Space and Missile Systems Center

Global Positioning Systems Directorate

GPS Program Update
to Civil GPS Service Interface
Committee (CGSIC)

17 Sep 2013

Col Bill Cooley
Director, GPS Directorate

Building the Future of Military Space

Global Positioning Systems Directorate

Mission:

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

Col Bill Cooley

Deliver and Sustain Global Navigation and Timing Service

GPS Program Partnership

- Civil representatives integral members of GPS team
  - Resident in the GPS Directorate – DOT (1), FAA (1), NASA (½)

- Support program, Interface Control Document and Specification reviews
  - Civil GPS Service Interface Committee (CGSIC)
  - Signal Monitoring Working Group (SMWG)
  - Interface Control Working Group (ICWG)
  - L1C Product Implementation Teams
  - Positioning Signal Integrity and Continuity Assurance (PSICA) Team
  - Interagency Forum for Operational Requirements (IFOR)
  - National Space-Based PNT Engineering Forum (NPEF)
  - Nation Space-Based Coordination Office (NCO)

Interagency partnerships are critical to GPS modernization success!

GPS Constellation

- Robust constellation
  - 31 space vehicles currently in operation
    - 8 GPS IIA, 12 GPS IIR, 7 GPS IIR-M, 4 GPS IIF
  - 4 additional satellites in residual status, 1 in test status

- Extensive International and Civil Cooperation
  - Agreements with 56 international customers
  - 1 billion civil/commercial users
  - Countless applications…and growing

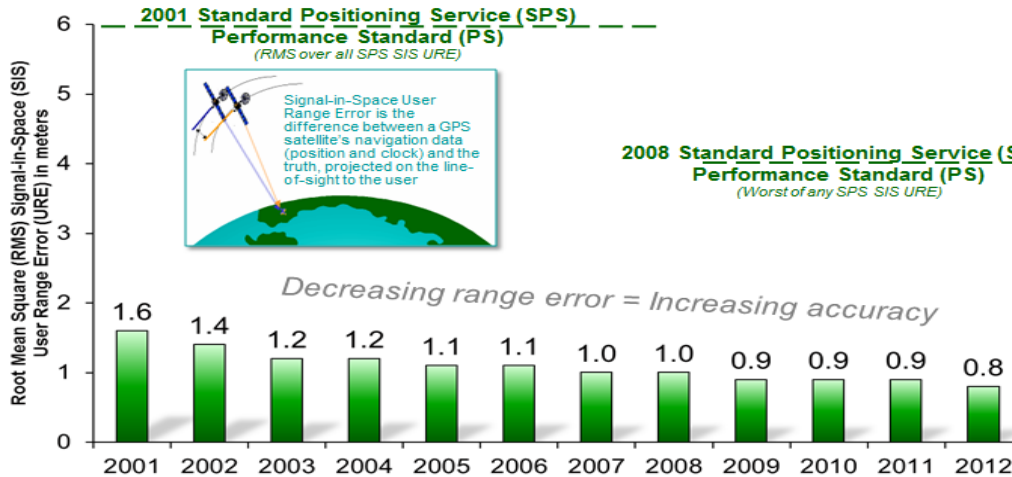- Global GPS civil service performance commitment met continuously since Dec 1993

