Space and Missile Systems Center

Global Positioning Systems Directorate Update

Stanford's 2015 PNT Symposium

13 Nov 15

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Deputy Director
Global Positioning Systems Directorate

Global Positioning Systems Directorate

SPACE AND MISSILE SYSTEMS CENTER

GPS Enterprise View

SPACE AND MISSILE SYSTEMS CENTER

Civil Cooperation
- 1+ Billion civil & commercial users
- Search and Rescue
- Civil Signals
  - L1 C/A (Original Signal)
  - L2C (2nd Civil Signal)
  - L5 (Safety of Life)
  - L1C (International)

Spectrum
- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements

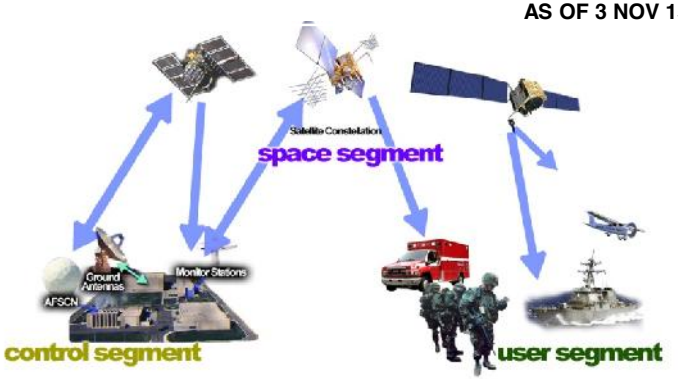
Department of Transportation
- Federal Aviation Administration

Department of Homeland Security
- U.S. Coast Guard

40 Satellites / 30 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	1	24.9	24.9
GPS IIR	12	13.8	18.3
GPS IIR-M	7	8.3	10.1
GPS IIF	10	2.1	5.4
Constellation	30	9.0	24.9

AS OF 3 NOV 15



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

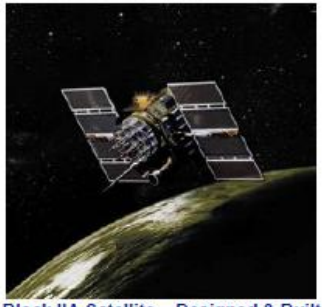
International Cooperation
- 56 Authorized Allied Users
  - 25+ Years of Cooperation
- GNSS
  - Europe - Galileo
  - China - Beidou
  - Russia - GLONASS
  - Japan - QZSS
  - India - IRNSS

Space Segment

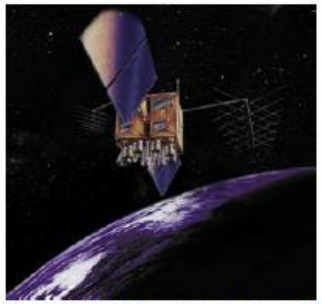
4 Generations of Operational Satellites

- **Block IIA - 1 Operational, 8 Residual**
  - 7.5 year design life (oldest operational satellite will be 25 yrs old in Nov)
  - Launched 1990-1997
- **Block IIR - 12 Operational**
  - 7.5 year design life
  - 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 - 10 Operational**
  - 12 year design life
  - Launched 2010-present
  - Added 3rd civil navigation signal (L5)

*Current as of 3 Nov 15



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

Cool Videos

- IIF-10 Encapsulation -- https://www.youtube.com/watch?v=FRFQMM_Gcbk
- IIF-10 Mate -- https://www.youtube.com/watch?v=6N3ArhzDApA
- IIF-11 Launch -- http://www.ulalaunch.com/file-library.aspx?launchEventID=248

GPS IIF

- **11 total GPS IIFs on-orbit**
  - -- **Mission IIF-11 launched from Cape on 31 Oct 15**
- **1 more GPS IIF in the pipeline**
  - -- **Mission IIF-12 shipped to Cape on 7 Oct 15**

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

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
- **SV01 System Module Core Mate completed 7 Apr 15**
- **Mission Data Unit software qualification complete 6 Aug 15**
- **SV-level thermal vacuum started Oct 15**
- **SV01 "available for launch" Aug 2016**

