U.S. GPS Policy, Programs & International Cooperation Activities

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Overview

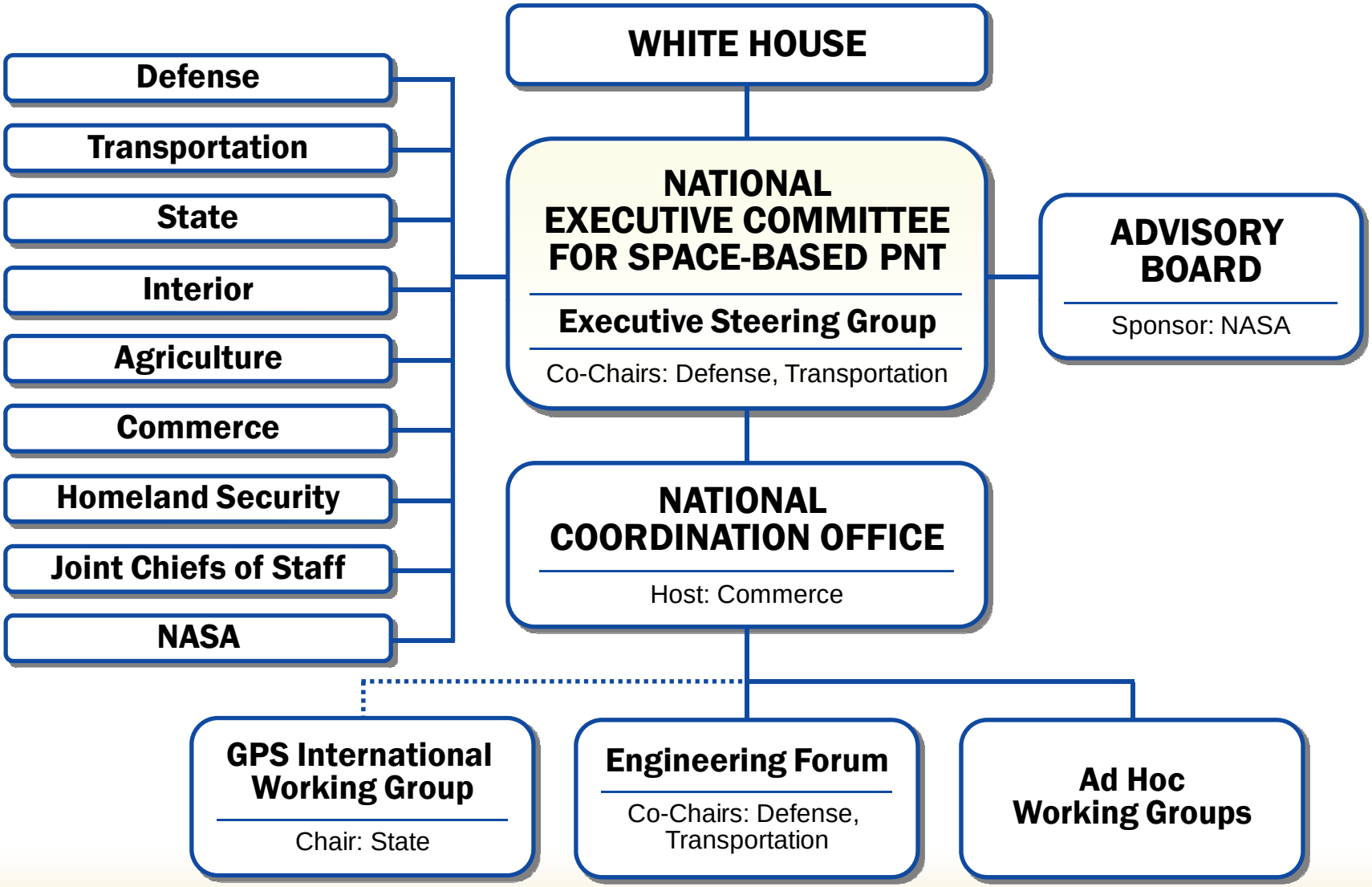
- **U.S. Space-Based PNT Policy**
- GPS & Augmentation Programs Status
- International Cooperation Activities
- Summary

