



# SPACE-BASED POSITIONING NAVIGATION & TIMING

NATIONAL EXECUTIVE COMMITTEE

## **U.S. GPS Policy and U.S. International Cooperation Activities**

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Civil GPS Service Interface Committee  
U.S. States and Local Government Subcommittee  
Groton, Connecticut  
April 27, 2011

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U.S. Department of State  
National Space Based PNT Coordination Office



# Overview



- **U.S. Space-Based PNT Policy**
- International Cooperation Activities



# New U.S. National Space Policy

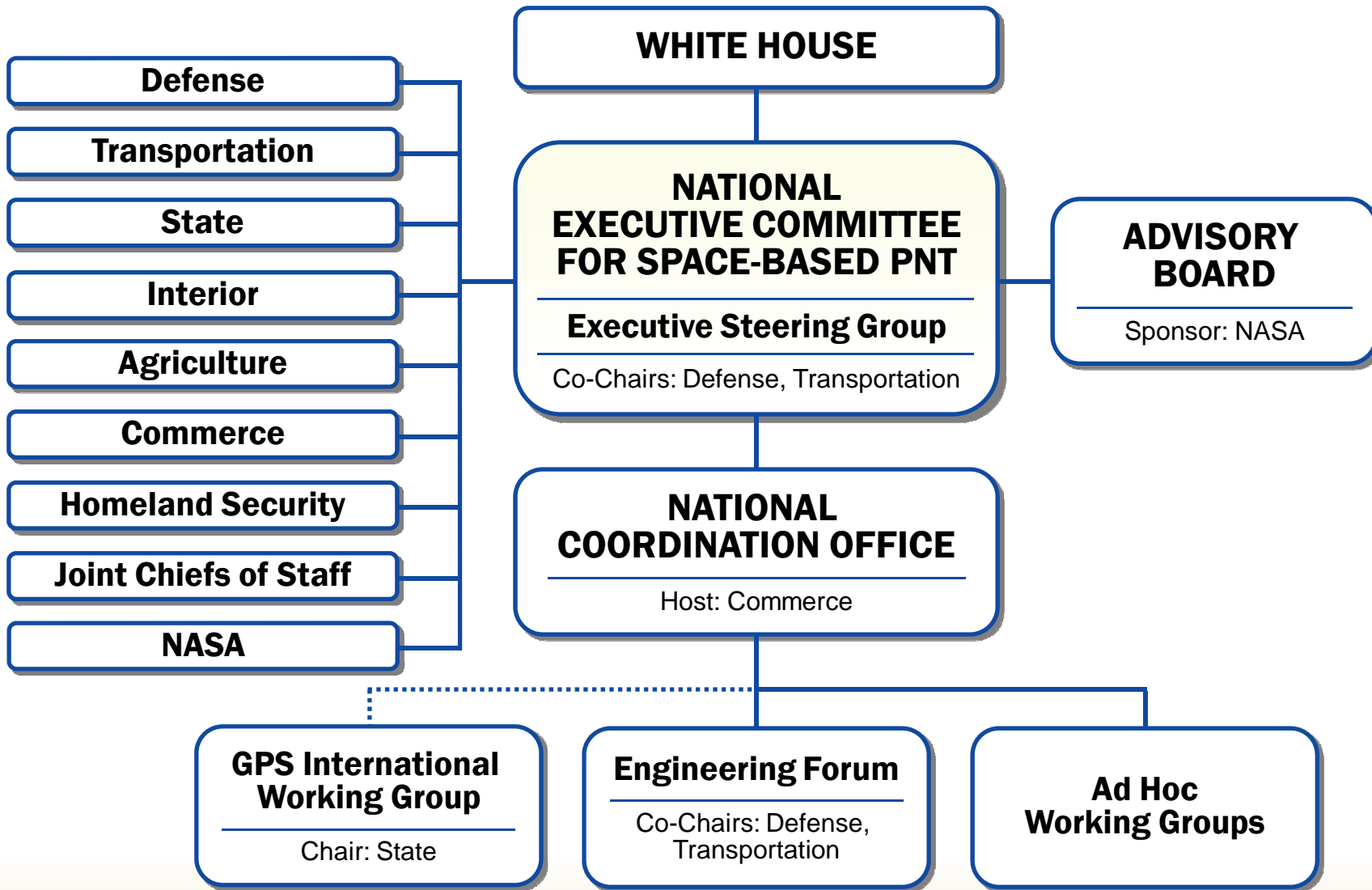


## *Space-Based PNT Guideline: Maintain leadership in the service, provision, and use of GNSS*

- Provide civil GPS services, free of direct user charges
  - Available on a continuous, worldwide basis
  - Maintain constellation consistent with published performance standards and interface specifications
  - Foreign PNT services may be used to complement services from GPS
- Encourage global compatibility and interoperability with GPS
- Promote transparency in civil service provision
- Enable market access to industry
- Support international activities to detect and mitigate harmful interference



