United States Global Positioning System (GPS) and Augmentation Systems Update

Provider’s Forum of the International Committee on GNSS

Vienna, Austria

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Contents

Policy and International Cooperation Update  David Turner

System Updates

GPS  Jules McNeff

WAAS/LAAS  Hank Skalski
Services and Provision Policies

- The U.S. supports free access to civilian GNSS signals with public domain documentation necessary to develop user equipment
- GPS is a critical component of the global information infrastructure
  - Compatible with other satellite navigation systems and interoperable at the user level
  - Guided at a national level as multi-use asset
  - Acquired and operated by Air Force on behalf of the USG
- U.S. Government policy promotes open competition and market growth for commercial GNSS

GPS is a Global Public Service providing consistent, predictable, dependable performance
International Cooperation Update

• Multi-lateral
  – ICAO General Assembly in mid-Sept. 2007 – U.S. Transportation Secretary Peters announced that Selective Availability would not exist in new GPS III satellites
  – Providers Forum and ICG Planning meetings
  – ICG-3 to be hosted by the U.S. at Pasadena, California in December 2008
  – The U.S. will also participate in ICG working group meetings

• Bi-lateral
  – EU: Next radiofrequency compatibility and interoperability working group to be held in April in France
  – Japan: Working to establish QZSS Monitoring Stations at Hawaii and Guam
  – India: U.S.-India meeting at Bangalore, January 22-24 on GPS & IRNSS compatibility, interoperability, spectrum issues, and ITU coordination requirements
  – South Africa: Sept. 2007 discussions on coordination and co-location of GPS instruments throughout Africa to provide data streams for geologic research, space weather observations, and geodetic reference
Global Positioning System (GPS) Status

Jules McNeff
representing
Office of the Assistant Secretary of Defense
Networks and Information Integration
U.S. Department of Defense
Overview

- System Update
- Current Status
- Near-Term Plans
Operational Control Segment (OSC) Modernization: Architecture Evolution Plan (AEP)

- Transitioned to the new AEP OCS (10-14 Sep 07)
- IIR-17(M) launched 17 Oct 07 was controlled by new system
  - Replaced previous Command & Control System (CCS)
30 Healthy Satellites
Baseline Constellation: 24

- 13 Block IIA satellites
- 12 Block IIR satellites
- 5 Block IIR-M satellites
  - 3 additional IIR-M satellites to launch
- Since Dec 93, U.S. DoD met/exceeded GPS service performance commitments
  - SPS & PPS Performance Standards
- U.S. DoD committed to improving GPS service
GPS Launch Update

- **Most Recent Launch**
  - IIR-18(M) – 5th modernized SV
    - Launched Wednesday, 20 Dec 07
    - SVN 57, PRN 29, slot C1
    - Set healthy on 2 Jan 08

- **Next Launches**
  - IIR-19(M) – Mar 08
  - IIR-20(M) – Jun 08
    - L5 demo payload
  - IIR-21(M) – Sep 08

- **IIF-1 launch in 2009**
GPS Modernization

**Space Segment**

<table>
<thead>
<tr>
<th>Block IIA/IIR</th>
<th>Block IIR-M</th>
<th>Block IIF</th>
<th>Block III</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basic GPS</td>
<td>• 2nd civil signal (L2C)</td>
<td>• 3rd civil signal (L5)</td>
<td>• Increased accuracy</td>
</tr>
<tr>
<td>• Std Pos. Service</td>
<td>• M-Code signals (L1M, L2M)</td>
<td></td>
<td>• Increased power</td>
</tr>
<tr>
<td>• C/A civil signal (L1C/A)</td>
<td></td>
<td></td>
<td>• Signal integrity</td>
</tr>
<tr>
<td>• Precise Pos. Service</td>
<td></td>
<td></td>
<td>• Search and Rescue</td>
</tr>
<tr>
<td>• L1 &amp; L2 P(Y)</td>
<td></td>
<td></td>
<td>• Common signal with Galileo (L1C)</td>
</tr>
</tbody>
</table>