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

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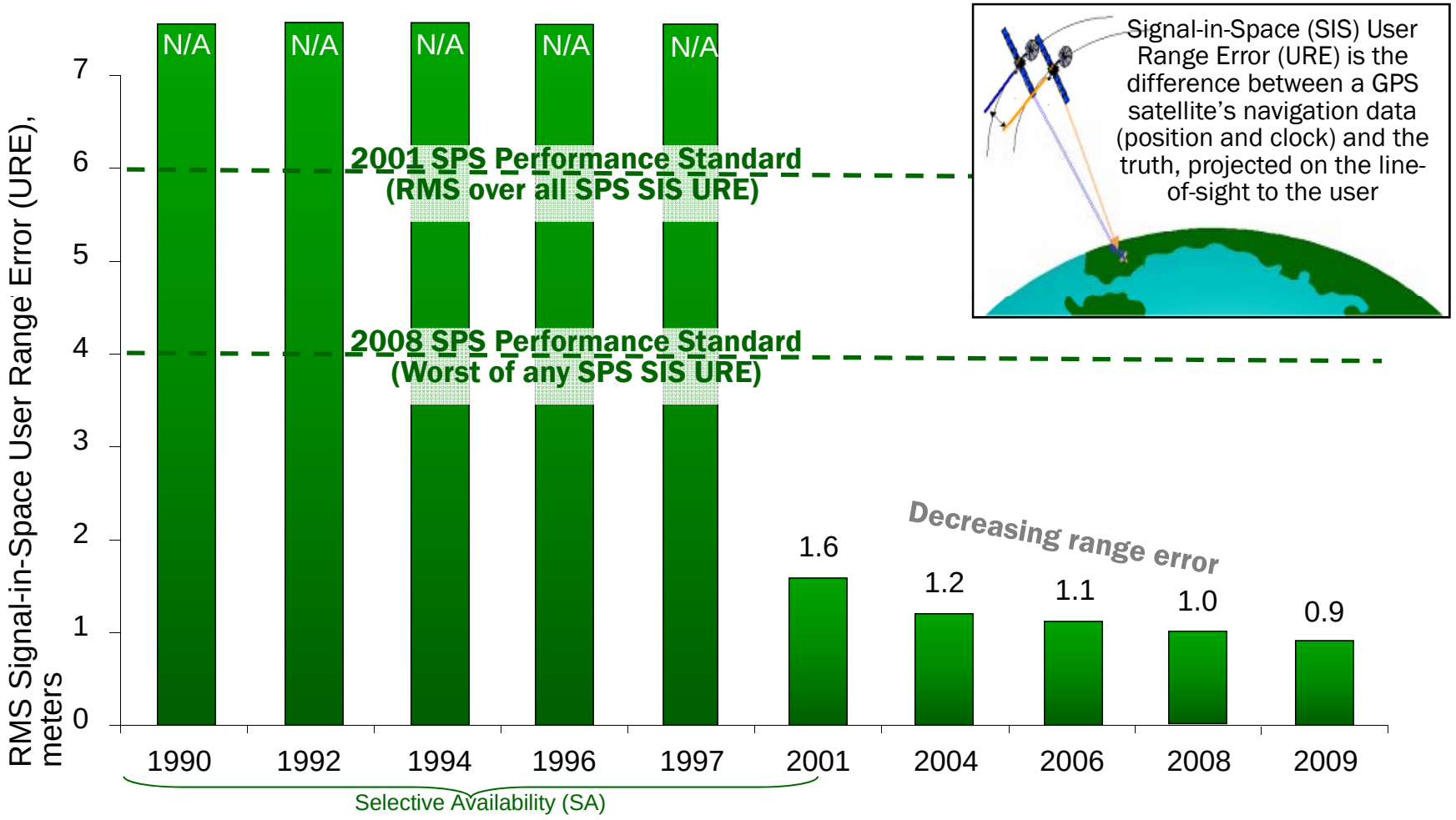
GPS Constellation

- 31 space vehicles currently operational
  - 11 GPS IIA
  - 12 GPS IIR
  - 7 GPS IIR-M
  - 1 GPS IIF
- 3 additional satellites in residual status
- IIF SV-2 scheduled to launch in July 2011
- IIIA SV-1 scheduled launch 2014
- Continuously assessing constellation health to determine launch need

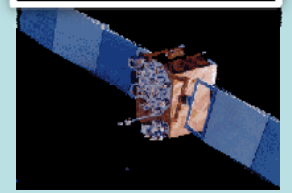
Global GPS service performance commitment met continuously since December 1993