# U.S. Space-Based PNT Organization Structure



# U.S. Policy Promotes Global Use of GPS Technology



- No direct user fees for civil GPS services
  - Provided on a continuous, worldwide basis
- Open, public signal structures for all civil services
  - Promotes equal access for user equipment manufacturing, applications development, and value-added services
  - Encourages open, market-driven competition
- Global compatibility and interoperability with GPS
- Service improvements for civil, commercial, and scientific users worldwide
- Protection of radionavigation spectrum from disruption and interference



# U.S. Objectives in Working with Other GNSS Service Providers



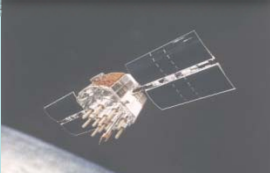



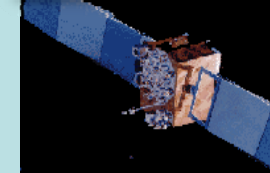

- Ensure **compatibility** — ability of U.S. and non-U.S. space-based PNT services to be used separately or together without interfering with each individual service or signal
  - Radio frequency compatibility
  - Spectral separation between M-code and other signals
- Achieve **interoperability** – ability of civil U.S. and non-U.S. space-based PNT services to be used together to provide the user better capabilities than would be achieved by relying solely on one service or signal
  - Primary focus on the common L1C and L5 signals

***Pursue through Bilateral and Multi-lateral Cooperation***



# GPS Modernization Program



1978 - 1985	1989 - 1997	1997 - 2004	2005 - 2009	2010 - Present	2014 - 2024
					
Block I	Block II/IIA	Block IIR	Block IIR-M	Block IIF	Block III

11 (10) Satellites	28 Satellites	13 (12) Satellites	8 Satellites	12 Satellites	32 Satellites
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<b>Demonstration system</b>	<b>Basic GPS</b> Provides Initial Navigation Capabilities	<b>IIA/IIR Capabilities "Plus"</b>	<b>IIR -M Capabilities "Plus"</b>	<b>IIF Capabilities "Plus"</b>
<ul style="list-style-type: none"> <li>• L1 (CA) Navigation signal</li> <li>• L1 &amp; L2 (P Code) Navigation signal</li> <li>• 5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>Standard Service</li> <li>• Single Frequency (L1)</li> <li>• C/A code navigation</li> <li>Precise Service</li> <li>• Two frequencies (L1 &amp; L2)</li> <li>• P (Y) -Code navigation</li> <li>• 7.5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>• 2<sup>nd</sup> Civil Signal L2 (L2C)</li> <li>• Earth Coverage M-Code on L1/L2</li> <li>• L5 Demo</li> <li>• Anti-Jam Flex Power</li> <li>• 7.5 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>• 3<sup>rd</sup> Civil Signal L5</li> <li>• Reprogrammable Nav Processer</li> <li>• Increased Accuracy requirement</li> <li>• 12 Year Design Life</li> </ul>	<ul style="list-style-type: none"> <li>IIIA</li> <li>• Increased accuracy</li> <li>• Increased Earth Coverage power</li> <li>• 15 Year Design Life</li> <li>• 4<sup>th</sup> Civil Signal (L1C)</li> <li>IIIB</li> <li>• Real-time Communications</li> <li>IIIC</li> <li>• Navigation Integrity</li> <li>• Spot Beam for AJ</li> </ul>

Increasing Space System Capabilities - Increasing Military/Civil User Benefits



# Overview



- U.S. Space-Based PNT Policy
- International Cooperation Activities



# Planned GNSS

- Global Constellations
  - **GPS (24+)**
  - GLONASS (30)
  - Galileo (27+3)
  - Compass (30 global and 5 regional satellites)
  - GINS - Global Indian Navigation System (24)
- Regional Constellations
  - QZSS (3)
  - IRNSS (7)
- Satellite-Based Augmentations
  - **WAAS (2+1)**
  - MSAS (2)
  - EGNOS (3)
  - GAGAN (2)
  - SDCM (2)



