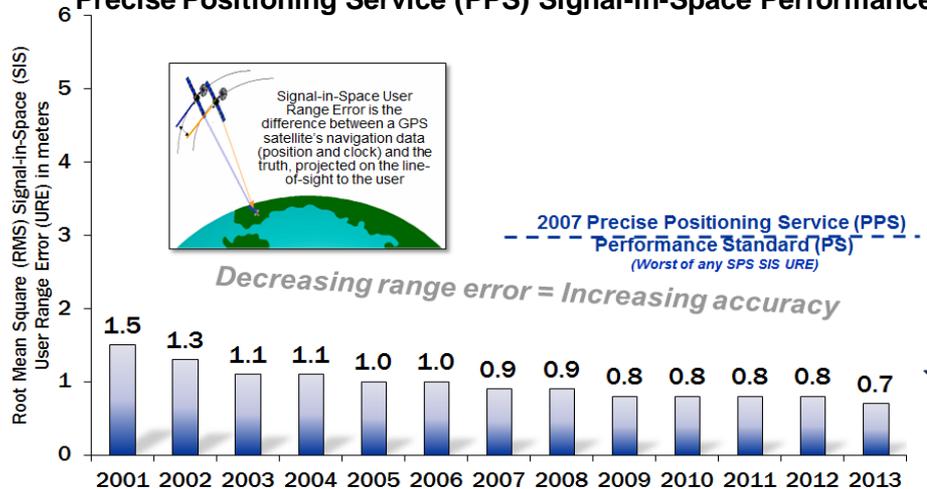
# GPS Signal-in-Space Performance

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



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



- US Law: (10 U.S.C. § 2281) “SecDef shall provide GPS for both military & civilian purposes”
- The Standard Positioning Service (SPS) Performance Standard defines commitment to civil users and is approved by PNT EXCOM
- Information is for the user community – in particular, aviation users for receiver certification
- Last updated in 2008

**System accuracy exceeds published standard**

# GPS Modernization Program

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## Legacy GPS IIA/IIR

- Single Frequency (L1)
- Coarse acquisition (C/A) code
- Y-Code (L1Y & L2Y)

## GPS IIR-M

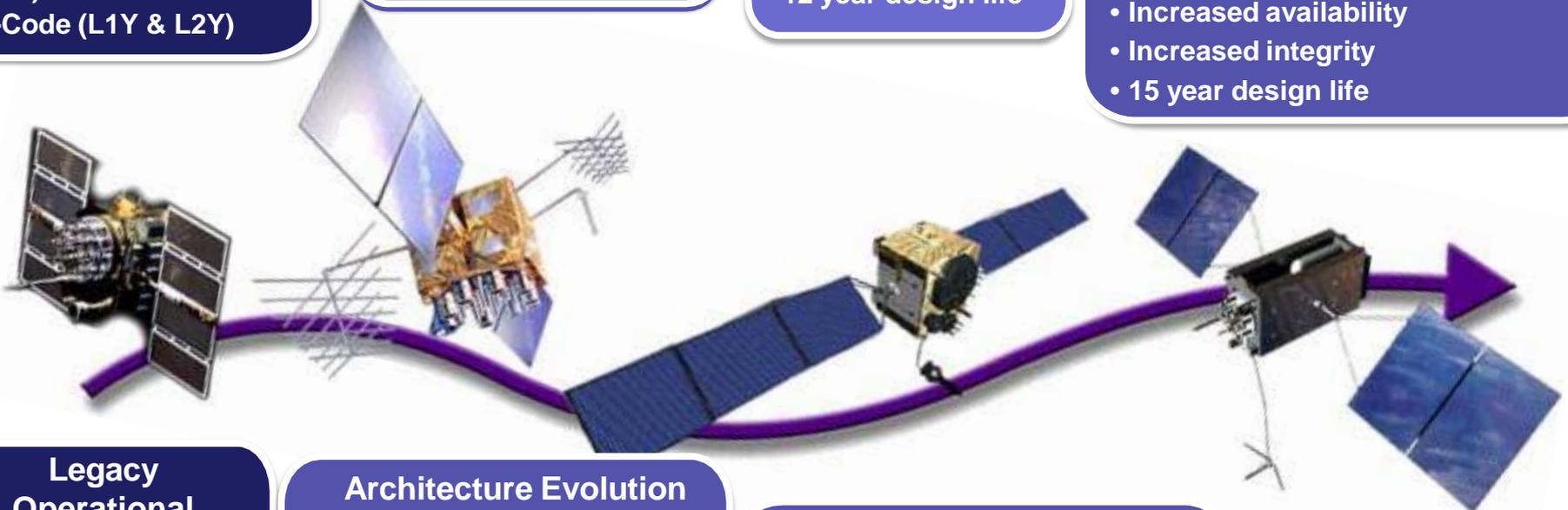
- 2<sup>nd</sup> Civil Signal (L2C)
- M-Code (L1M & L2M)