GPS SPS Signal in Space Performance



System accuracy exceeds published standard

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**
Demonstration system	**Basic GPS Provides Initial Navigation Capabilities**	**IIA/IIR Capabilities "Plus"**	**IIR -M Capabilities "Plus"**	**IIF Capabilities "Plus"**	
• L1 (CA) Navigation signal • L1 & L2 (P Code) Navigation signal • 5 Year Design Life	• Standard Service • Single Frequency (L1) • C/A code navigation • Precise Service • Two frequencies (L1 & L2) • P (Y) -Code navigation • 7.5 Year Design Life	• 2nd Civil Signal L2 (L2C) • Earth Coverage M-Code on L1/L2 • L5 Demo • Anti-Jam Flex Power • 7.5 Year Design Life	• 3rd Civil Signal L5 • Reprogrammable Nav Processer • Increased Accuracy requirement • 12 Year Design Life	IIIA • Increased accuracy • Increased Earth Coverage power • 15 Year Design Life • 4th Civil Signal (L1C) IIIB • Real-time Communications IIIC • Navigation Integrity • Spot Beam for AJ	

Increasing Space System Capabilities – Increasing Military/Civil User Benefits

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

Under Trees

Urban Canyons

Fourth civil signal "L1C"

- 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

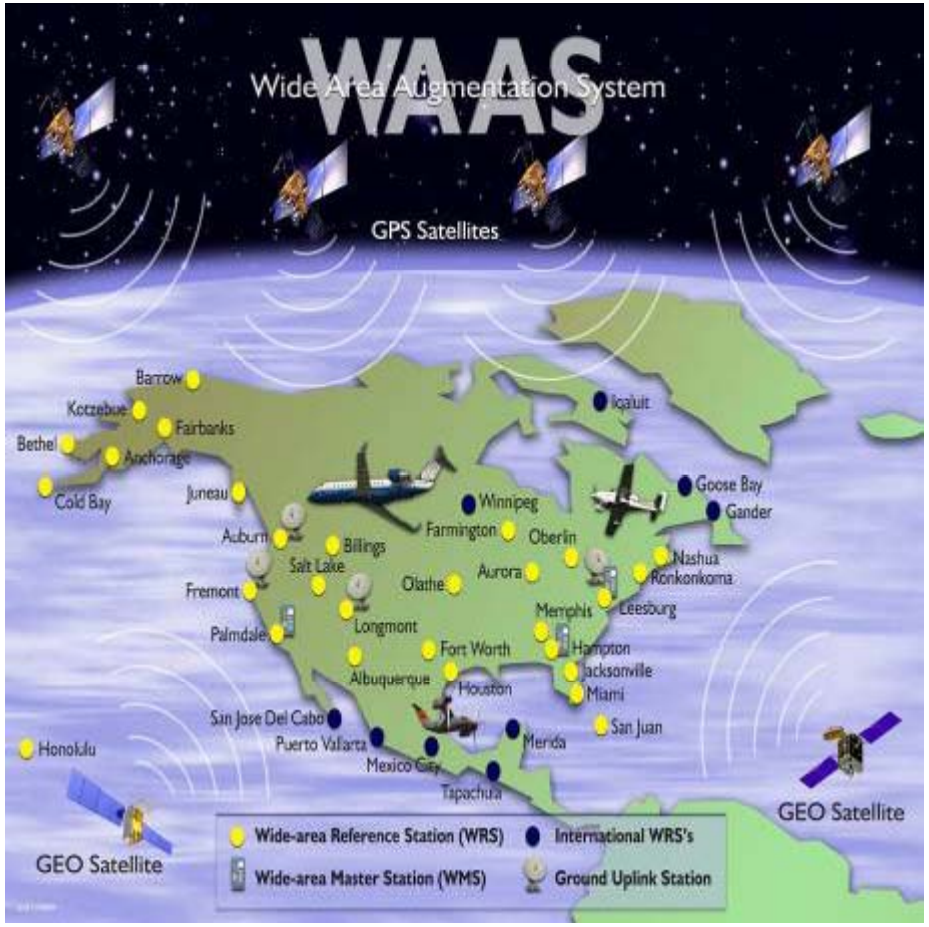
Modernized Operational Control Segment (OCX)