# Bilateral Cooperation



- **U.S.-EU** GPS-Galileo Cooperation Agreement signed in June 2004
  - Four working groups set up under the Agreement
- **U.S.-Japan** Joint Statement on GPS Cooperation 1998
  - Quasi Zenith Satellite System (QZSS) designed to be fully compatible and highly interoperable with GPS
  - Bilateral agreements to set up QZSS monitoring stations in Hawaii and Guam
- **U.S.-Russia** Joint Statement issued December 2004
  - Working Groups: compatibility/interoperability, search/rescue



# Bilateral Cooperation (continued)



- **U.S.-China** operator-to-operator coordination under ITU auspices is complete
  - Bilateral Meetings in 2007, 2008, 2009, 2010
- **U.S.-India** Joint Statement on GNSS Cooperation 2007
  - Technical Meetings focused on GPS-India Regional Navigation Satellite System (IRNSS) compatibility and interoperability held in 2008 and 2009
  - Continuation of ITU compatibility coordination is pending
- **U.S.-Australia** Joint Delegation Statement on Cooperation in the Civil Use of GPS in 2007
  - Bilateral meeting in Washington, D.C., Oct. 26-27, 2010
  - GNSS and applications to be included in expanded space cooperation, as discussed in an October 27 Joint Announcement



# International Committee on Global Navigation Satellite Systems (ICG)



- Emerged from 3rd UN Conference on the Exploration and Peaceful Uses of Outer Space July 1999
  - Promote the **use of GNSS** and its **integration into infrastructures**, particularly in developing countries
  - Encourage **compatibility and interoperability** among global and regional systems
  - Met annually since 2006
- Members include:
  - **GNSS Providers** — China, EU, India, **Japan**, Russia, **United States**
  - Other interested Member States of the United Nations
  - International organizations/associations



# APEC GNSS Implementation Team (GIT)



- Established in 2002
- Promote implementation of regional GNSS augmentation systems to enhance inter-modal transportation and recommend actions to be considered in the Asia Pacific Region
- Reports to Transportation Working Group (TPT-WG) through the Inter-modal Experts Group (IEG)
- Adopted a GNSS Strategy designed to promote adoption of GNSS technologies throughout the Asia Pacific region, especially with regard to transportation



# Summary



- **GPS performance is better than ever and will continue to improve**
  - Augmentations enable even higher performance
  - New civil GPS signal available now
  - Many additional upgrades scheduled
- **U.S. policy encourages worldwide use of civil GPS and augmentations**
- **International cooperation is a priority**
  - Compatibility and interoperability very important



# Contact Information



SPACE-BASED POSITIONING  
NAVIGATION & TIMING

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# BACKUP







# GPS Modernization – New Civil Signals



## Second civil signal “L2C”

- Designed to meet commercial needs
- Higher accuracy through ionospheric correction
- Available since 2005 without data message
  - Currently, 7 IIR-Ms transmitting L2C
- Full capability: 24 satellites ~2016



## Third civil signal “L5”

- Designed to meet demanding requirements for transportation safety-of-life
- Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
- On orbit broadcast 10 APR 2009 on IIR-20(M) secured ITU frequency filing
- Full capability: 24 satellites ~2018



# GPS Modernization – Fourth Civil Signal (L1C)



*Under Trees*



*Urban Canyons*

- Designed with international partners for interoperability
- Modernized civil signal at L1 frequency
  - More robust navigation across a broad range of user applications
  - Improved performance in challenged tracking environments
  - Original signal retained for backward compatibility
- Specification developed in cooperation with industry recently completed
- Launches with GPS III in 2014
- On 24 satellites by ~2021



