



U.S. Space-Based PNT Policy, Programs, and International Cooperation



ICG International Committee on
Global Navigation Satellite Systems



GNSS International Symposium

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Overview

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



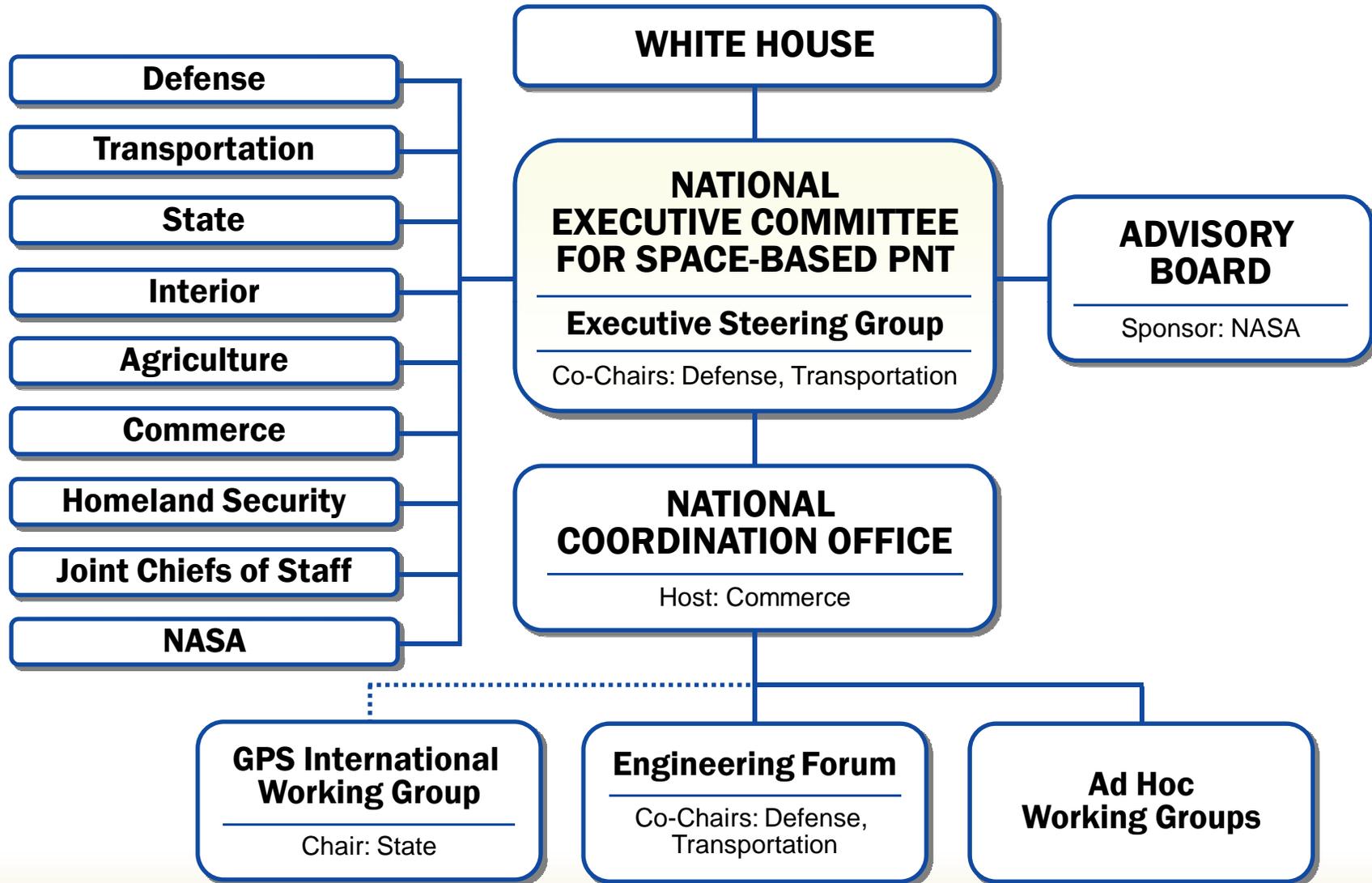
U.S. Space-Based PNT Policy

GOAL: Ensure the U.S. maintains space-based PNT services, augmentation, back-up, and service denial capabilities that...

