Global Positioning
Systems Directorate

GPS Program Update to
Stanford PNT Symposium

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Col Steve Steiner
Chief, Space Systems Division
GPS Directorate
International Cooperation
- Europe - Galileo
- China - COMPASS
- Russia - GLONASS
- India, Japan and others

Department of Defense
- Services (Army, Navy, AF, Marines)
- Agencies (NGA, DISA, etc.)

Civil Applications
- 1+ Billion civil & commercial users
- Search and rescue
- Banking and finance
- Surveying and mapping
- Aviation, trucking/shipping
- Offshore drilling
- Fishing and boating

Department of Transportation
- Federal Aviation Administration

Department of Homeland Security
- U.S. Coast Guard
GPS Constellation

• **Very robust constellation**
  • 30 space vehicles currently in operation
    • 9 GPS IIA
    • 12 GPS IIR
    • 7 GPS IIR-M
    • 2 GPS IIF
    • 3 additional satellites in residual status

• **Global GPS civil service performance commitment met continuously since Dec 1993**
GPS Signal in Space Performance

**2001 SPS Performance Standard**
(RMS over all SPS SIS/UE)

- Signal-in-Space User Range Error is the difference between a GPS satellite's navigation data (position and clock) and the truth projected on the line-of-sight to the user.

**2008 SPS Performance Standard**
(Worst of any SPS SIS/UE)

- Decreasing range error = Increasing accuracy

**2007 PPS Performance Standard**
(Worst of any SPS SIS/UE)

- Decreasing range error = Increasing accuracy

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GPS IIR/IIR-M Status

• All GPS IIR and IIR-M satellites are on orbit
  • Current backbone of the GPS constellation

• Excellent on-orbit performance
  • SIS URE of .50 meters (1 yr performance Jul 2011)

• Excellent life expectancy
  • Solar array capacity far exceeds specified Mean Mission Duration
  • No clock failures to date
GPS IIF Status

• Excellent on-orbit performance for GPS IIF-1
  • SIS URE of .30 meters (1 yr performance Jul 2011)

• Launched GPS IIF-2 on 16 Jul 11
  • SVN 63, PRN 1
  • Set healthy 14 Oct 11
  • Second operational L5
  • Increases the enhanced GPS clock performance coverage

• 10 more GPS IIFs in the pipeline
  • SVs 3-8 are in AI&T

• Next GPS IIF Launch scheduled for Sep 2012
GPS III Status

- Newest block of GPS satellites
  - First GPS 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
- Completed Critical Design Review
- Program granted Milestone C approval for SVs 1-8
- Prototype and engineering unit build/test underway
  - Completed 57 of 59 Manufacturing Readiness Reviews
  - Completed 43 of 59 Test Readiness Reviews
- GPS Nonflight Satellite Testbed (GNST) integration underway
- Completed System Design Review and initiated Capability Insertion Program for SV09+
Ground Segment Status

• **Current system Operational Control Segment (OCS)**
  - Now flying Block IIA/IIR/IIR-M/IIF constellation
  - Added the capability for anomaly resolution and disposal ops for IIF (LADO)

• **Next Generation Operational Control System (OCX) Phase B continues on track**
  - Preliminary Design Review held Jun 2011, closed Aug 2011
  - Milestone B approval expected 2nd Quarter 2012
  - OCX Block I deployment planned for 2015
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
  • Full capability: 24 satellites and full CNAV ~2016*

• Third civil signal “L5”
  • Designed to meet transportation safety-of-life requirements
  • Uses Aeronautical Radio Navigation Service band
  • Full capability: 24 satellites and full CNAV ~2020*

• Fourth civil signal “L1C”
  • Designed for GNSS interoperability
  • Specification developed in cooperation with industry
  • Launches with GPS III in 2014
  • Available on 24 SVs ~ 2026*
  • Improved tracking performance

Urban Canyons

* FOC dates are based on our best estimate of the launch schedule
LightSquared (LSQ) Status

- LSQ proposed open wireless broadband network adjacent to GPS L1
  - Offering terrestrial 4G service – 34,000+ ATCs across the U.S.A.

- FCC granted conditional waiver to LSQ – 26 Jan 11
  - Required LSQ study GPS overload and interference prevention NLT 15 Jun 11

- Supports National Broadband Plan – find 500 MHz for wireless broadband

- Numerous organizations conducted testing - all indicated interference
  - National PNT Engineering Forum Test Report - 1 Jun 11
  - Numerous separate filings with FCC by Industry


- LSQ proposing “10 Low” implementation as alternative

- Currently conducting additional testing per FCC request
  - Focusing on “10 Low”
  - Including LSQ handsets
  - Working with DoD and Civil agencies

Major Concern is Impact on Established User Base
GPS “Could Be” Architectures

Rationale

- Identify innovative “could be” architectures consistent with SAF/AQ and AFSPC/CC direction
- Evaluate relative to resiliency, affordability, and capability gaps
- Develop long term solutions and short term investments

Dramatic Improvement in Availability at 30+ SV

Capability Needs

- Availability of accuracy
  - Availability in mountainous terrain and urban canyons
- Resistance to jamming
  - High power from space vs improved receiver antenna technologies
- Enhanced Command and Control (EC2)
  - Timeliness to theater warfighter
- Signal Integrity
  - GPS contribution versus augmentations

Could Be Architectures

Dual-launched GPS III (GPS III DL)

Augmented w/ Minisats, Hosted Payloads and/or GEO overlays

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• Released GPS Enterprise Modernization Research and Prototype Demonstration “Broad Agency Announcement” – 22 Aug 11
  • Soliciting proposals for research and prototypes of GPS capabilities
  • Released thru Space and Naval Warfare Systems Center, Pacific
  • Specific areas of interest include:
    • GPS Alternative Architectures: Dual Launch and Minisat enablers
    • Information Assurance
    • Software Defined Radios
    • Advanced Integrity
PRN Expansion

• Current constellation has 30 operational satellites and 3 residual non-operational satellites

• Control segment is currently limited to 32 PRNs
  • Limitation removed with OCX

• Legacy UE are limited to 32 satellites

• Developed CONOPS and ICD changes to exploit additional PRN capability while remaining backward compatible with legacy UE
  • Assign higher PRNs to the worse performing satellites
  • Allows legacy UE to use best performing satellites
GPS Program Partnership

- Civil representatives integral members of GPS team
  - Resident in the GPS Directorate – DOT (2), 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)

DOT/FAA team critical to GPS modernization success!
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