GPS Signal in Space Performance

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

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

Mining and Construction

Precision Agriculture

Aviation

Wildlife Research
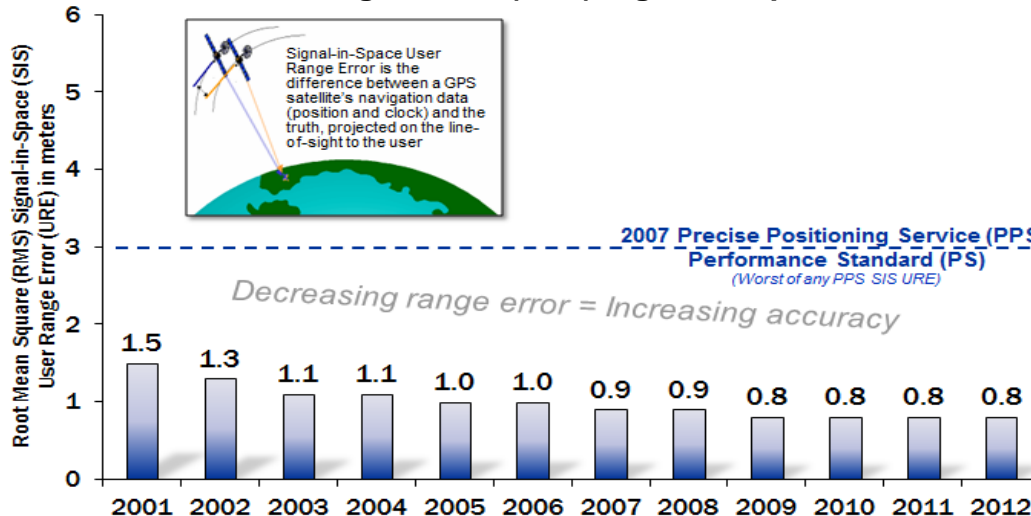
Precision Navigation

System accuracy exceeds published standard

GPS IIF Status

- Launched GPS IIF-4 on 15 May 13
  - Satellite Vehicle Number 66, PRN 27
  - Set healthy 21 Jun 13
  - Fourth operational L5 signal
  - Providing enhanced GPS clock performance
- 4 total GPS IIFs on orbit
  - Continued demonstration of Flex Power capability
- 8 more GPS IIFs in the pipeline
  - SV-3 scheduled for 17 Oct 13 launch
  - SVs 6-9 are in storage
  - SVs 10-12 are accepted pending testing
  - Improved Rubidium clocks on SVs 3 and 5-12

GPS III Status

- Newest block of GPS satellites
  - First satellite to broadcast common L1C signal
  - Multiple civil and military signals;
    L1 C/A, L1 P(Y), L1M, L1C, L2C, L2 P(Y), L2M, L5
  - Three Rubidium clocks
- Achieved SV01 initial power turn-on 27 Feb 13
- GPS Satellite Simulator delivered to support OCX, 21 May 13
- Shipped GPS Non-Flight Satellite Testbed to Cape Canaveral (19 Jul); will undergo launch processing

Enabling Affordability & Capability

- Dual launch of GPS III satellites significantly reduces launch costs
  - GPS and Launch Directorates are coordinating on final requirements for a GPS-specific dual payload adapter and mission profile requirements
  - Early studies indicate only minor changes needed to support this capability, with minimal changes in the production line of GPS III SV09+
- Future Size, Weight, Power (SWAP) considerations
  - Battery & Solar Array Efficiency, Efficient Amplifiers, etc…
- Added Capability
  - Search and Rescue/GPS
  - Laser Retroreflector Arrays
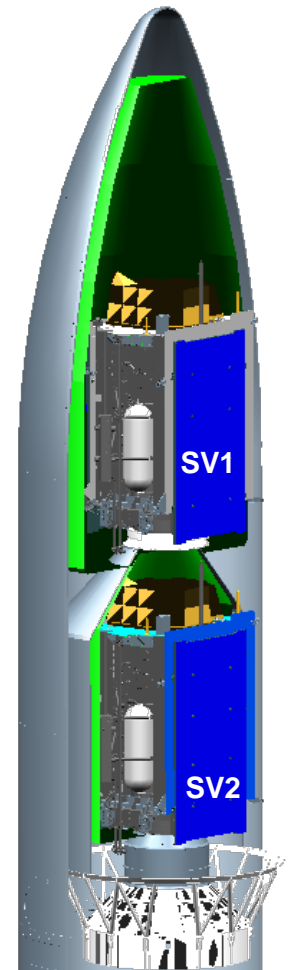
Notional Dual Launch Configuration

Ground Segment Status

- Current system Operational Control Segment (OCS)
  - Flying GPS IIA/IIR/IIR-M/IIF constellation with AEP 5.8.2 and LADO 2.11.2A currently deployed