- Provide uninterrupted availability of PNT services
- Meet growing national, homeland, economic security, and civil requirements, and scientific and commercial demands
- Remain the pre-eminent military space-based PNT service
- Continue to provide civil services that exceed or are competitive with foreign civil space-based PNT services and augmentation systems
- Remain essential components of internationally accepted PNT services
- Promote U.S. technological leadership in applications involving space-based PNT services



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 Status

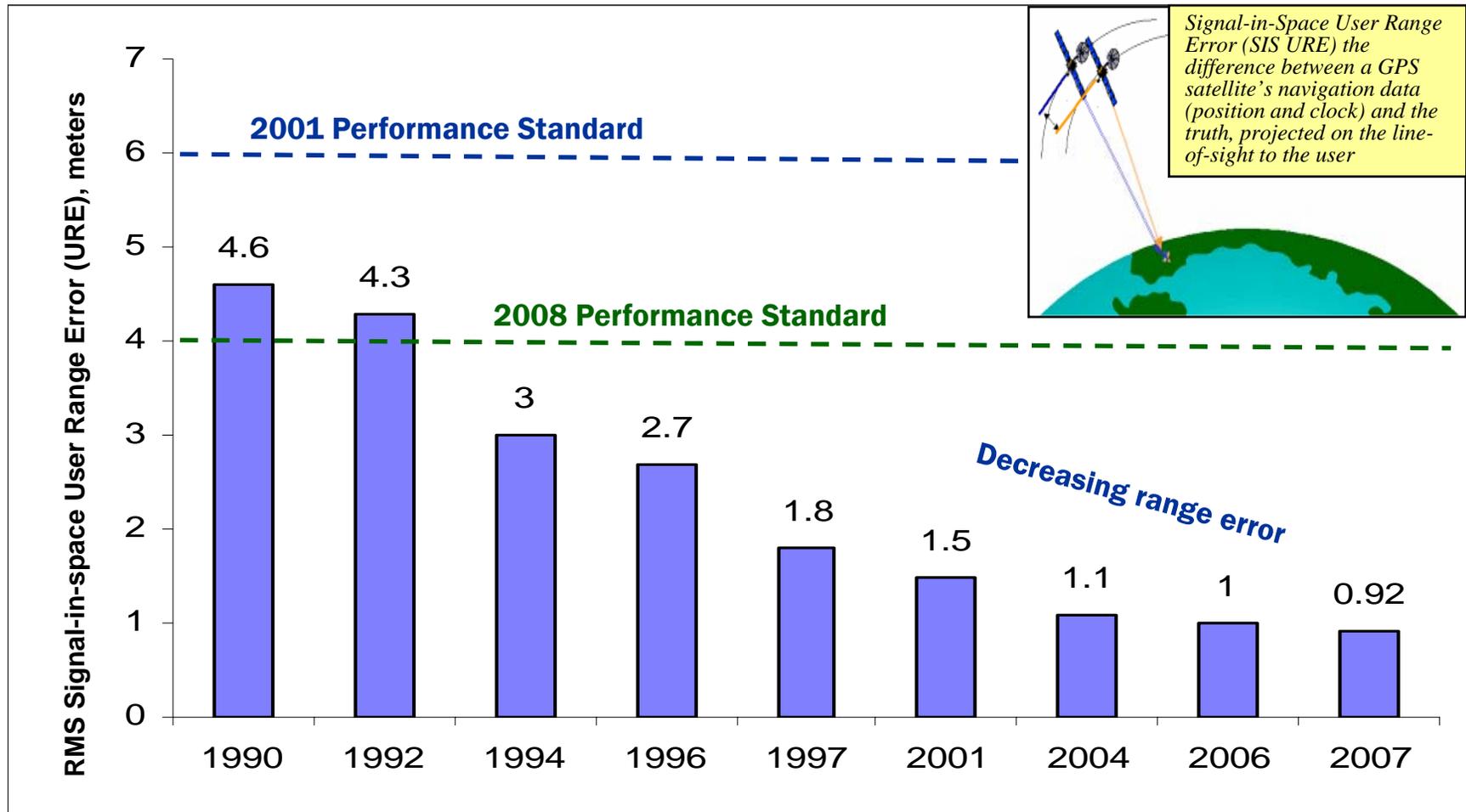
31 Operational Satellites (Baseline Constellation: 24)