- 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

GPS Modernization – Semi-codeless Transition

- GPS receivers attain very high accuracy by using "codeless" or "semi-codeless" techniques that exploit the encrypted military GPS signals without actually decoding them
  - Techniques will no longer be necessary once the new civil GPS signals are fully operational
- U.S. Government published a notice for users to transition to GPS civil-coded signals by 31 December 2020
  - Provided time for an orderly and systematic transition
  - Based on launch schedule and projected budget
- U.S. Government led community-wide collaboration on this transition plan
- U.S. is committed to continually improving GPS services as users complete a timely transition to dual-coded civil GPS equipment

Wide Area Augmentation System (WAAS) Architecture



38 Reference Stations

3 Master Stations

4 Ground Earth Stations

2 Geostationary Satellite Links

2 Operational Control Centers

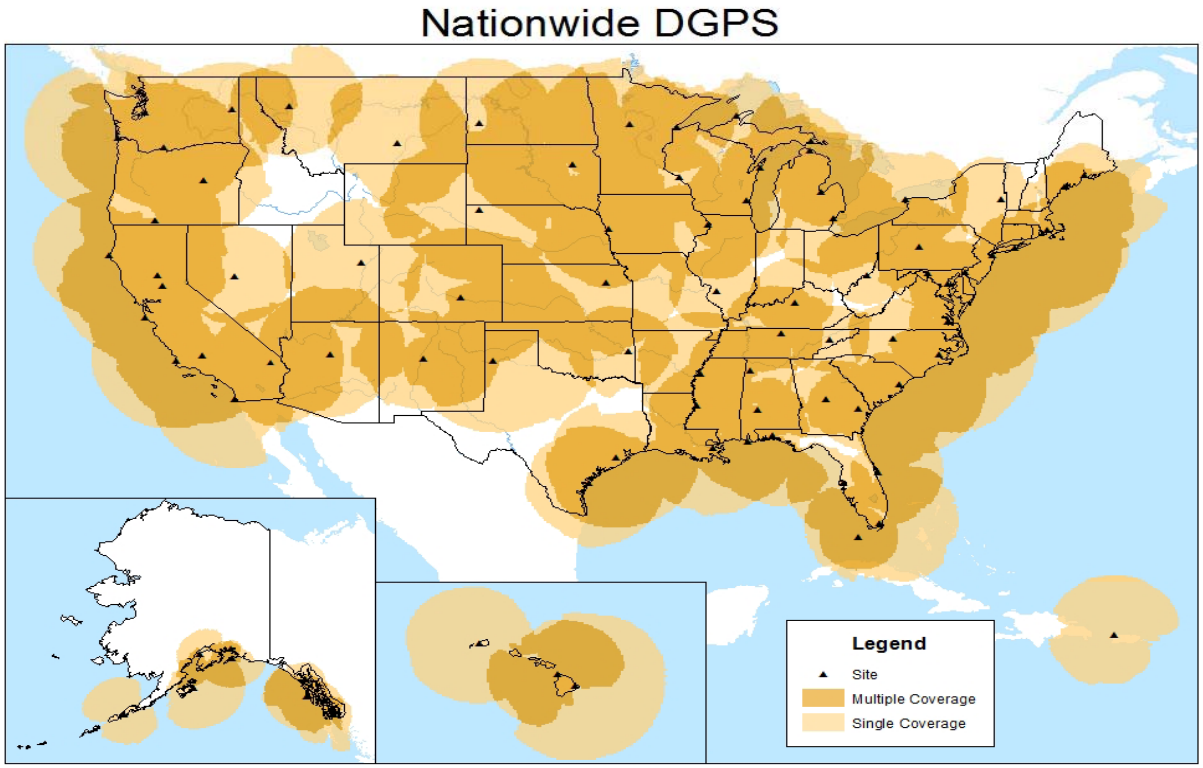
WAAS Phased Upgrades

- 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

- 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

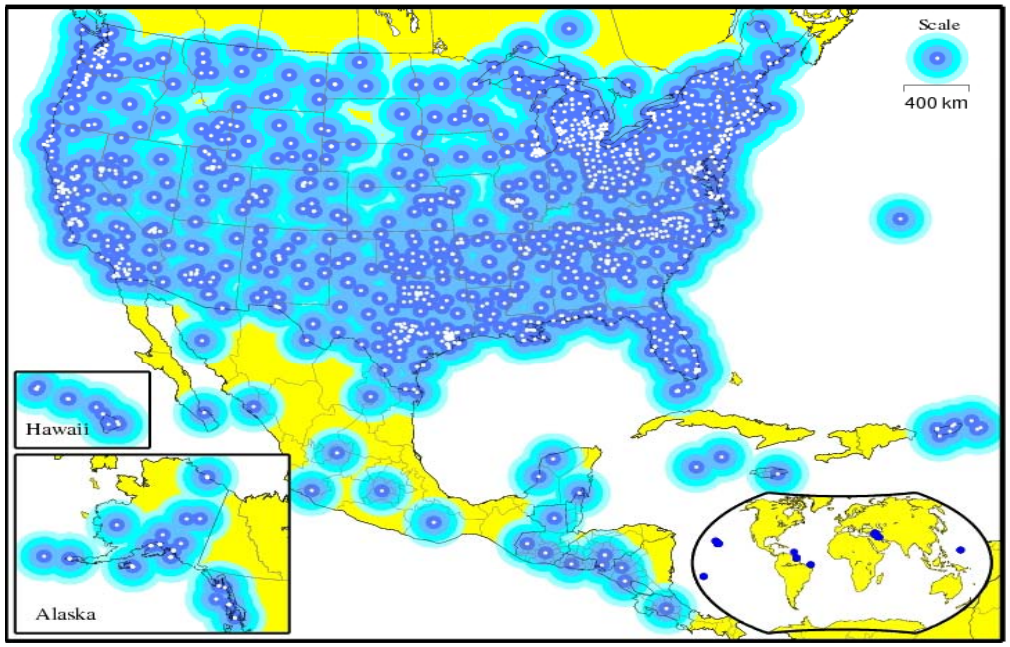
Nationwide Differential GPS



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

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

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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)

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
- Promote fair competition in the global marketplace

Pursue through Bilateral and Multilateral Cooperation

International Cooperation Venues

- Bilateral to include:
  - Japan
  - Europe
  - Russia
  - India
  - China
  - Others (Australia)
- Multilateral:
  - Asia Pacific Economic Cooperation
  - International Committee on GNSS

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

U.S. Bilateral Cooperation with China