GPS III SV11+

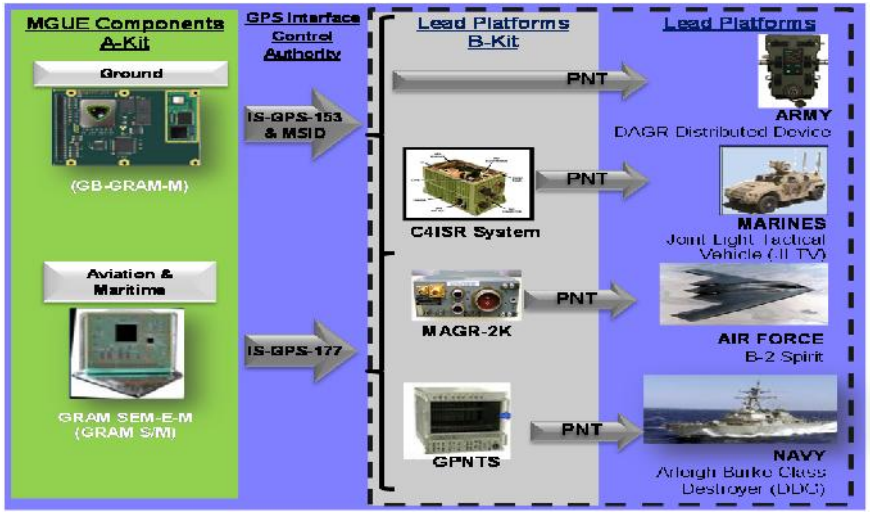
- **Competing GPS III SV11+ Production**
  - Drive down space vehicle costs by promoting effective competition
  - Mitigate reliance on single navigation payload vendor
  - Reduce production cost and schedule risk with minimal design phase
- **Two-phase acquisition approach allows contractors time to mature designs**
  - GPS III SV11+ Production Readiness Feasibility Assessment (Phase 1)
    - Gain insight into contractor-funded space vehicle and navigation payload production design maturity and risk
    - Full and open competition
    - Up to 3 Firm-Fixed Price contracts, $6M per source (incl/ options)
    - Request For Proposal release 1QFY16 with contract awards in 3QFY16
  - GPS III SV11+ Follow-on Production Competition (Phase 2)
    - Acquisition strategy to be informed by Feasibility Assessment performance and results
    - Notional full and open competition for up to 22 satellites
    - Projected award in FY18

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**

Military GPS User Equipment (MGUE)

- **Three vendors developing modernized receiver cards**
- **Pursuing commercial market-driven acquisition**
- **Initial test articles delivered 4Q 2015**
  - Developmental test started 24 Aug 2015



- **MGUE program is in process of completing 2366B documentation, ICE, and APB per ASD(A) direction to support a Milestone B decision**
- **Draft MGUE Increment 2 Capability Development Document (CDD) in coordination; defined as space receiver, hand-held, and Precision Guided Missile (PGM)**

Conclusion

- **Satellite constellation is healthy, but we're eager to take advantage of GPS III capabilities**
- **Next-Generation Operational Control System (OCX) addressing cost and schedule challenges**
- **MGUE fielding is being accelerated via commercial market strategy**
  - Key driver -- statute for Services to field in FY17 & increase user equipment performance and resiliency

We recognize the global utility of GPS
- **Committed to maintaining uninterrupted service**
- **Continue to advance availability, accuracy, security**


