Global Positioning Systems Directorate Update

Stanford’s 2015 PNT Symposium
13 Nov 15

Col Gerry Gleckel, USAF
Deputy Director
Global Positioning Systems Directorate
Global Positioning Systems Directorate

“We are... the Green Monsters!”

Mission:
Professionals acquiring, delivering and sustaining reliable GPS capabilities to America’s warfighters, our allies, and civil users

Col Steve Whitney
Director
GPS Enterprise View

Civil Cooperation
• 1+ Billion civil & commercial users
• Search and Rescue
• Civil Signals
  – L1 C/A (Original Signal)
  – L2C (2nd Civil Signal)
  – L5 (Safety of Life)
  – L1C (International)

Spectrum
• World Radio Conference
• International Telecommunication Union
• Bilateral Agreements

Department of Defense
• Services (Army, Navy, AF, USMC)
• Agencies (NGA & DISA)
• US Naval Observatory
• PNT EXCOMS
• GPS Partnership Council

Maintenance/Security
• All Level I and Level II
  – Worldwide Infrastructure
  – NATO Repair Facility
• Develop & Publish ICDs Semi-Annually
  – ICWG: Worldwide Involvement
• Update GPS.gov Webpage
• Load Operational Software on over 970,000 SAASM Receivers
• Distribute PRNs for the World
  – 120 for US and 90 for GNSS

International Cooperation
• 56 Authorized Allied Users
  – 25+ Years of Cooperation
• GNSS
  – Europe - Galileo
  – China - Beidou
  – Russia - GLONASS
  – Japan - QZSS
  – India - IRNSS

40 Satellites / 30 Set Healthy Baseline Constellation: 24 Satellites

<table>
<thead>
<tr>
<th>Satellite Block</th>
<th>Quantity</th>
<th>Average Age</th>
<th>Oldest</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS IIA</td>
<td>1</td>
<td>24.9</td>
<td>24.9</td>
</tr>
<tr>
<td>GPS IIR</td>
<td>12</td>
<td>13.8</td>
<td>18.3</td>
</tr>
<tr>
<td>GPS IIR-M</td>
<td>7</td>
<td>8.3</td>
<td>10.1</td>
</tr>
<tr>
<td>GPS IIF</td>
<td>10</td>
<td>2.1</td>
<td>5.4</td>
</tr>
<tr>
<td>Constellation</td>
<td>30</td>
<td>9.0</td>
<td>24.9</td>
</tr>
</tbody>
</table>

AS OF 3 NOV 15
4 Generations of Operational Satellites

- **Block IIA - 1 Operational, 8 Residual**
  - 7.5 year design life (oldest operational satellite will be 25 yrs old in Nov)
  - Launched 1990-1997

- **Block IIR - 12 Operational**
  - 7.5 year design life
  - Launched 1997-2004

- **Block IIR-M - 7 Operational, 1 Residual**
  - 7.5 year design life
  - Launched 2005-2009
  - Added 2nd civil navigation signal (L2C)

- **Block IIF - 10 Operational**
  - 12 year design life
  - Launched 2010-present
  - Added 3rd civil navigation signal (L5)

*Current as of 3 Nov 15*
Cool Videos

- IIF-10 Encapsulation -- https://www.youtube.com/watch?v=FRFQMM_Gcbk
- IIF-10 Mate -- https://www.youtube.com/watch?v=6N3ArhzDApA
Most aggressive GPS launch schedule since 1993

- 11 total GPS IIFs on-orbit
  -- Mission IIF-11 launched from Cape on 31 Oct 15

- 1 more GPS IIF in the pipeline
  -- Mission IIF-12 shipped to Cape on 7 Oct 15
• GPS III is the newest block of GPS satellites
  – 4 civil signals: L1 C/A, L1C, L2C, L5
    • First satellites to broadcast common L1C signal
  – 4 military signals: L1/L2 P(Y), L1/L2M

• SV01-SV08 on contract; SV09 & SV10 approved
  – 2 year delay due to technical challenges w/ payload

• SV01 System Module Core Mate completed 7 Apr 15

• Mission Data Unit software qualification complete 6 Aug 15

• SV-level thermal vacuum started Oct 15

• SV01 “available for launch” Aug 2016
GPS III SV11+

• **Competing GPS III SV11+ Production**
  – Drive down space vehicle costs by promoting effective competition
  – Mitigate reliance on single navigation payload vendor
  – Reduce production cost and schedule risk with minimal design phase

• **Two-phase acquisition approach allows contractors time to mature designs**
  – GPS III SV11+ Production Readiness Feasibility Assessment (Phase 1)
    • Gain insight into contractor-funded space vehicle and navigation payload production design maturity and risk
    • Full and open competition
    • Up to 3 Firm-Fixed Price contracts, $6M per source (incl/ options)
    • Request For Proposal release 1QFY16 with contract awards in 3QFY16
  – GPS III SV11+ Follow-on Production Competition (Phase 2)
    • Acquisition strategy to be informed by Feasibility Assessment performance and results
    • Notional full and open competition for up to 22 satellites
    • Projected award in FY18
GPS Next Generation Operational Control System (OCX)