- Operator-to-operator coordination under ITU auspices
  - Geneva, Switzerland - June 2007
  - Xian, China - May 2008
  - Geneva, Switzerland - October 2008
  - Hainan, China – December 2009
  - Coordination completed in Chengdu, China in September 2010
- U.S. is interested in engaging in further bilateral discussions with China on civil GNSS services and applications

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
- Members include:
  - **GNSS Providers** (U.S., EU, Russia, China, India, Japan)
  - Other Member States of the United Nations
  - International organizations/associations

http://www.icgsecretariat.org

ICG Providers Forum

- Six space segment providers listed previously are members
- Purpose:
  - Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
  - Exchange detailed information on systems & service provision plans
  - Exchange views on ICG work plan and activities
- Providers have agreed that all GNSS signals and services must be compatible and open signals and services should also be interoperable to the maximum extent possible
  - Working definition of **compatibility** includes respect for spectral separation between each system's authorized service signals and other systems' signals
  - **Interoperability** definition addresses signal, geodetic reference frame realization, and system time steerage considerations

APEC GNSS Implementation Team

- GNSS Implementation Team (GIT) established in 2002
- Mission – 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 through the Inter-modal Experts Group
- Adopted a GNSS Strategy designed to promote adoption of GNSS technologies throughout the Asia Pacific region, especially with regard to transportation

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- **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
  - In pursuit of systems **Compatible** and **Interoperable** with GPS