**Legacy OCS**

- TT&C
- L1 & L2 monitoring

**AEP**

- IIR-M IIF TT&C
- WAGE, AII, LADO
- SAASM
- New MCS/AMCS

**OCX V1**

- New Architecture
- Signal Monitoring

**OCX V2**

- GPS III TT&C
- L1C, L2C, L5
- Real-Time C2

**GPS modernization process looks ahead beyond 2020**
GPS Modernization - Spectrum

Previous
since Dec 2005 (5 SVs)
Planned

ARNS Band
RNSS Band
ARNS Band

Block IIA 1990
Block IIR 1997
Block IIR-M, 2005
Block IIF, 2009
Block III, 2014
(artists concept)
New Block III Signal for Civil Users – L1C

- L1C will have the following benefits compared to L1 C/A:
  - Separate pilot carrier without data (75% of L1C power)
    - Pilot carrier provides 4.8 dB better code & carrier tracking threshold
  - Advanced FEC – 1.4 dB better data demodulation threshold
  - Ability to demodulate messages down to carrier tracking threshold
  - More precise message structure (as with L2C and L5)
  - Longer PRN codes (better correlation performance)
  - Min L1C power specified to be 1.5 dB higher than C/A
  - EU & US teams designed new MBOC power spectral density
    - GPS TMBOC: BOC(1,1) chips time-multiplexed with BOC(6,1) chips
      - Provides more code transitions to enhance multipath mitigation
  - L1C draft specification, IS-GPS-800, available
    - Final approval is expected soon
    - Wait for approved version before committing to silicon
Summary

GPS has been operational and has met its civil service performance commitment continuously since Dec 2003

– Performance continues to exceed standards

• GPS modernization is underway

  – New civil signals being launched
  – Modernized control capabilities being implemented
Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) Update

Hank Skalski
DOT/FAA Liaison to Air Force Space Command
WAAS Architecture

- 38 Reference Stations
- 3 Master Stations
- 4 Signal Generator System/Ground Earth Stations
- 2 Geostationary Satellite Links
- 2 Operational Control Centers
### WAAS Performance

<table>
<thead>
<tr>
<th></th>
<th>GPS Standard</th>
<th>GPS Actual</th>
<th>WAAS LPV-200 Standard</th>
<th>WAAS LPV-200 Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal 95%</strong></td>
<td>36 m</td>
<td>2.74 m</td>
<td>16 m</td>
<td>1.08 m</td>
</tr>
<tr>
<td><strong>Vertical 95%</strong></td>
<td>77 m</td>
<td>*3.89 m</td>
<td>4 m</td>
<td>1.26 m</td>
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</tbody>
</table>

* Use of GPS vertical not authorized for aviation without augmentation (SBAS or GBAS)

**WAAS Performance evaluated based on a total of 1,761 million samples (or 20,389 user days)**
WAAS Enterprise Schedule

FLP Segment (Phase II)
LPV-200 Segment (Phase III)
Dual Frequency (Phase IV)

Inmarsat
GEO #3 – Intelsat
GEO #4 – TeleSat
GEO #5 – TBD
GEO #6 – TBD

Approach Development
GEO Satellite Improvements

• Phase I – IOC
  – Inmarsat Satellites
    • AOR-W – 54W
    • POR – 178E
  – AOR-W Moved to 142W
  – Leases Expired July 2007

• Phase II - FLP
  – New GEOs
    • Intelsat (Galaxy XV) – 133W
    • Telesat Canada (Anik F1R) – 107W
  – Operational July 2007
  – 10 Year Lease
WAAS RNP Coverage
- Current -

RNP 0.3 Service: Dashed Black line HPL = 555 m
RNP 0.1 Service: Dashed Red line HPL = 185 m
Color Scale is Horizontal Protection Level (HPL)
05-Nov-07 12:58:10 GMT (W.J. FAA Tech. Ctr., NJ USA)

Longitude (5 degree sample size)

W.J., FAA Technical Center
WAAS ed team
05 Nov 07 12:03:10 GMT