Global Positioning Systems Directorate

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

18 Sep 2012

Col Bernie Gruber
Director
GPS Directorate

Global Positioning Systems Directorate

Mission:

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

Col Bernie Gruber

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)

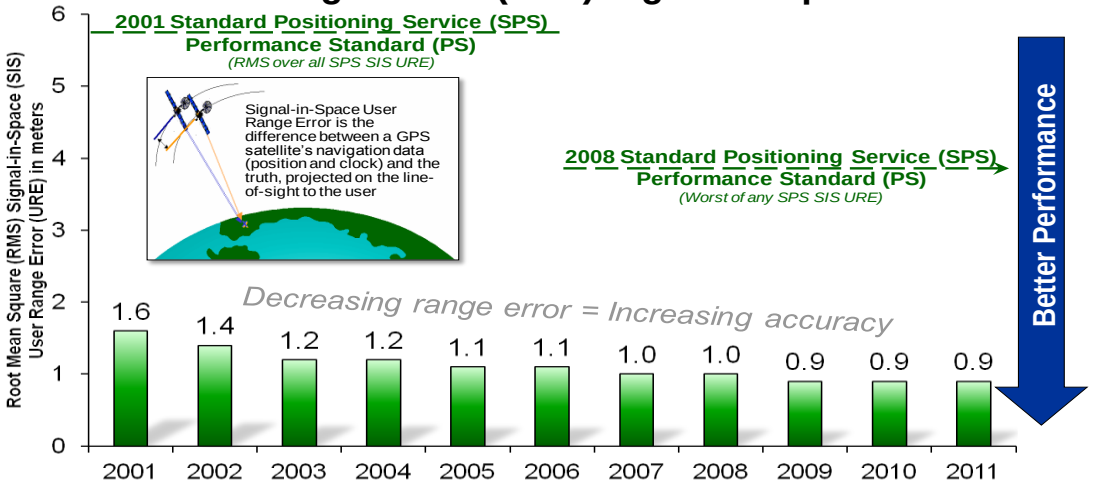
Interagency partnerships are critical to GPS modernization success!

GPS Constellation

- **Robust constellation**
  - 31 space vehicles currently in operation
    - 10 GPS IIA, 12 GPS IIR, 7 GPS IIR-M, 2 GPS IIF
  - 3 additional satellites in residual status
- **Extensive International and Civil Cooperation**
  - Agreements with 55 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