- 13 Block IIA
- 12 Block IIR
- 6 Block IIR-M
 - Transmitting new second civil signal
- Continuously assessing constellation health to determine launch need
 - 2 Block IIR-M's remaining
- Global GPS civil service performance commitment met continuously since December 1993





GPS Signal in Space Performance



System accuracy far exceeds published standard



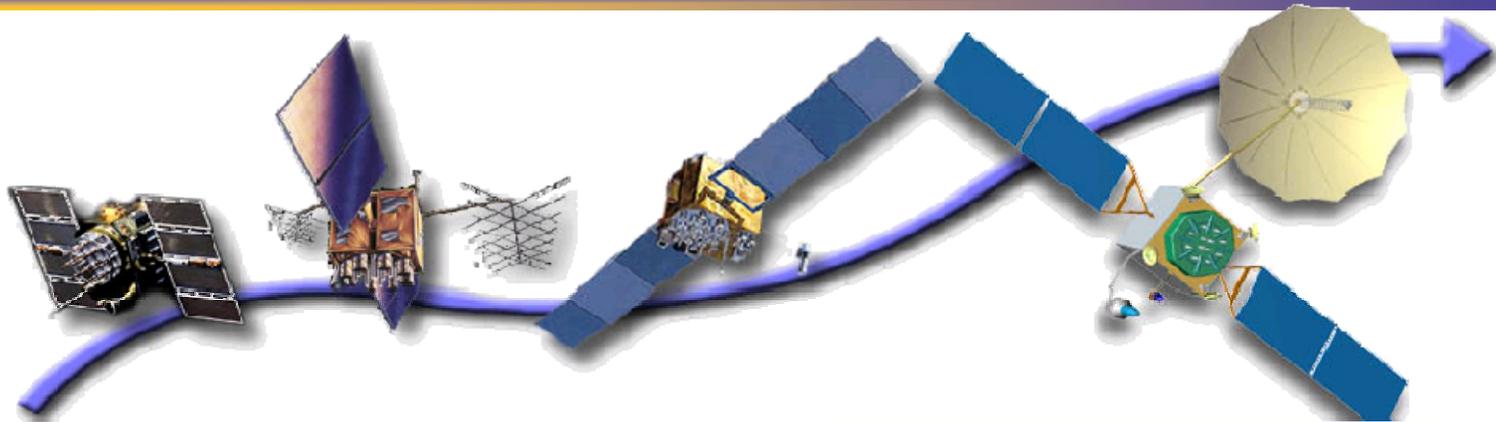
Recent Program Successes

- GPS IIR(M): 3 Successful launches since Oct 07
- GPS IIF: Completed all functional and performance tests; Currently in vacuum test
- GPS IIIA: Awarded to Lockheed Martin Space Systems Company (Newton, PA), May 08
- Operational Control Segment (OCS)
 - Architecture Evolution Plan (AEP)/Launch & Early Orbit, Anomaly Resolution & Disposal Operations (LADO) switch over – Sep 07
 - Alternate Master Control Station fully functional
- Next Generation Operational Control Segment (OCX)
 - Needed for Block III satellites & full functionality of modernized signals
 - Awarded Phase A contracts to Northrop Grumman & Raytheon, Nov 07





GPS Modernization Program



Increasing System Capabilities ♦ Increasing Defense / Civil Benefit

Block IIA/IIR

Basic GPS

- Standard Service
 - Single frequency (L1)
 - Coarse acquisition (C/A) code navigation
- Precise Service
 - Y-Code (L1Y & L2Y)
 - Y-Code navigation

Block IIR-M, IIF

IIR-M: IIA/IIR capabilities plus

- 2nd civil signal (L2C)
- M-Code (L1M & L2M)

