U.S. Space-Based Positioning, Navigation and Timing (PNT) Policy Update

Robert Wray
16 October 2023
GPS Constellation

GPS Signal in Space Performance
From 01 Jan 23 to 12 Oct 23

<table>
<thead>
<tr>
<th>Satellite Block</th>
<th>Quantity</th>
<th>Average Age (yrs)</th>
<th>Oldest (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS IIR</td>
<td>7</td>
<td>21.7</td>
<td>26.1</td>
</tr>
<tr>
<td>GPS IIR-M</td>
<td>7</td>
<td>16.1</td>
<td>17.9</td>
</tr>
<tr>
<td>GPS IIF</td>
<td>11</td>
<td>9.6</td>
<td>13.3</td>
</tr>
<tr>
<td>GPS III</td>
<td>6</td>
<td>2.9</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Average URE*

<table>
<thead>
<tr>
<th>Average URE*</th>
<th>Best Day URE</th>
<th>Worst Day URE</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.4 cm</td>
<td>34.1 cm</td>
<td>163.7 cm</td>
</tr>
<tr>
<td>(23 Jun 23)</td>
<td>(25 Jan 23)</td>
<td></td>
</tr>
</tbody>
</table>

*All User Range Errors (UREs) are 95% Root Mean Square values

- 6 Additional satellites in test/residual configuration
- GPS Operates in 6 Planes, at an altitude of 20,200 km
  - 12 hour orbit
  - 100% global coverage
Launch Schedule

- The U.S. will launch (4) GPS-III satellites over next 2 years
- GPS III-F satellites will begin launch in 2026

SV06 – Jan 2023
SV07 – June 2024
SV08 – Feb 2025
SV09 – 2026
SV10 – 2026
GPS IIIF Program

- Continues GPS III modernization efforts, provides backwards compatibility and includes:
  - Regional Military Protection (RMP) for boosted M-code signal
  - M-code power increased by 8x in localized area to give resiliency in disadvantaged areas
  - Re-designed Nuclear Detection suite
  - Canadian-built search and rescue (SAR) payload
    - Up to 85% faster detect and locate of distress signals
  - Laser Retro reflector Array (LRA)
- Status: Purchased SVs 11 thru 20
  - GNST+ assembly complete 2QFY24
  - GPS IIIF SV11 AFL planned for 2026
**Wide Area Augmentation System**

**Current Status**

- **WAAS provides high availability service to aviation users in North America**
  
- **Developing Dual Frequency WAAS**
  - Will enable high availability of WAAS vertical service during ionospheric disturbances
  
- **GEO Sustainability**
  - Currently maintaining 3 GEO constellation
  
- **WAAS Modernization Efforts**
  - Dual Frequency Multi-Constellation (DFMC)
  - Advanced Receiver Integrity Monitoring (ARAIM)
  - Authentication/Resiliency
  - Transition to IP based communications network

**Typical WAAS LPV Coverage**

**WAAS LPV Coverage April 23, 2023 Iono event**
WAAS Avionics Equipment Status

- Procedures:
  - 4,127 Localizer Performance with Vertical Guidance (LPV) approaches in the NAS
  - 1,116 provide CAT I (200’) equivalent performance

- Equipage
  - General Aviation:
    - Over 131,000 equipped aircraft in the NAS
    - All classes of aircraft / all phases of flight
  - Commercial Aviation:
    - Avionics currently available for Boeing 737-600/700/800 and Airbus A220 & A350
  - Enabling technology for NextGen Programs
    - Automatic Dependent Surveillance Broadcast (ADS-B)
    - Performance Based Navigation (PBN)
New Civil Signals

- **New: L1C Signal**
  - Enable interoperability
  - Common civil signal for GPS and Galileo
  - Japan's Quasi-Zenith Satellite System (QZSS) and China's BeiDou system are adopting L1C-like signals
  - Improve GPS reception in cities and other challenging environments