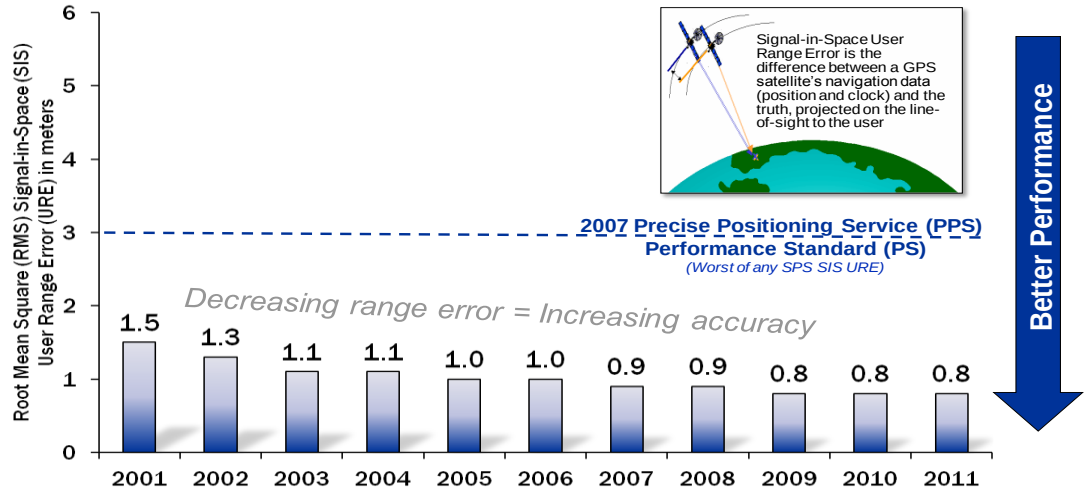

Mining and Construction


Precision Agriculture


Wildlife Research


Aviation

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




Precision Navigation

System accuracy exceeds published standard

GPS IIF Status

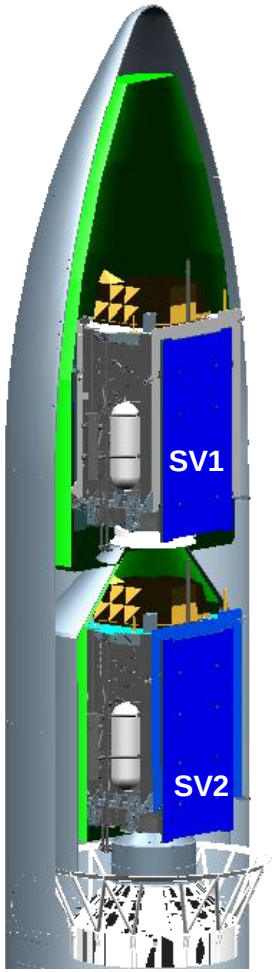
- **Launched GPS IIF-2 on 16 Jul 11**
  - Satellite Vehicle Number 63, PRN 1
  - Set healthy 14 Oct 11
  - Second operational L5 signal
  - Providing enhanced GPS clock performance
- **2 total GPS IIFs on orbit**
  - Best accuracies in constellation (0.38 m RMS)
  - Demonstrated Flex Power capability
- **10 more GPS IIFs in the pipeline**
  - SVs 5-7 are in storage
  - SVs 3, 8 and 9 in assembly, integration and test
  - On-track to complete all production by Summer 2013
- **Next GPS IIF Launch scheduled for 4 Oct 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
- **SV01 initial power turn-on 1QFY13**
- **GPS Processing Facility (GPF) ribbon cutting**
- **GPS Satellite Simulation delivered**
- **Factory to Factory link established June 2012**

Enabling Affordability

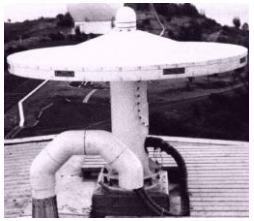
- **Dual launch of GPS III satellites significantly reduces launch costs**
  - GPS and Launch Directorates are coordinating on final requirements for a GPS-specific dual payload adapter and mission profile requirements
  - Early studies indicate only minor changes needed to support this capability, with minimal changes in the production line of GPS III SV09+
- **Future Size, Weight, Power (SWAP) considerations**
  - Battery & Solar Array Efficiency, Star Tracker/IMU, etc…
  - Allows SV-9+ payload considerations
  - SAR GPS, Laser Reflectors, USB



Notional Dual Launch Configuration on Atlas V 551

Ground Segment Status

- **Current system Operational Control Segment (OCS)**
  - Now flying GPS IIA/IIR/IIR-M/IIF constellation
  - Added the capability for anomaly resolution & disposal ops for GPS IIF
  - AEP 5.8 deployed Mar 2012, preceded by strategic communication plan and test
    - Additional automation and SAASM support
    - Deployed successfully without negative impact to users



Monitor Station

- **Next Generation Operational Control System (OCX) on track**
  - Exercise 1 completed on schedule, passed telemetry & commands
  - OCX Block I full operational capability planned for 2016
  - Will provide full support of monitoring of L2C and L5

Ground Antenna

- **OCX affordability initiative:**
  - Resulted in some requirements rescoping and rephasing
  - Accelerated modernized civil signals
  - Supports L2C and L5 in OCX Block I, Oct 2016

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 9 SVs in operation

- **Third civil signal "L5"**
  - Designed to meet transportation safety-of-life requirements
  - Uses Aeronautical Radio Navigation Service band
  - Currently 2 SVs in operation

- **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 capability currently in development