IIF: IIR-M capability plus

- 3rd civil signal (L5)
- Anti-jam flex power

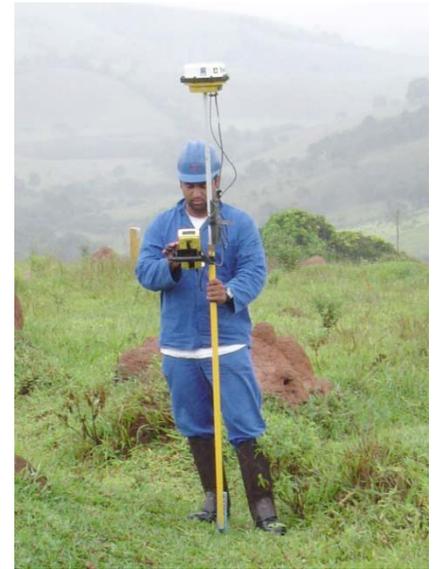
Block III

- Backward compatibility
- 4th civil signal (L1C)
- Increased accuracy
- Increased anti-jam power
- Assured availability
- Navigation surety
- Controlled integrity
- Increased security
- System survivability



GPS Modernization – New Civil Signals

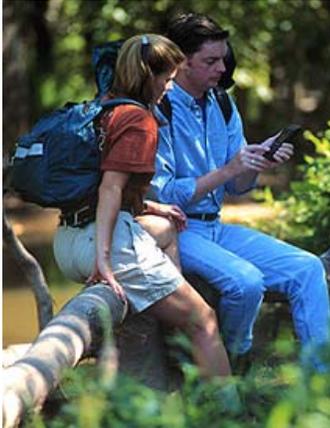
- **Second civil signal “L2C”**
 - Designed to meet commercial needs
 - Higher accuracy through ionospheric correction
 - Available since 2005 without data message
 - Phased roll-out of CNAV message starting in 2009
 - Full capability: 24 satellites ~2016



- **Third civil signal “L5”**
 - Designed to meet demanding requirements for transportation safety-of-life
 - Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
 - 1st launch: 2009; 24 satellites ~2018



Fourth Civil Signal (L1C)