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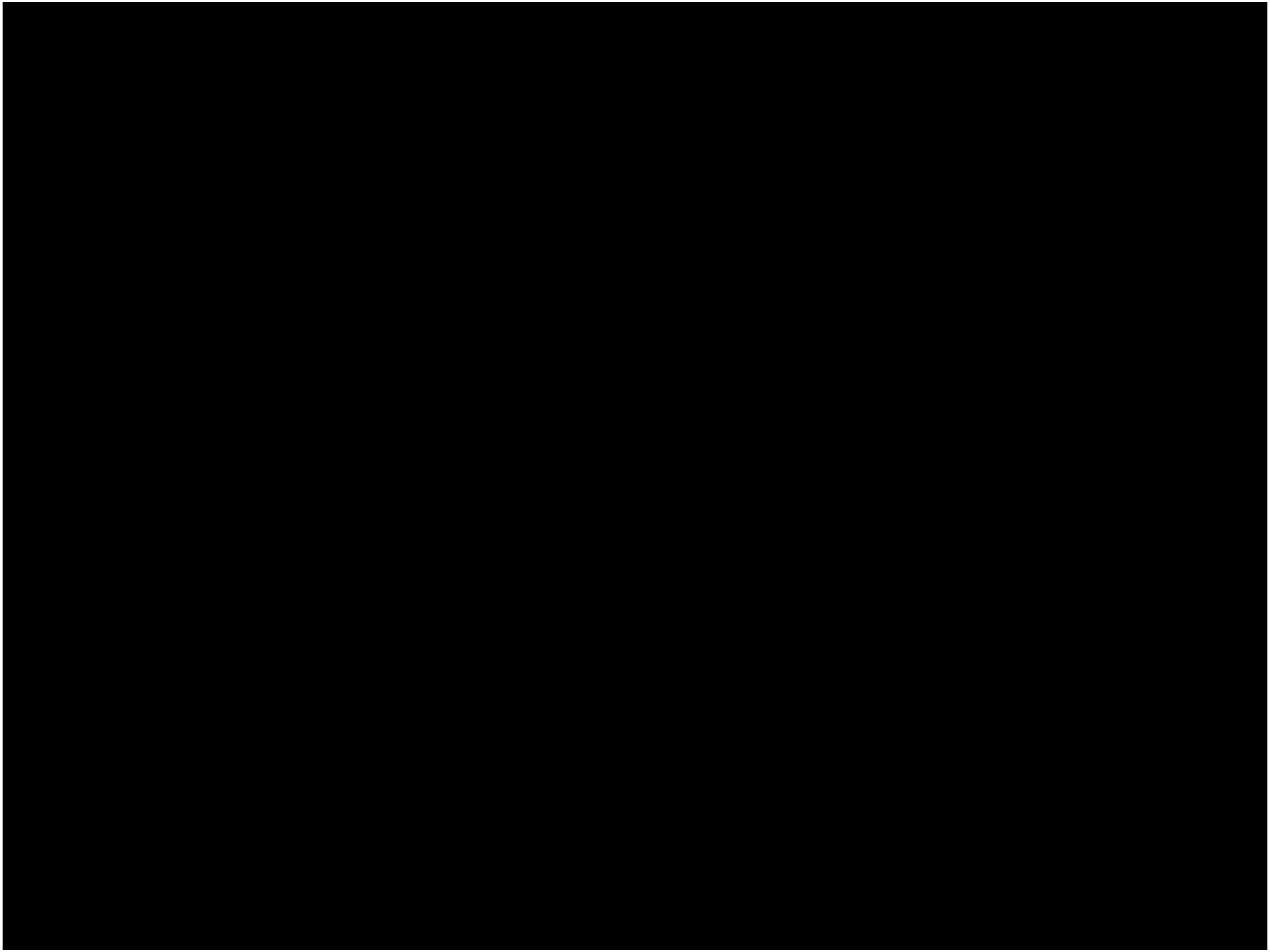
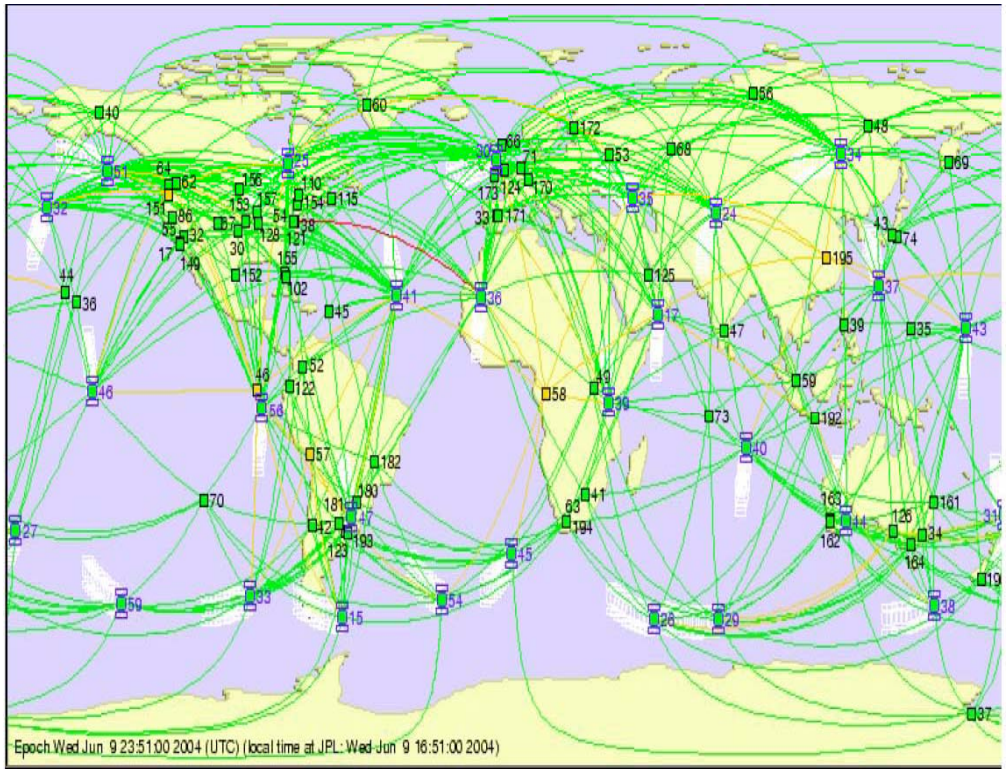