- Next Generation Operational Control System (OCX) on track
  - Exercise 3 completed on schedule, demonstrated:
    - End to end capability from satellite separation to on orbit planning
    - Successful anomaly resolution
  - OCX Block I Ready to Transition to Operations planned for 2016

- OCX development successes:
  - Interim Authority to Test granted to Launch and Checkout System by Space Designated Accreditation Authority (Jun 2013)
  - Demonstrated reduction in navigation estimation error (JPL Data)

- OCX to GPS III Integration Status
  - Initiated Hardware in the Loop (HWIL) testing using OCX LCS
  - Communicated with Ground Non-flight Satellite Testbed at Cape Canaveral
  - Actively working System Integration demonstrations highlighting key system interactions

Monitor Station

Ground Antenna

GPS Modernization – New Civil Signals

- Second civil signal "L2C"
  - Designed to meet commercial needs
  - Available since 2005 without data message
  - Phased roll-out of CNAV message
  - Currently 11 SVs broadcasting L2C

- Third civil signal "L5"
  - Designed to meet transportation safety-of-life requirements
  - Uses Aeronautical Radio Navigation Service band
  - Currently 4 SVs broadcasting L5

- Fourth civil signal "L1C"
  - Designed for GNSS interoperability
  - Specification developed in cooperation with industry
  - Launches with GPS III in 2015
  - Improved tracking performance

Urban Canyons

Improved performance in challenged environments

Early CNAV test conducted in Jun 2013

US Gov't Committed to Civil Signals

- The modernized civil signal deployment is in progress
  - 11 L2C and 4 L5 capable SVs on orbit
  - OCX will implement full command & control of L2C & L5
  - Expect the 1st L1C SV launch in 2015
- Intend to maintain semi-codeless phase relationships until 31 Dec 20
  - Documented in Federal Register Notice Vol. 73, No. 185 (Ref. 31) 23 Sep 08
- Semi-codeless users should start transitioning to L2C
  - Most high-precision manufacturers already offer L2C capable receivers
  - Significant benefits available now
- Complete civil signal constellation implementation limited by:
  - Constellation health – currently enjoy a robust combination of legacy signals
  - Launch opportunities – acceleration possible with dual launch of GPS III

The PNT EXCOM drives civil signal implementation

Summary

- GPS has continuously met its commitments to all users

- GPS had multiple operational and acquisition successes in the past year

- Modernization of all GPS Segments is on track

- Striving to continually improve navigation and timing services while maintaining backward compatibility with legacy equipment