Under trees



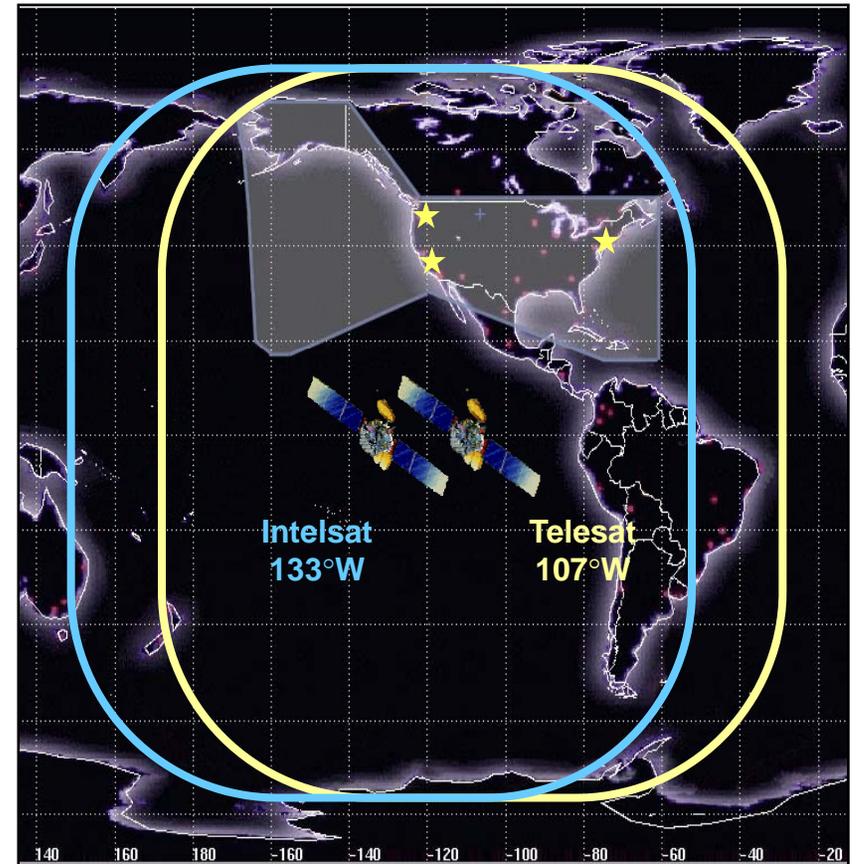
Urban Canyons

- 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



Wide Area Augmentation System

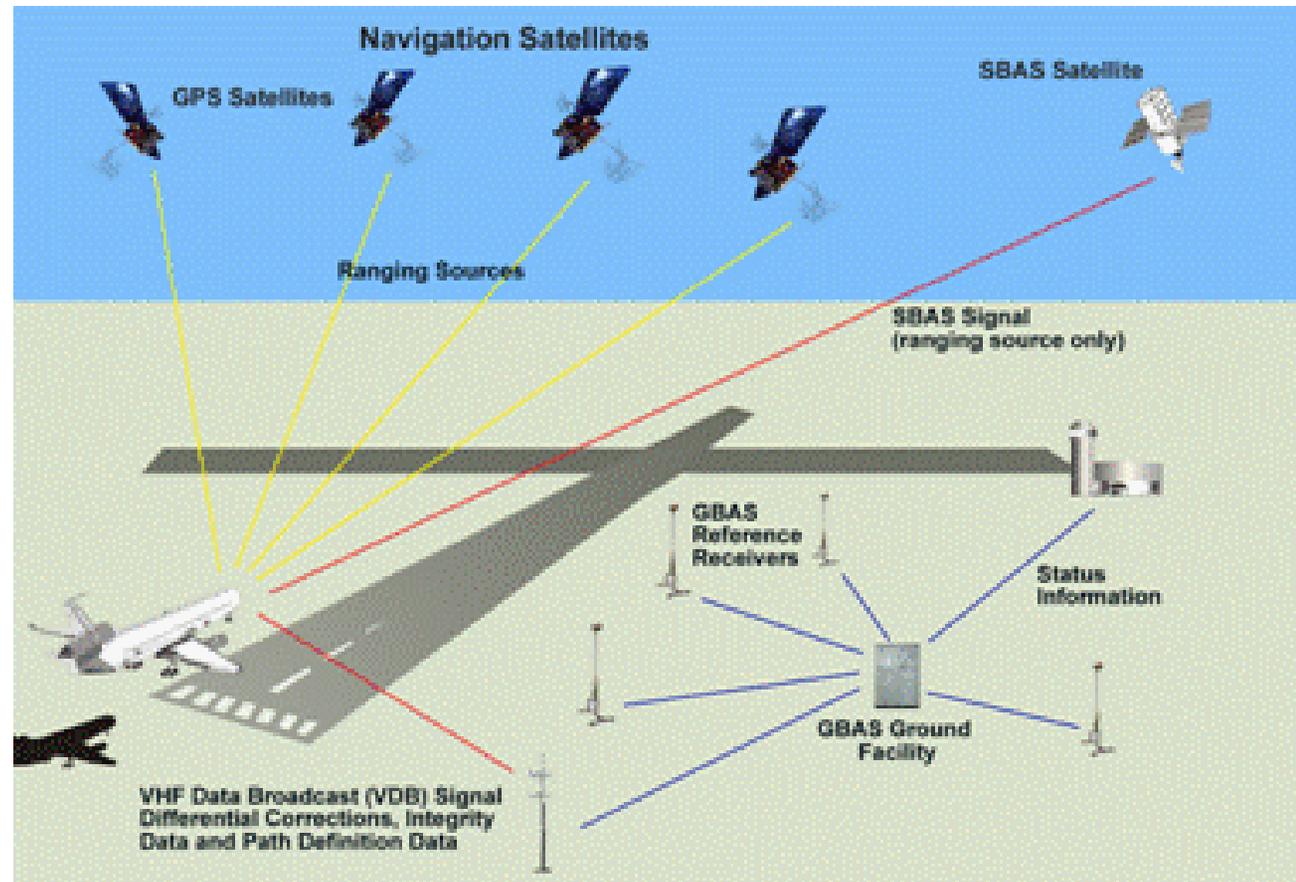
- Two replacement satellites launched in 2005
 - Intelsat (Galaxy XV) and Telesat Canada (Anik F1R)
 - Provides dual coverage over United States
- Service expanded into Canada and Mexico
 - New reference stations in Mexico (5) and Canada (4)
 - Operational Sep 2007