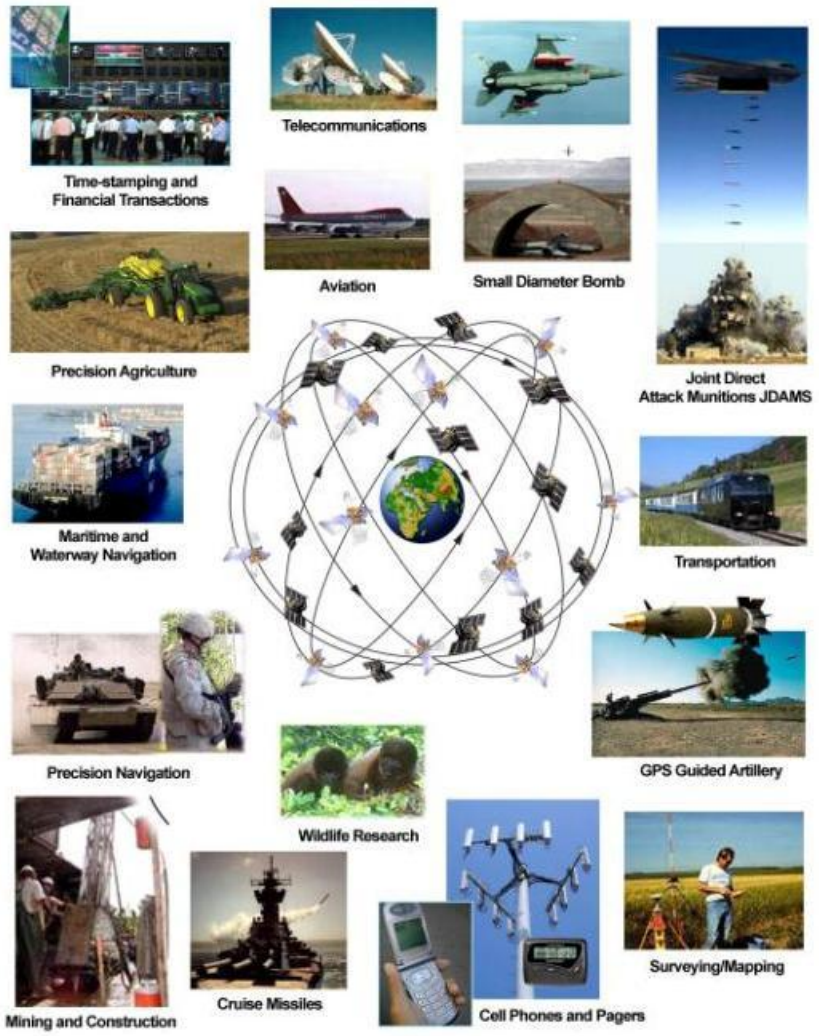
US Gov't Committed to Civil Signals

- **The modernized civil signal deployment is in progress**
  - 10 L2C and 2 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



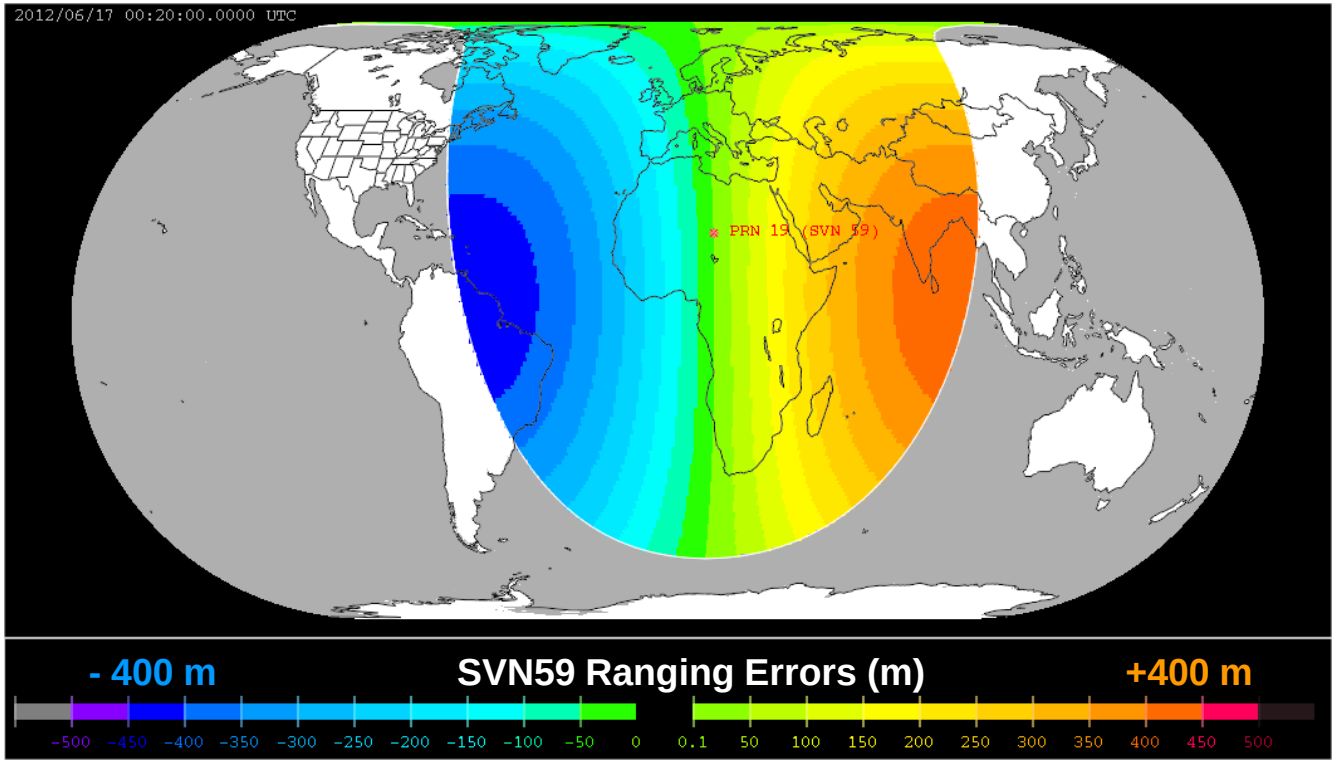
Maintaining and improving GPS services for all users is Job #1

