GPS Modernization and Program Update

GPS Update to ION
Southern California Chapter

22 Feb 2011

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Director
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Contents

- Current Constellation
- Modernization
- Other Improvements
GPS Constellation

- Very robust constellation
  - 31 space vehicles currently in operation
    - 11 GPS IIA
    - 12 GPS IIR
    - 7 GPS IIR-M
    - 1 GPS IIF
    - 3 additional satellites in residual status
    - 1 satellite in “test” mode – SVN 49
- Global GPS civil service performance commitment met continuously since Dec 1993
Current Satellite Positions

Expanded Constellation will be fully achieved by Jun 2011
Coming Up: SPS PS Update

- Planning a draft update of the SPS PS by 1QFY11
  - Name change to "Open Service Performance Standard" (OS PS)
  - Addition of L2C signal to current L1 C/A signal
  - Same performance values
  - Draft update will be circulated for review & comment within U.S. Government
  - 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
Contents

• Current Constellation
• Modernization
• Other Improvements
GPS Enterprise Schedule

Based on FY12 POM as of Feb 11

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Enterprise Milestones

**SPACE SEGMENT**

IIF
- IIF-1 Ops

IIIA
- CDR
- dSRR
- dSDR
- dPDR
- dCDR

IIIB
- AFL
- IIIIB-1 AFL

**CONTROL SEGMENT**

OCX Block 1
- CA
- SSR
- PDR
- B1 CDR
- SRT/FQT
- RTO
- DD250

OCX Block 2
- KO
- PDR
- B2 CDR
- SRT/FQT
- RTO
- DD250

OCX Block 3
- KO
- SRR
- CDR
- RTO

**USER SEGMENT**

MUE Contract
- Issue Contract
- MUE Contract Complete

Increment 1 GB-GRAM
- PDR
- RFP
- CA
- CDR
- FA
- GB-GRAM FRP

Increment 1 Aviation/Maritime
- ATP
- SRR
- CDR

Increment 2 CGM/HH
- Capability Insertion Plan Complete
- RFP
- CA
- CDR
- CGM-Based HH

Decision Points

- M5 A
- M5 B
- M5 C
- PPDRA
- PPORA
- PPORA

Acquisition Phases

- Technology Development
- Bnr & Mfg Development
- Production & Deployment
- Operations & Support

- IFP Available for Launch (SV Delivery)
- GPS II Available for Launch (SV Delivery)
- SV Operational
- Capability Milestone
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
  • Available since 2010; 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 by ~ 2026*

* FOC dates are based on our best guess for launch schedule
IIR/IIR-M Satellites

- All GPS IIR and IIR-M satellites have now been launched
  - Current backbone of the GPS constellation

- Excellent on-orbit performance
  - SIS URE of .50 meters - 1 Year Performance Jul 2010

- Excellent life expectancy
  - Solar array capacity far exceeds specified Mean Mission Duration
  - No clock failures to date

- Completed deployment of IIR-M
  - L2C CNAV message type 0 capability deployed this year on IIR-M to support testing of civil UE
  - Full CNAV message with OCX
IIF Satellites

• Launched GPS IIF SV-1 in May 2010
  • SVN62, PRN 25
  • Was set healthy 26 Aug 10
  • First operational L5

• 11 more IIFs in the pipeline
  • SVs 2-5 are in production

• IIF SV-2 launch by Summer 2011
• 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
  • +10 dB earth coverage power increase on M-Code
  • Three Rubidium clocks

• Completed Critical Design Review for Block IIIA
  • Two months in advance

• Completed Delta System Requirements Review for Block IIIB

• Conducting Analysis of Alternatives for Blocks IIIB and IIIC
  • Revalidate requirements and associated cost/benefits
Ground Segment

- Deployed several AEP upgrades including SAASM upgrade
- Conducted flex power demo with live IIR-M SVs
- Awarded OCX Phase B to Raytheon Feb 2010
  - Completed Technical Baseline Review Mar 2010
  - Completed Independent Baseline Review Aug 2010
  - Completed Software Specification Review Sep 2010
  - Preliminary Design Review planned for Apr 2011
  - OCX Block I deployment planned for 2015
User Segment

- Delivers new set of GPS receivers to support service nominated lead platforms
  - Support operations in a Navigation Warfare (NAVWAR) environment and countering current and emerging PNT threats
  - Upgrade GPS receivers to exploit new technologies: M-Code, Blue Force Electronic Attack (BFEA), Anti-Jam, Anti-Spoof & Anti-Tamper
  - Prevent PNT service disruptions due to non-compliance
- Common GPS Module (CGM) proposed to meet long-term needs of DoD GPS users & authorized foreign allies
- Modernized User Equipment (MUE)
  - Prototype GB-GRAM-M receiver deliveries completed 1QFY11
  - Undergoing independent Govt testing. Est. Completion ~4QFY11
- Military GPS User Equipment (MGUE)
  - Entering Technology Development Phase leveraging the success and achievements of MUE
  - Technical Requirement Document (TRD) anticipated CCB ~ 2QFY11
  - Targeting MGUE RFP release 1QFY12
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Flex Power

• Modernized GPS SVs have Flex Power capabilities
  • Can shift power between M-Code, P(Y) code and C/A code

• Previous on-orbit testing conducted in 2005 and 2007

• Conducted extensive on-orbit Flex Power test Sep 7-11, 2010
  • Turned on Flex Power for 8 IIR-M satellites

• Identified two issues
  • Canadian Differential GPS Service - planned for decommissioning NLT Mar 2011
  • FAA integrity monitors gave false positives – mitigations being developed

• Developing Flex Power Concept of Operations (CONOPS)
Capability Deployment

• GPS receiver anomalies were reported several times this year coinciding with testing activities
  • Almanac problem in Nov 2009, SAASM problem in Jan 2010, etc.

• Problems were traced to non-compliant UE
  • Unauthorized use of reserved bits, incorrect assumption on almanac time, incorrect implementation/interpretation of a security function

• Problems mitigated by working extensively with UE vendors to fix non-compliance issues

• Undertaking improvements in deployment method and certification paradigm

Smooth Deployment of New Capabilities Key to Modernization
New Transition and Certification Paradigms

- Instituting methodical capability transition process
  - Carefully planned transition event testing
  - Extensive participation by representative users and applications
  - Identification of potential issues prior to capability deployment

- Improvements in compliance verification are being put in place
  - Exploring Underwriters Laboratories construct for independent certification of ICD compliance and associated testing

- Seeking feedback from user community on transition approaches and compliance verification

ICD Compliance is Critical for GNSS Success
PRN Expansion

- Control segment is currently limited to 32 PRNs, limitation removed with OCX
- Legacy UE are limited to 32 satellites
- Current constellation has 31 operational satellites and 3 residual non-operational satellites
- 63 sets of L1 C/A, L2C, L5, and L1C codes have been defined
- Developing CONOPS and ICD changes to exploit additional PRN capability while remaining backward compatible with legacy UE
  - Proposing to assign higher PRNs to the worse performing satellites
  - Soliciting feedback from user community
Metrics

• Developing an updated set of performance metrics
  • Include different user applications and terrain environments

• Need to shift away from just counting satellites in the sky
  • 95% probability of 24 satellites anywhere in the constellation

• Goal is to identify a short list of most meaningful metrics and report on them regularly
  • Cover the big five, i.e. Availability, Accuracy, Bounded inaccuracy, Integrity, Interference (inadvertent or malicious)
  • Cover key user applications

• Challenge is representing the metrics in terms of effect on users/application
Summary

- Modernization of all GPS Segments is on track
- GPS has continuously met its commitments to all users since FOC
- 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*