# Modernized Operational Control Segment (OCX)



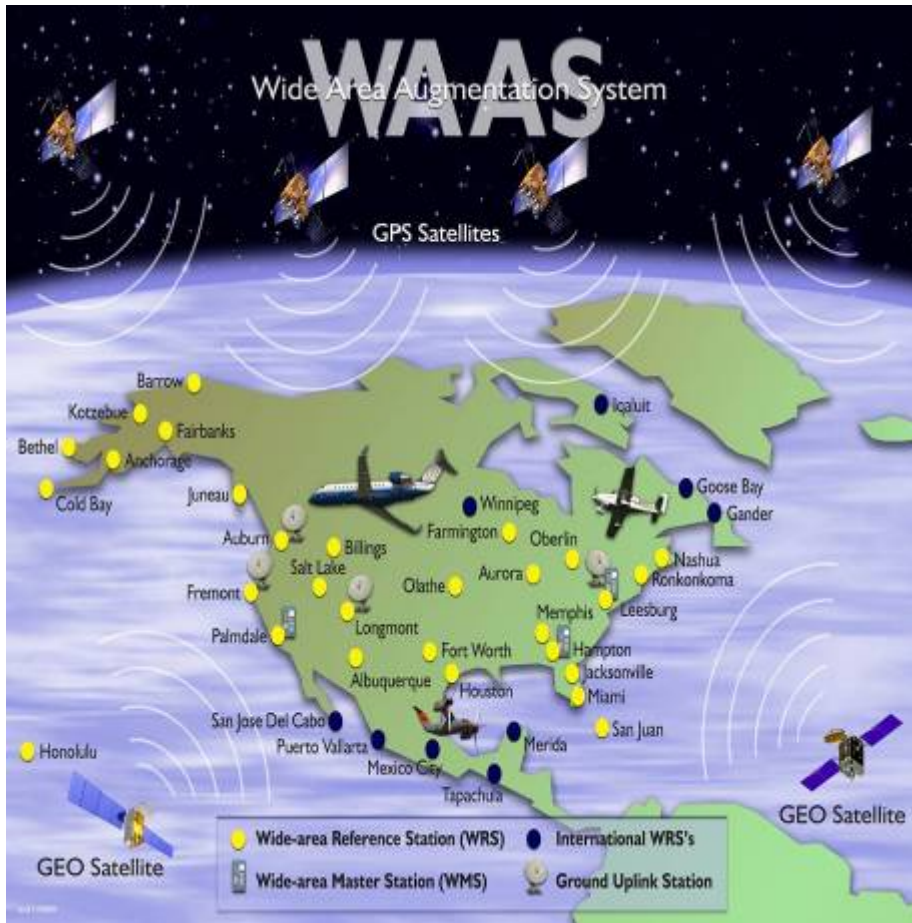
- Architecture Evolution Plan (AEP)
  - Transitioned in 2007
  - Increased worldwide commanding capability
  - Increased capacity for monitoring of GPS signals
  - Modern distributed system replaced 1970s mainframes
  - Current software version (5.5D) enabled SAASM functionality
- Next Generation Control Segment (OCX)
  - Controls more capable constellation, and monitors all GPS signals
  - \$1.5B contract awarded 25 February 2010
  - Capability delivered incrementally to reduce risk
  - On track for Preliminary Design Review in ~April 2011
  - Full Capability by ~2016







# Wide Area Augmentation System (WAAS) Architecture



**38 Reference Stations**



**3 Master Stations**



**4 Ground Earth Stations**



**2 Geostationary Satellite Links**



**2 Operational Control Centers**



# WAAS Phased Upgrades



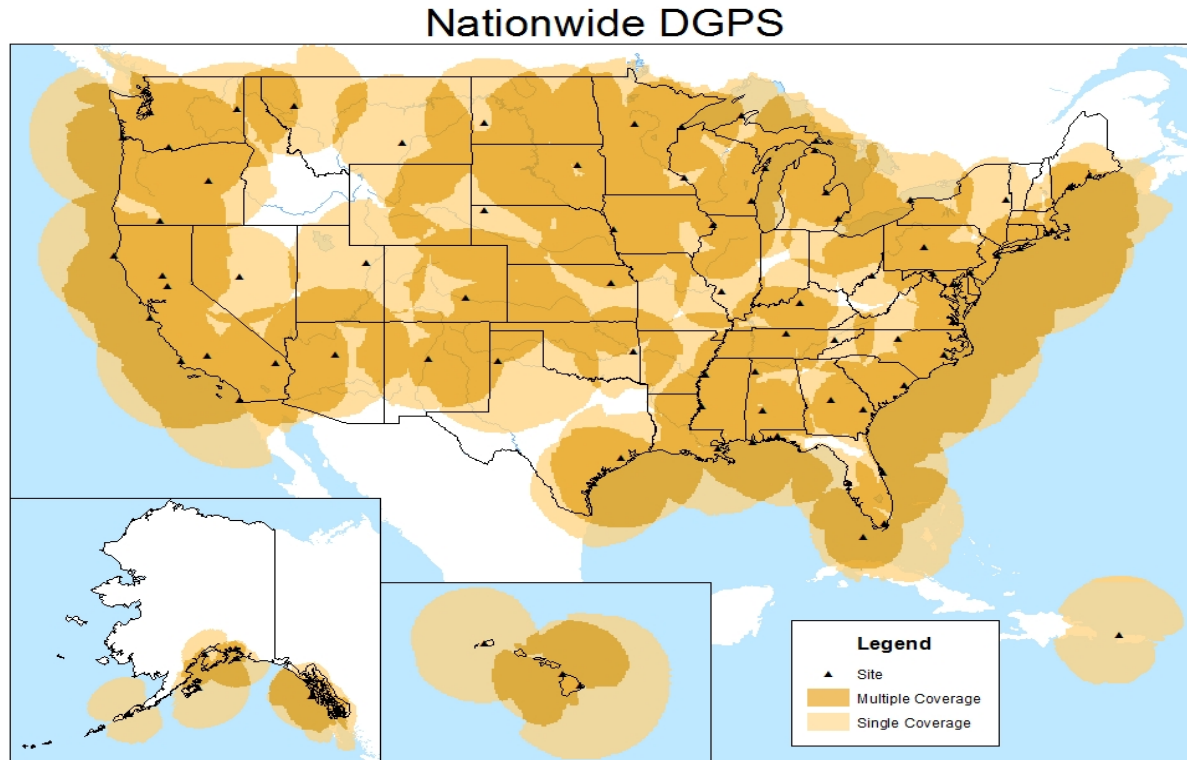
- **Phase I: IOC (July 2003) Completed**
  - Provided LNAV/VNAV/Limited LPV Capability
- **Phase II: Full LPV (FLP) (2003 – 2008) Completed**
  - Improved LPV availability in CONUS and Alaska
  - Expanded WAAS coverage to Mexico and Canada
- **Phase III: Full LPV-200 Performance (2009 – 2013)**
  - Software enhancements, hardware upgrades
  - Steady state operations and maintenance
  - Transition to FAA performed 2nd level engineering support
  - Begin GPS L5 transition activities
- **Phase IV: Dual Frequency (L1,L5) Operations (2013 – 2028)**
  - Complete GPS L5 transition
  - Will significantly improve availability and continuity during severe solar activity
  - Provide additional protection against GPS interference
  - Will continue to support single frequency users