Homepage for General Public

Backup

17 Jun 12 SVN 59 Integrity Failure

- **Large broadcast ephemeris error (>1,900 m) from SVN59/PRN19**
  - 17 Jun 12, 0009-0037 GPS Time
  - First SPS PS integrity failure since 22 Feb 10
- **Caused by SVN 59 upload with invalid Earth orientation data**
  - Fixed by second upload with valid data after 28 minutes
  - Remedial actions taken to prevent reoccurrence



Other Recent Anomaly Investigations

- **Alcatel-Lucent timing receiver events, Jun 2012**
  - Large timing errors from some cell tower timing receivers
  - Several hypotheses formulated, none confirmed
  - No recent reports of reoccurrence from Alcatel-Lucent
- **SVN45/PRN21 phase jumps, May 2012**
  - Short-duration phase jumps reported by Fugro (e.g., Omnistar)
  - Same symptoms reported by FAA WAAS network
  - Root cause still TBD

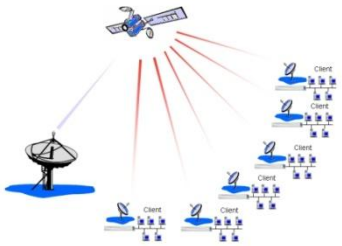
New Certification Paradigm

- **2009/10 - receiver problems experienced during segment upgrades**
  - Problems traced to non-ICD compliant User Equipment
    - Incorrect implementation/interpretation of interface specifications
- **DoD "Performance Certification" strategy**
  - GPS Directorate will provide Constellation Simulator Test Vectors to selected receiver manufacturers to efficiently verify Signal-in-Space ICD compliance
  - The receiver manufacturer will be asked to self-certify that their receiver was tested and is compatible with the Test Vectors
  - GPS Directorate does not plan to independently review manufacturers test plans or results, but may choose to do so in selected cases in the future
  - Initial application will be limited to confirming Military-user compatibility for newly-procured P(Y)-M-C/A receivers
- **Implementing actions**
  - Developing policy guidance recommendations for DoD
  - Developing implementation guidance document for GPS Directorate
  - Developing model contract language for future contracts
  - Developing Constellation Simulator Test Vectors

ICD Compliance is Critical for GPS Modernization

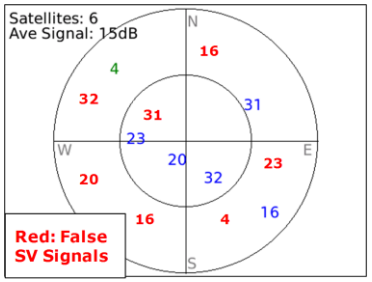
Modernized Military GPS Capability Features

Key Management
Reduced burdens, Improved user autonomy

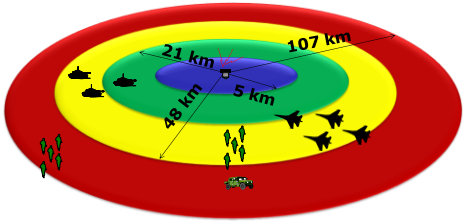


Jamming Resistance
Initial fix enhanced, Anti-Jam extended

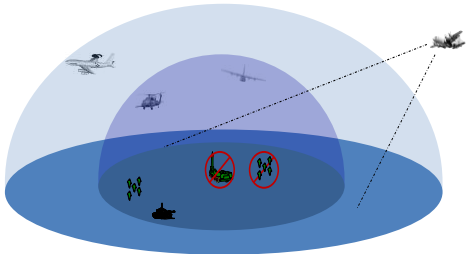
Anti-Spoof
Detect and reject false signals



M-Code Power
Operate closer to jammer, under trees



Blue Force Electronic Attack
Operate near friendly jamming



M-Code Cryptography
More secure, more flexible

External Augmentations
Extend GPS accuracy/ availability in challenged environments

Performance Standard Update

- **Developing update to SPS and PPS Performance Standard**
  - Adding L2C signal to current L1 C/A signal
  - Same performance values
  - Draft update will be circulated for review & comment within U.S. Government (30 Sep 12)
  - SPS PS update approval before Initial Operational Capability (IOC) declaration for L2C
- **Planning subsequent draft updates for L5 signal & for L1C signal**
  - Prior to each subsequent IOC declaration
- **Developing an updated set of performance metrics**
  - Include different user applications and terrain environments