Telecommunications

Time-stamping and Financial Transactions

Aviation

Small Diameter Bomb

Precision Agriculture

Joint Direct Attack Munitions JDAMS

Maritime and Waterway Navigation

Transportation

Precision Navigation

Wildlife Research

GPS Guided Artillery

Mining and Construction

Cruise Missiles

Cell Phones and Pagers

Surveying/Mapping

Maintaining and improving GPS services for all users is Job #1

Homepage for General Public

Backup

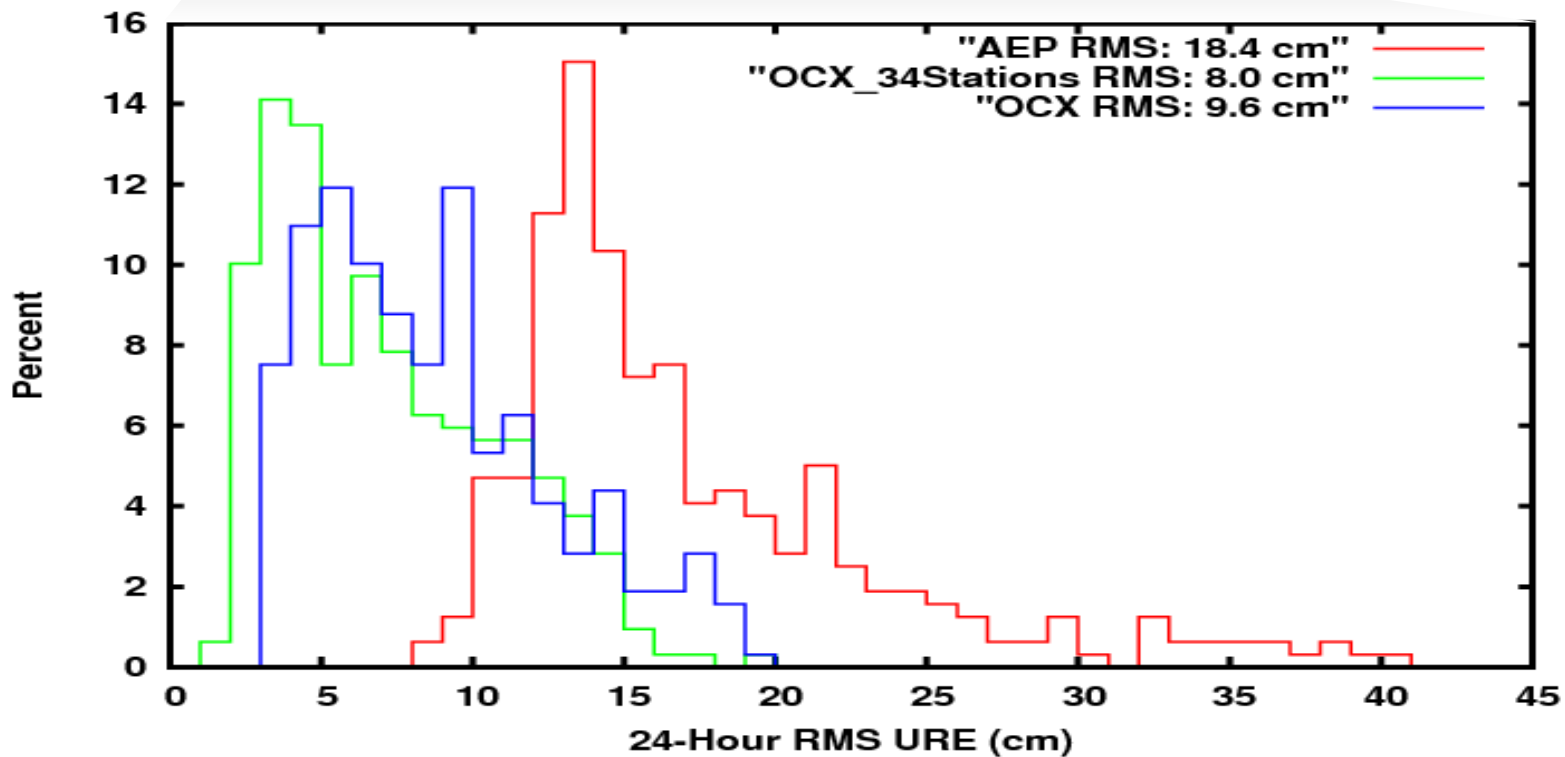# OCX Estimated Performance

- JPL has employed OCX core Kalman filter for over 6 months

- User Range Error = Satellite Ephemeris Error + Satellite Clock Error

Aug. 5-15, 2012 Zero Age of Data RMS URE

* Zero Age of Data is a current estimation, not a prediction

Jun 2013 CNAV Testing

- GPS CNAV testing publicized in advance through various PNT conferences and online at GPS.gov
- First CNAV live-sky test broadcast with civil input
  - Demonstrated CNAV messaging on GPS IIR-M & GPS IIF SVs (L2C, L5)
  - Focused on basic PNT functionality
- Broadcast populated messages for two weeks
  - Contents included: CNAV ephemeris, clock, almanac, and non-navigation message types
- Perfect opportunity to identify or explore any CNAV message issues in order to implement fixes before operations
- CNAV message set unhealthy at the conclusion of testing
- Further CNAV tests will be conducted to continue to troubleshoot before CNAV message is set healthy