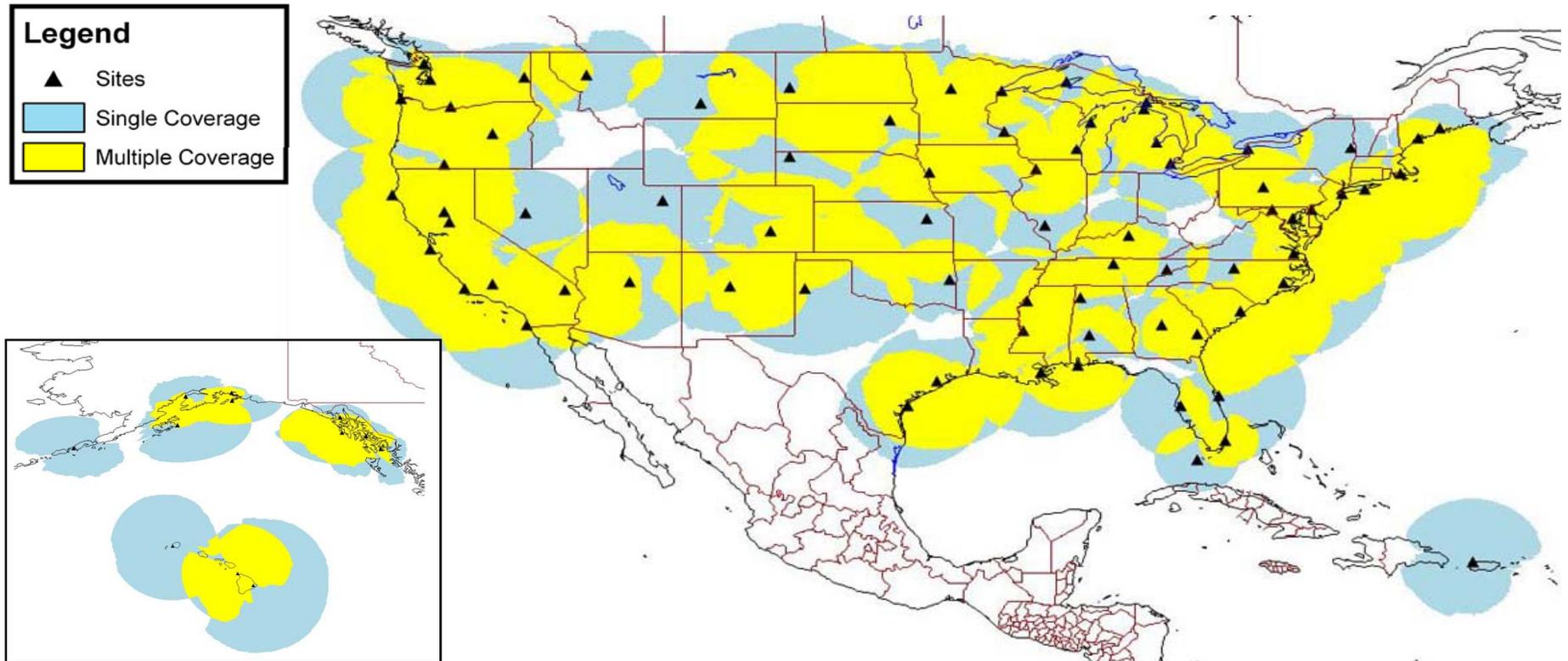
Local Area Augmentation System (LAAS)