- **Modernized command & control system**
  - GPS III command & control
  - M-Code
  - Robust cyber security infrastructure
  - Modern civil signals & monitoring
  - Improved PNT performance

- **Prime: Raytheon (Aurora, CO)**

- **OCX Block 0: launch & checkout for GPS III**
  - Currently in test
  - Successfully completed seven launch exercises/simulations

- **OCX Block 1: replaces AEP, adds modern features**
  - Currently in design and risk reduction testing prior to restart of coding

- **OCX Block 2: adds advanced NAVWAR and Civil Signal Performance Monitoring capabilities**
Military GPS User Equipment (MGUE)

- Three vendors developing modernized receiver cards
- Pursuing commercial market-driven acquisition
- Initial test articles delivered 4Q 2015
  - Developmental test started 24 Aug 2015

- MGUE program is in process of completing 2366B documentation, ICE, and APB per ASD(A) direction to support a Milestone B decision

- Draft MGUE Increment 2 Capability Development Document (CDD) in coordination; defined as space receiver, hand-held, and Precision Guided Missile (PGM)
Conclusion

• Satellite constellation is healthy, but we’re eager to take advantage of GPS III capabilities
• Next-Generation Operational Control System (OCX) addressing cost and schedule challenges
• MGUE fielding is being accelerated via commercial market strategy
  – Key driver -- statute for Services to field in FY17 & increase user equipment performance and resiliency

We recognize the global utility of GPS
- Committed to maintaining uninterrupted service
- Continue to advance availability, accuracy, security
The men and women of the GPS Directorate
Back-Up
• Block IIA satellites, 1 Operational, 8 Spare
• Block IIR satellites, 12 Operational
• Block IIR-M satellites, 7 Operational, 1 Spare
• Block IIF satellites, 10 Operational
• Oldest Satellite is SVN23; will be 25 Yrs Old, Nov 15
• U.S. Government continuously assessing constellation optimization to determine launch need

*Current as of 3 Nov 15
Accuracy: Civil Commitments
Standard Positioning Service (SPS) Performance Standard

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

2008 SPS Performance Standard (PS)
Worst of Any Healthy Satellite, 7.8 m @ 95%

Equivalen RMS Value from 2008 SPS PS (4 m)

Worst of Any Healthy Satellite (95%)

Better Performance

System accuracy better than published standard
Accuracy: Military Commitments
Precise Positioning Service (PPS) Performance Standard

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

2007 PPS Performance Standard (PS)
Worst of Any Healthy Satellite, 5.9 m @ 95%

User Range Error (URE) in Meters

Across All Healthy Satellites (RMS, 68%) 1.5 1.3 1.1 1.1 1.0 1.0 0.9 0.9 0.8 0.8 0.8 0.7 0.7


Equivalent RMS Value from 2007 PPS PS (3 m)
Worst of Any Healthy Satellite (95%)

Better Performance

Decreasing range error = Increasing accuracy

System accuracy better than published standard
### Current & Historical Statistics

#### SIS vs JPL RMS URET (cm)

<table>
<thead>
<tr>
<th>Period Ending</th>
<th>Best Day Date</th>
<th>Worst Day Date</th>
<th>Mean AoD hours</th>
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</thead>
<tbody>
<tr>
<td>Current Week</td>
<td>10/09/2015</td>
<td>10/12/2015</td>
<td>11.41</td>
</tr>
<tr>
<td>Last Week</td>
<td>10/07/2015</td>
<td>10/05/2015</td>
<td>11.63</td>
</tr>
<tr>
<td>Rolling Quarter</td>
<td>10/09/2015</td>
<td>10/12/2015</td>
<td>11.42</td>
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<tr>
<td>Rolling 1/2 Year</td>
<td>06/13/2015</td>
<td>05/23/2015</td>
<td>11.36</td>
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<tr>
<td>Rolling Year</td>
<td>06/13/2015</td>
<td>01/15/2015</td>
<td>11.32</td>
</tr>
<tr>
<td>Best Day Ever</td>
<td>06/13/2015</td>
<td>01/15/2015</td>
<td>11.42</td>
</tr>
<tr>
<td>Best Week Ever</td>
<td>09/10/2015</td>
<td>04/17/2015</td>
<td>11.51</td>
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<tr>
<td>Worst Week Rolling Year</td>
<td>04/17/2015</td>
<td>04/17/2015</td>
<td>11.44</td>
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</tbody>
</table>

**Best day/week ever achieved this year!**
Civil Navigation (CNAV)

• **CNAV is being broadcast today!**
  - L2C CNAV set Healthy, 18 SVs by the end of the year
  - L5 CNAV set Unhealthy, available for test
  - Intended to support modernized civil receiver development

<table>
<thead>
<tr>
<th>CNAV message types currently being broadcast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>33</td>
</tr>
</tbody>
</table>

• **Collaborating on GPS/GNSS Time Offset (GGTO) test plan with Civil community**