- **New: L2C Signal**
  - When combined with L1 C/A in a dual-frequency receiver, L2C enables ionospheric correction, which can increase accuracy; civilians with dual-frequency GPS receivers may achieve the same accuracy as the military user

- **Improved: L5 – Safety of Life Signal**
  - Safety-of-life transportation and other high-performance applications
  - Improved signal structure for enhanced performance
  - Higher transmitted power than L1/L2 signal (~3 dB, or 2× as powerful)
  - Wider bandwidth provides a 10× processing gain at the receiver
  - Signal in protected International Telecommunications Union and Aeronautical Radionavigation Services (RNSS) band
Sample Analysis Support Products
Sample Analysis Support Products

Dilution of Precision (DOP) Spike Chart

GPS Accuracy Prediction
01 Aug 2022 00:00 - 01 Aug 2022 23:59 | N 48° 30' 00.0000" | E 034° 00' 00.0034"

- HDOP
- PDOP
- VDOP

Product Generated on Thu Jul 28 23:16:40 2022
Terrain: Off
Altitude: 5 (ft) AGL
Number of Channels: 4
Receiver Mask Angle: 5 (deg)
GPS as a Global Utility

GPS is utilized across multiple infrastructures and impacts almost every industry. Some of these industries include:

- Agriculture
- Maritime
- Public Safety
- Recreation
- Space
- Aviation
- Finance
- Telecommunications
- Telematics
- Oil/Gas

US GPS economic benefit ~$1.4 Trillion

30 Years of GPS Reliability = Dependability for Carbon Cutting Strategies and Technologies
GPS CO₂ Reduction

**Total Cost of Fleet Operation**
- Others (Tax, Interest): 22%
- Driver wages: 30%
- Fuel: 26%
- Maintenance: 5%
- Tires: 16%
- Insurance: 6%
- Depreciation: 10%

Fleet Telematics seen as a ‘Productivity Tool’ is best placed to support Transport companies to optimise and maximize their fleet better.

**Benefits After Effective Deployment of Fleet Management System**
- 10-15% Increase in Productivity
- 10-15% Overtime Reduction
- 20-25% Reduction in Fuel Expenses
- 5-10% Reduction in Total Miles
- 20-30 minutes Day/Driver Labour Savings
- 15-20% Increase in Vehicle Utilization
- 20-30% Reduction in Vehicle Idle Time
GPS CO₂ Reduction

• Agriculture
  • GPS enables a controller to keep a machine on course from pass to pass, 95% of the time perfectly parallel in a field.
  
  • Yields increase up to 20%, but waste less fuel, reducing CO₂ emissions
  
  • Precision agriculture has a projected growth rate of 12.8% globally.
  
• Environmental Benefits:
  • Up to 25% less water
  • Up to 20% less pesticides, herbicides
GPS CO2 Reduction

**Maritime**

- Marine operations such as search and rescue, underwater surveying, buoy placement, and hazard navigation have been vastly improved with GPS.

- Container management in port facilities have seen a 4-8% decrease in costs, and a 5-10% increase in efficiency.

- Most of the world’s cargo transits via commercial shipping
  - Greater efficiency = reduced CO2 output
  - Houston, Texas (2022) increased its volume 34%, but did not create a backlog of idling ships or trucks
GPS CO2 Reduction

- **Aviation**
  - Helps improve flight efficiency by allowing aircraft to fly user preferred direct routes waypoint to waypoint without depending on ground infrastructure.
  - GPS driven networks installed on aircraft saved an estimated 5.3 billion liters of fuel and 12.7 billion kilograms of carbon emissions during 2020 alone.
  - Commercial crashes have been significantly reduced in the last 20 years with accidents being cut upwards of 75%.
Thank you!

1973-2023: Honoring 50 Years of GPS Program
1993-2003: Celebrating 30 Years of GPS Full Operations
2003-2023: Celebrating 20 Years of WAAS Commissioning