# Nationwide Differential GPS (NDGPS) is a National PNT Utility

- Operated/managed by U.S. Coast Guard as a Combined NDGPS (Maritime + Department of Transportation sites + ACOE sites)
- System Specifications
  - Corrections broadcast at 285 and 325 kHz using Minimum shift Keying (MSK) modulation
  - Real-time differential GPS corrections provided in Radio Technical Commission for Maritime Services (RTCM) SC-104 format
  - No data encryption
  - Real-time differential corrections for mobile and static applications
- Single coverage terrestrial over 92% of Continental United States (CONUS) ; double coverage over 65% of CONUS



# Nationwide Differential GPS



September 2009

- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries

# Terrestrial NDGPS Capabilities and Uses

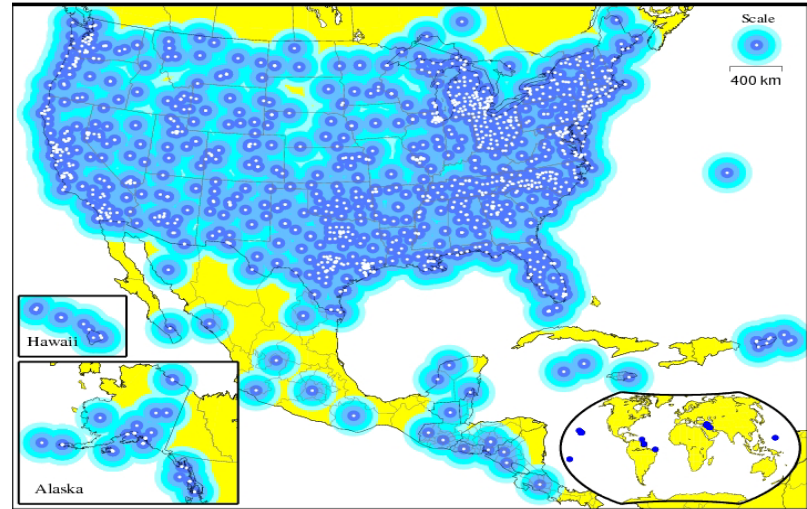
- Transportation operational requirements:
  - Federal Highway Administration (FHWA)
    - *on behalf of state and local DOT stakeholders*
    - *routine use in Federal-Aid Program*
    - *survey, construction, quality, asset management*
    - *roadside management*
    - *law enforcement*
  - Association of Am. Railroads
    - *baseline reference*
  - National Governor's Association
    - *use by state DOTs,*
    - *resource management agencies*





# National Continuously Operating Reference Stations (CORS)

- Enables highly accurate, 3-D positioning
  - Centimeter-level precision
  - Tied to National Spatial Reference System
- 1,200+ sites operated by 200+ public, private, academic organizations



- NOAA's Online Positioning User Service (OPUS) automatically processes coordinates submitted via the web from around the world
- OPUS-RS (Rapid Static) declared operational in 2007
- NOAA considering support for real-time networks