- Precision Approach For CAT- I, II, III
- Multiple Runway Coverage At An Airport
- 3D RNP Procedures (RTA), CDAs
- Navigation for Closely Spaced Parallels
- Super Density Operations
- First certified ground system- early 2009
- LAAS is Expected to Achieve Category-III By 2012





Nationwide Differential GPS



- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries
- Department of Transportation recently re-committed to continuing inland element of NDGPS



Overview

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U.S. Space-Based PNT Policy

(Excerpts focused on International Relations)

Goals:

- U.S. space-based PNT systems and services remain essential components of internationally accepted PNT services
- Promote U.S. technological leadership in applications involving space-based PNT services

To achieve this, the United States Government shall:

- Encourage foreign development of PNT services/systems based on GPS
 - Seek to ensure foreign space-based PNT systems are **interoperable** with civil GPS and augmentations
 - At a minimum, ensure **compatibility**

The Secretary of State shall:

- Promote the use of civil aspects of GPS and its augmentation services and standards with foreign governments and other international organizations
- Lead negotiations with foreign governments and international organizations regarding civil PNT matters



Planned GNSS

- **Global Constellations**
 - GPS (24+)
 - GLONASS (30)
 - Galileo (27)
 - Compass (38)
- **Regional Constellations**
 - QZSS (3)
 - IRNSS (7)
- **Satellite-Based Augmentations**
 - WAAS (3)
 - MSAS (2)
 - EGNOS (3)
 - GAGAN (3)
 - SDCM (2?)



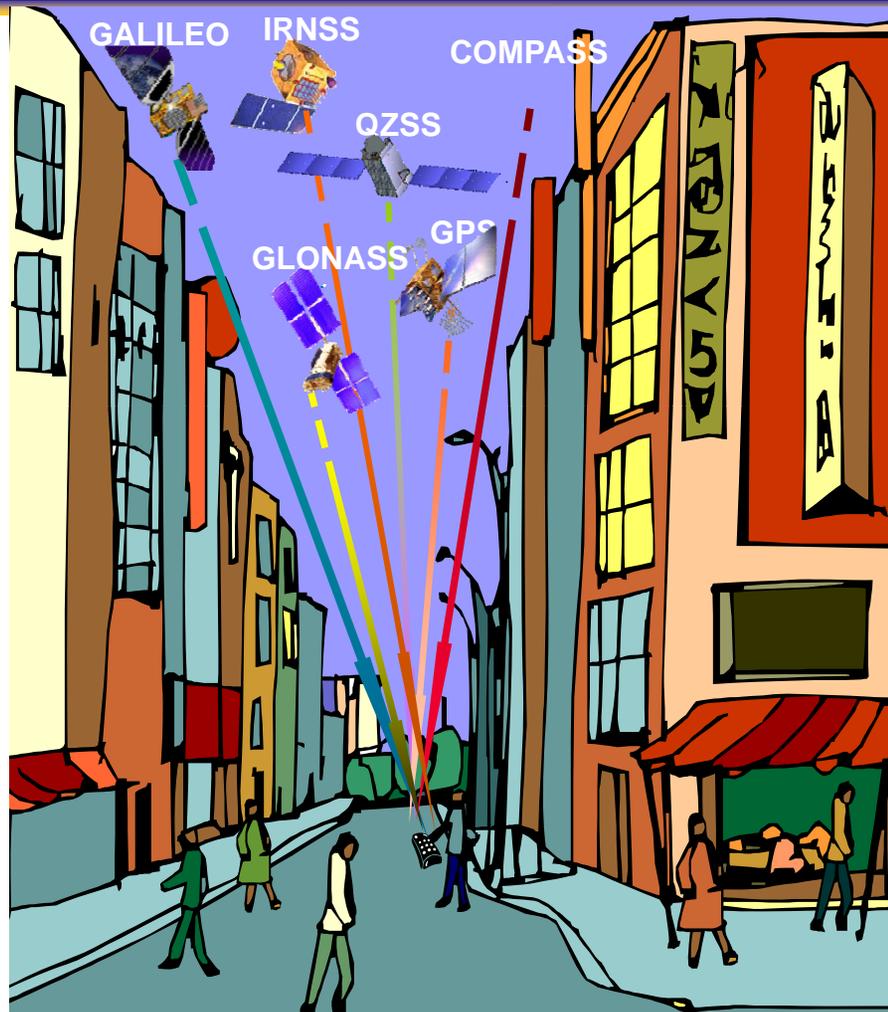
U.S. Objectives in Working with Other GNSS Service Providers

