U.S. Laws and Policies

- **10 United States Code 2281 GPS**
  - Direction to provide civil GPS on a continuous, worldwide basis, free of direct user fees.

- **49 United States Code 44505**
  - The Federal Aviation Administration is responsible for safe systems for aviation – supports International Civil Aviation Organization

- **51 United States Code 50112**
  - Promotion of GPS as an international standard, promote cooperation with foreign governments and international partners, and for the protection of the radio spectrum used by GPS

- **Space Policy Directive 7**
  - Encourage interoperability with likeminded nations, promote transparency in civil service provision
  - Integrate multiple PNT services
  - Ensure GNSS non-interference to support mutual security concerns
PNT Policy in the United States

National Space-Based PNT Organization

WHITE HOUSE
National Security Council / National Space Council / Office of Science and Technology Policy

NATIONAL EXECUTIVE COMMITTEE FOR SPACE-BASED PNT
Executive Steering Group
Co-Chairs: Defense, Transportation

NATIONAL COORDINATION OFFICE
Host: Commerce

ADVISORY BOARD
Sponsor: NASA

Civil GPS Service Interface Committee
Chair: Transportation
Deputy Chair: Coast Guard

GPS International Working Group
Chair: State

Engineering Forum
Co-Chairs: Defense, Transportation

Ad Hoc Working Groups
**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>

<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 (23 Jun 23)</td>
<td>163.7 cm (25 Jan 23)</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
GPS Constellation Disposal History

Reason For Satellite Disposals

AVCS – Attitude and Velocity Control Subsystem
HPA – High Powered Amplifier
NDU – Navigation Data Unit
RCS – Reaction Control Subsystem
GPS III 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
U.S. Military Role with GPS

- The US Government recognizes how vital the uninterrupted access of Positioning, Navigation, and Timing data is to our modern way of life.

- GPS is essential to 14 out of 16 sectors for the United States’ critical infrastructure.

- The Department of Defense’s control of GPS represents the United States’ full backing and commitment to the free provision of GPS to the world and the responsibility to protect it.

  - Ownership ensures rapid reaction capability for threats and timely notification for users
  
  - Supports tertiary mission of nuclear detonation detection
  
  - The Space Force builds and launches all GPS satellites
## Examples of U.S. GPS Dependencies

<table>
<thead>
<tr>
<th>Critical Infrastructure Sector</th>
<th>Areas Dependent on PNT (Not all inclusive)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Earth Drilling</td>
</tr>
<tr>
<td></td>
<td>Pipelines</td>
</tr>
<tr>
<td></td>
<td>Industrial Control Systems (ICS)</td>
</tr>
<tr>
<td></td>
<td>All Modes of Transpiration</td>
</tr>
<tr>
<td>Communications</td>
<td>Wired/Wireless</td>
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<tr>
<td></td>
<td>Internet of Things</td>
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<tr>
<td></td>
<td>Health Care Monitoring</td>
</tr>
<tr>
<td>Critical Manufacturing and Defense Industrial base</td>
<td>Supervisory Control Data Acquisition (SCADA)</td>
</tr>
<tr>
<td></td>
<td>ICS</td>
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<tr>
<td></td>
<td>Monitoring</td>
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<tr>
<td></td>
<td>Workforce/Asset Tracking</td>
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<tr>
<td>Dams</td>
<td>Power Generation</td>
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<tr>
<td></td>
<td>SCADA</td>
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<tr>
<td></td>
<td>Waterway Surveillance</td>
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<tr>
<td>Energy</td>
<td>Timestamping</td>
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<tr>
<td></td>
<td>Measurement and Monitoring</td>
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<tr>
<td></td>
<td>Control System</td>
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<tr>
<td></td>
<td>Automation</td>
</tr>
<tr>
<td></td>
<td>Protection</td>
</tr>
<tr>
<td>Financial Services</td>
<td>System Forensics</td>
</tr>
<tr>
<td></td>
<td>Food Control</td>
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<tr>
<td></td>
<td>Workforce/Asset tracking</td>
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<tr>
<td></td>
<td>Environmental Protection</td>
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<tr>
<td>Information Technology</td>
<td>Smart Devices</td>
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<tr>
<td></td>
<td>Cloud Operations</td>
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<tr>
<td></td>
<td>Incident Investigation</td>
</tr>
<tr>
<td></td>
<td>Boot/Runtime Security</td>
</tr>
<tr>
<td>Transportation</td>
<td>Aviation</td>
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<tr>
<td></td>
<td>Maritime</td>
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<td></td>
<td>Pipelines</td>
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<tr>
<td></td>
<td>Rail</td>
</tr>
<tr>
<td>Water and Wastewater systems</td>
<td>Power Generation</td>
</tr>
<tr>
<td></td>
<td>SCADA</td>
</tr>
<tr>
<td></td>
<td>Waterway Surveillance</td>
</tr>
</tbody>
</table>
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 ~$365 billion per year

30 Years of GPS Reliability = Dependability for Environmental Solutions and new Technologies
**Telematics**

**Total Cost of Fleet Operation**

- Others (Tax, interest): 22%
- Driver wages: 30%
- Fuel: 26%
- Maintenance: 5%
- Tires: 19%
- 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
Public Safety Applications

- Over 30 million emergency calls are responded to per year in the U.S. alone for EMT services, and the response times are dependent on GPS accuracy.

- GPS Jamming in Northern Norway (2019-2020) led to severe delays for medical and fire personnel responding to emergencies.
Finance Applications

• All financial services use GPS to timestamp financial transactions, match trading orders, and synchronize financial computer systems.

• The U.S. processes $1.5 quadrillion dollars through SWIFT banking system with GPS timestamped transfers.
GPS for oil fleet managers allows them to rapidly verify the location of assets in the field as well as vehicles and/or drivers on the highway.

Oil companies use telematics by providing enhanced safety for truck drivers and ships.

A 5 trillion-dollar industry, oil/gas would not be as effective today without the use of GPS telematics to steer the fleets.
Agricultural Applications

• 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
Maritime Applications

- 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
Aviation Applications

• 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%.
Wide Area Augmentation System
Current Status

- Provides high availability aviation service in North America
- Developing Dual Frequency WAAS
  - Enable high WAAS vertical service in ionospheric disturbances
- Procedures
  - 4,127 Localizer Performance with Vertical Guidance (LPV) approaches in the National Airspace
  - 1,116 provide CAT I (67m) 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
GPS Future: 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
  - 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 for the receiver
  - Signal in protected International Telecommunications Union and Aeronautical Radionavigation Services (RNSS) band
GPS Future: The 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
  - Key Upgrade: Laser Retro reflector Array (LRA)
    - SV 11 and SV 12 will have 907 kg greater mass than GPS III
    - SV 13 – 20 will have a new evolved “combat bus” – size not set
      - Critical to allow for future upgrades
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
Outages:
Terrain: Off
Altitude: 5 (ft) AGL
Number of Channels: 4
Receiver Mask Angle: 5 (deg)
Thank you!

Product Request (Any Governmental Organization) E-mail: GPSOperationsCenter@us.af.mil
US Coast Guard Navigation Center: +1-703-313-5900

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