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

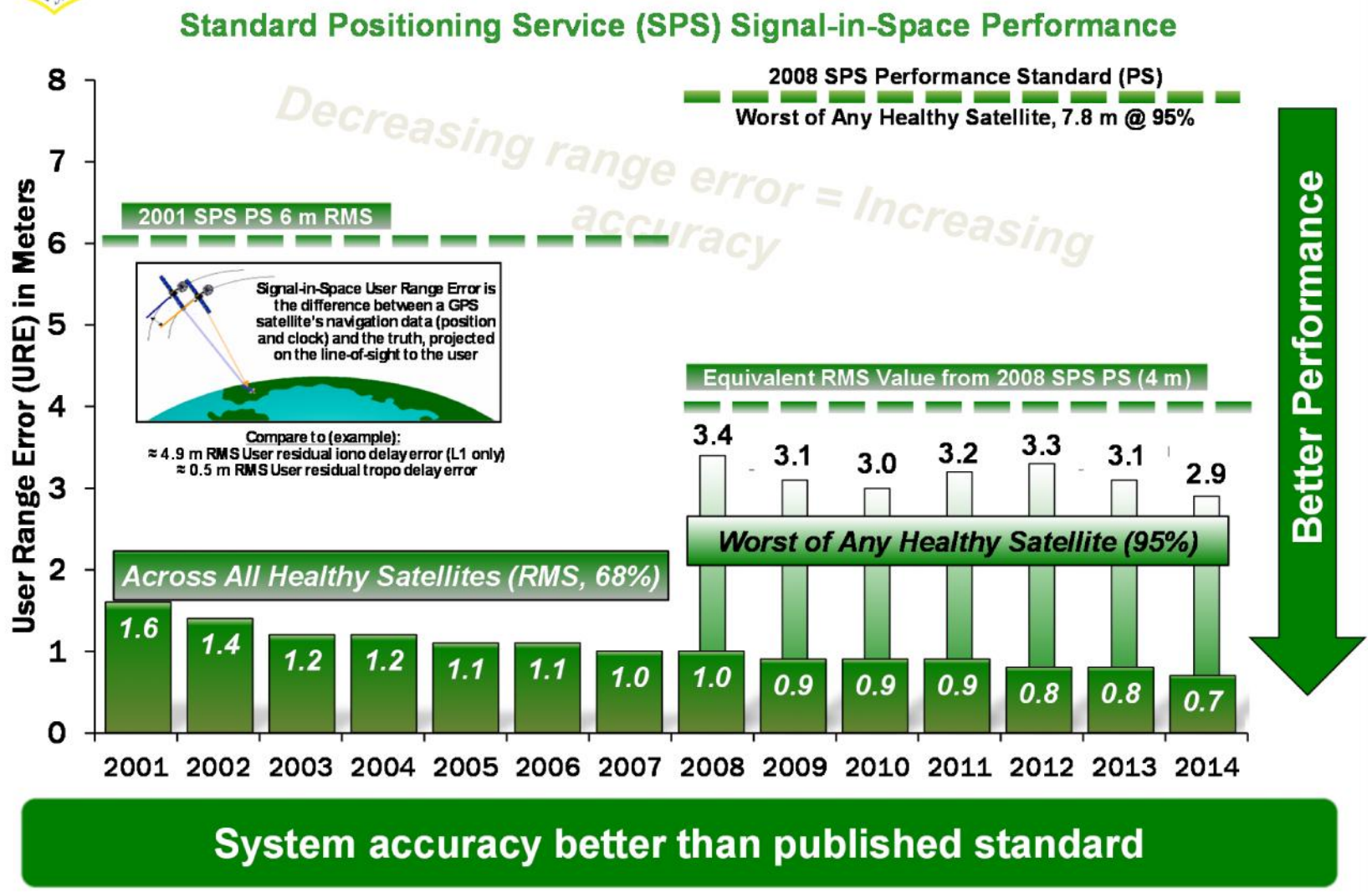
Constellation Snapshot

- **Block IIA satellites, 1 Operational, 8 Spare**
- **Block IIR satellites, 12 Operational**
- **Block IIR-M satellites, 7 Operational, 1 Spare**
- **Block IIF satellites, 10 Operational**
- **Oldest Satellite is SVN23; will be 25 Yrs Old, Nov 15**
- **U.S. Government continuously assessing constellation optimization to determine launch need**