- 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
 - Primary focus on the common L1C and L5 signals
- Ensure a level playing field in the global marketplace

Pursue through Bi-lateral and Multi-lateral Cooperation



The Goal of RNSS Civil Interoperability



- Ideal interoperability allows navigation with **one signal each** from four or more systems with no additional receiver cost or complexity

Interoperable = Better Together than Separate



U.S. - Europe Cooperation

- 2004 U.S.-EU agreement provides foundation for cooperation
- Four working groups were set up under the agreement:
 - Technical, trade, and security issues working groups have met
- Improved new civil signal (MBOC) adopted in July 2007
- First Plenary Meeting successfully held in October 2008



Oct. 22, 2008 , EU-U.S. Plenary delegations meeting under the auspices of the GPS-Galileo Cooperation Agreement



Signing ceremony for GPS-Galileo Cooperation Joint Statement, Oct. 23, 2008
(Michel Bosco, European Commission;
Kenneth Hodgkins, U.S. Department of State)



U.S. - Japan Cooperation

- Japan's status as a world leader in GPS applications and user equipment makes it an important partner
- Regular policy consultations and technical meetings on GPS cooperation began in 1996 and led to the 1998 Clinton-Obuchi Joint Statement
 - Annual Plenary meeting just occurred on Monday in Tokyo
- Both countries have benefited from the close relationship:
 - QZSS designed to be **compatible & interoperable** with GPS
 - U.S. and Japan's Satellite-Based Augmentation Systems, WAAS & MSAS are highly interoperable and based on GPS
 - U.S. working with Japan to **set up QZSS monitoring stations** in Hawaii and Guam



U.S. - Russian Federation Cooperation

- U.S.- Russia Joint Statement issued in December 2004
- Negotiations for a U.S.-Russia Agreement on satellite navigation cooperation have been underway since late 2005
- Several very productive technical working group meetings have been held:
 - Russia is adopting two new civil CDMA signals at L1, L5 to be interoperable with GPS
 - Next technical working group meeting is planned for December 2008



U.S. - India Cooperation

- Policy and technical consultations on GPS cooperation underway since 2005
 - One aim is to ensure **interoperability** between the **Wide-Area Augmentation System (WAAS)** and India's planned **GAGAN augmentation system**, both based on GPS
 - Another important topic is **ionospheric distortion and solutions to this phenomena**
- U.S.-India Joint Statement on GNSS Cooperation issued in February 2007 in Washington
 - Bi-lateral meeting held in Bangalore in September 2007
 - Technical Meeting focused on **GPS-IRNSS compatibility and interoperability** held in January and July 2008



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





International Committee on Global Navigation Satellite Systems (ICG)

- ICG-2 held in September, 2007 in India
- Established **Providers Forum**
- Began implementation of the ICG Work Plan within established working groups:
 - A. Interoperability and compatibility
 - B. Enhancement of performance of GNSS services
 - C. Information dissemination, education, outreach & coordination
 - D. Interaction with monitoring & reference station network organizations
- U.S. will host the 3rd ICG in December 2008
 - <http://www.geolinks.org/ICG3/>
- Russia will host the 4th ICG in St. Petersburg in 2009



ICG Providers Forum

- Six space segment providers listed previously are members
- Purpose:
 - Focused discussions on **compatibility and interoperability**, encouraging development of complimentary systems
 - Exchange of detailed information on systems & service provision plans
 - Exchange views on ICG work plan and activities
- Consensus reached at the first meeting on general definitions for compatibility and interoperability
 - Including spectral separation between each system's authorized service signals and other systems' signals

<http://www.unoosa.org/oosa/en/SAP/gnss/icg.html>



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 are critical



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