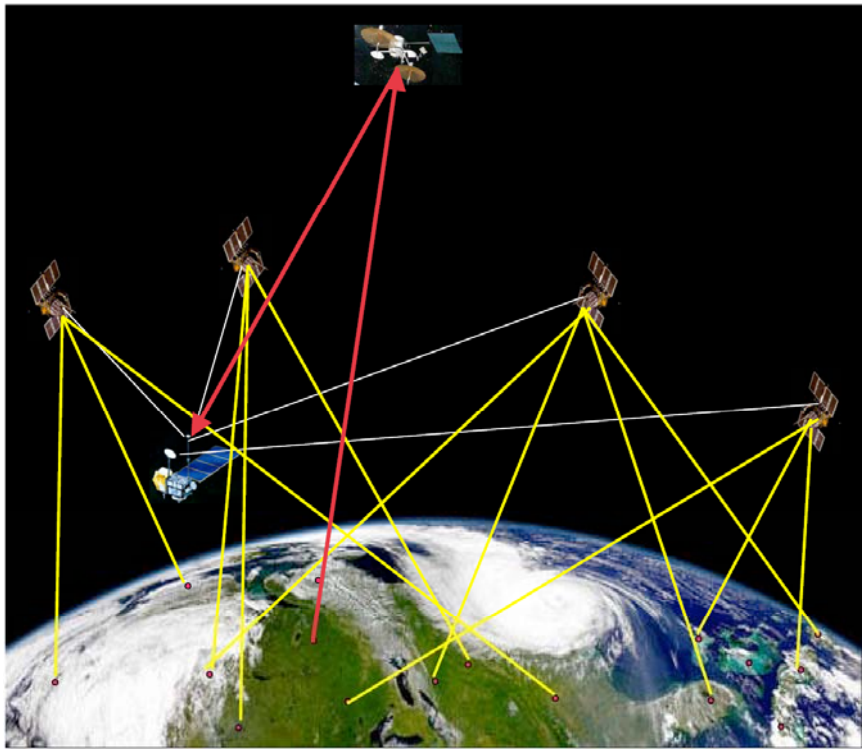
Global Differential GPS (GDGPS) and TDRSS Augmentation Service for Satellites (TASS)

Sponsor: NASA

GDGPS: More than 100 real-time tracking sites
- Real-Time Positioning, Timing, and Orbit-Determination

TASS: Future plans to disseminate GDGPS corrections to satellites for autonomous orbit determination and science missions





Ground Based Augmentation System (GBAS)

- Architecture
  - Ground Station/Processing Unit/Power Supply (one shelter on airport property)
  - 4 Reference Receivers/Antennas
  - VHF Data Link Antenna
- Specifications
  - Supports Category I approach with growth to Category III
  - Single facility can provide service up to 23 mile radius