*Current as of 3 Nov 15

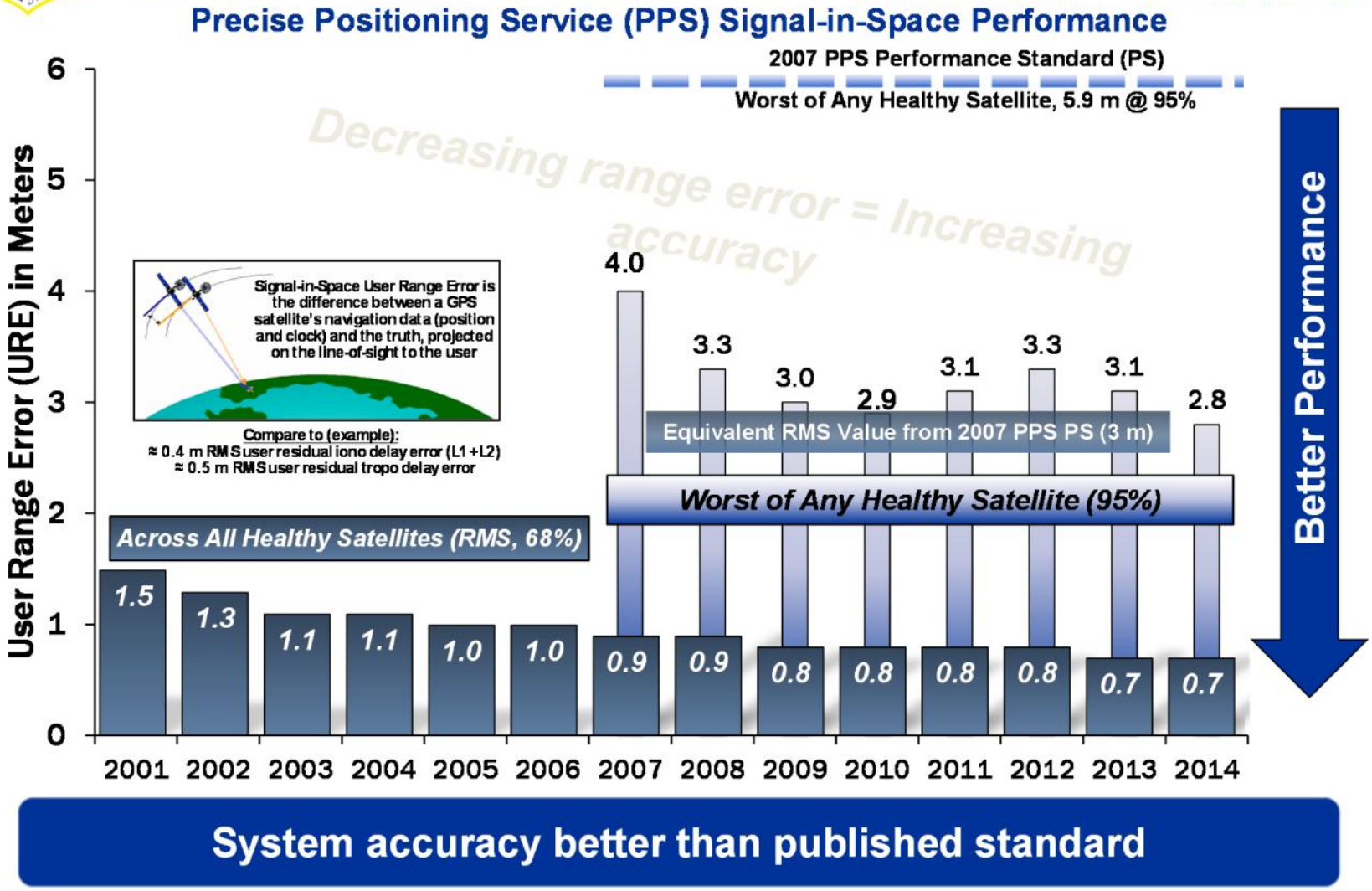
Accuracy: Civil Commitments

Standard Positioning Service (SPS) Performance Standard



Accuracy: Military Commitments

Precise Positioning Service (PPS) Performance Standard



Current & Historical Statistics

	SIS vs JPL RMS URET (cm)						Mean
	Period		Best Day		Worst Day		AoD
	Ending	SIS	Date	SIS	Date	SIS	hours
Current Week	10/14/2015	55.7	10/09/2015	40.4	10/12/2015	67.8	11.41
Last Week	10/07/2015	50.0	10/07/2015	42.9	10/05/2015	55.0	11.63
Rolling Quarter	10/14/2015	54.5	10/09/2015	40.4	10/12/2015	67.8	11.42
Rolling 1/2 Year	10/14/2015	56.6	06/13/2015	40.3	05/23/2015	71.5	11.36
Rolling Year	10/14/2015	57.9	06/13/2015	40.3	01/15/2015	76.0	11.32
Best Day Ever			06/13/2015	40.3			11.42
Best Week Ever	09/10/2015	48.6					11.51
Worst Week Rolling Year	04/17/2015	65.8					11.44

Best day/week ever achieved this year!

Civil Navigation (CNAV)

- **CNAV is being broadcast today!**
  - L2C CNAV set Healthy, 18 SVs by the end of the year
  - L5 CNAV set Unhealthy, available for test
  - Intended to support modernized civil receiver development

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

- **Collaborating on GPS/GNSS Time Offset (GGTO) test plan with Civil community**

CNAV Broadcast is performing as expected.