## GPS IIF

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

## GPS III

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



## Legacy Operational Control Segment (OCS)

- Mainframe system
- Command & Control
- Signal monitoring

## Architecture Evolution Plan (AEP)

- Distributed architecture
- Increased signal monitoring
- Security
- Accuracy
- Launch and disposal ops

## Next Generation Operational Control System (OCX) Block 0

- Launch & On-Orbit Checkout of GPS III

## OCX Block 1

- Transition to OCX for all GPS command and control operations

**Increasing system capabilities - Increasing user benefit**

# GPS III Status

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- 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
  - Three improved Rubidium atomic clocks
- SV07/08 contract awarded 31 Mar 14
- SV09/10 planned to be purchased under current Lockheed contract
- Navigation payload panel began space environment testing at Lockheed Martin's Colorado facility Sep 14
- GPS III Non-Flight Satellite Testbed accomplished launch processing at Cape Canaveral; reduced risk for integration & test and launch processing
- GPS III SV01 available for launch CY 2016



Lockheed-Martin (Waterton, CO) – Prime



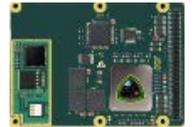
# Military GPS User Equipment (MGUE)

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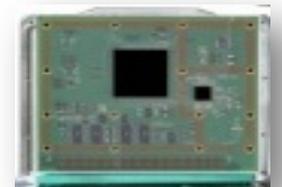
- Building next-generation of military GPS receivers that incorporate M-Code (required in statute by FY17)
- Direction from USD(AT&L) to accelerate MGUE Increment 1
- Requirements approved by JROC July 2014
- Successfully completed Preliminary Design Reviews for MGUE Increment 1 contractors Aug-Sep 2014
- Security Certification Underway
- Updated Lead Platforms
  - Army: Raven to DAGR Distributed Device (D3)
  - Air Force: F-15E to B-2 Spirit (B-2)



MAGR-2K



Ground-Based Card



Aviation/Maritime Card

# Ground Segment

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- Current system Operational Control Segment (OCS)
  - Flying GPS constellation on Architecture Evolution Plan (AEP) and Launch & early orbit, Anomaly, and Disposal Operations (LADO) software systems
  - Cyber security enhancements in progress
- Next Generation Operational Control System (OCX)
  - Modernized command & control system with M-Code, modern civil signal monitoring, info assurance infrastructure and improved PNT performance: Raytheon (Aurora, CO) - Prime
  - Successfully completed four GPS III launch exercises
  - OCX Block 0 supports launch & checkout for GPS III; currently in integration & test; delivery expected Jan 2016
  - OCX Block 1 supports transition from OCS in 2019
  - Civil Signal Performance Monitoring capability scheduled for OCX Block 2 in 2020



**Monitor Station**



**Ground Antenna**



# Now on The Air: Modernized Civil Signals

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- U.S. initiated continuous CNAV message broadcast (L2C & L5) on 28 Apr 2014; began with twice-a-week uploads and moving to daily (nominal) uploads on 15 Dec 2014
  - Position accuracy not guaranteed during pre-operational deployment
  - L2C message currently set “healthy”
  - L5 message set “unhealthy” until sufficient monitoring capability established
- User-Range Error (URE) CNAV Performance
  - CNAV URE within 3 meters of LNAV performance with 3x per week uploads
  - Daily uploads consistent with or exceed LNAV performance
- Currently 14 L2C- and 7 L5-capable satellites on orbit



# GLOBAL POSITIONING SYSTEMS DIRECTORATE

