



SPACE-BASED POSITIONING  
NAVIGATION & TIMING  
NATIONAL COORDINATION OFFICE

# Global Positioning System

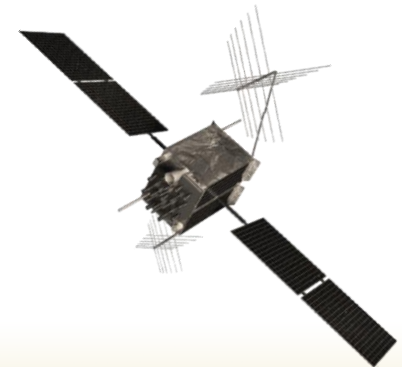
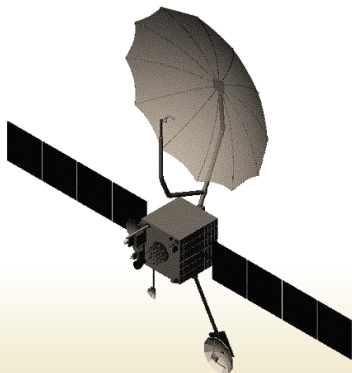
*A Revolution Now in Evolution...*

**Anthony J. Russo**  
Director, National Coordination Office  
United States of America

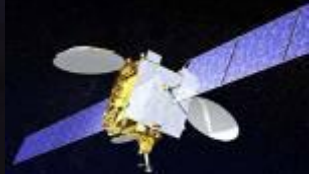
**Ohio State University**

**GPS Workshop**

**March 17, 2011**



# GPS is Essential to Our Economy and National Critical Infrastructures



**Satellite Operation**



**Surveying & Mapping**



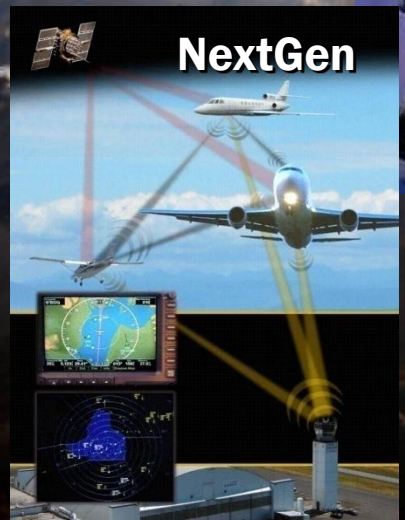
**Power Grids**



**Precision Agriculture**



**Transit Operations**



**NextGen**



**Trucking & Shipping**



**IntelliDrive**



**Telecom**



**Navigation**



**Disease Control**



**Oil Exploration**



**Fishing & Boating**



# U.S. Policy History

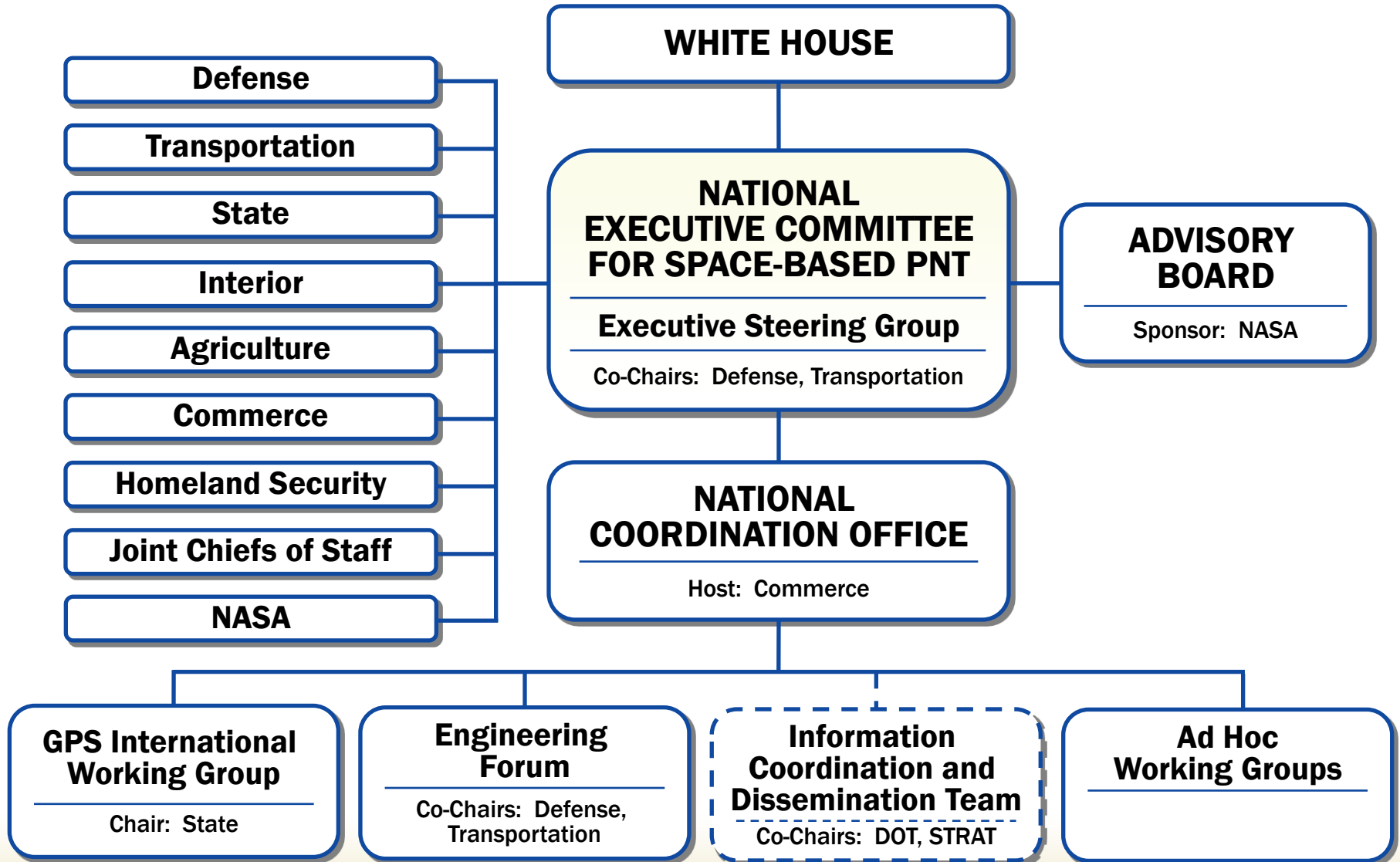


- **1983:** President announces civilian access to GPS following KAL 007
- **1991:** U.S. offers free civil GPS service to the International Community
- **1996:** First U.S. GPS Policy establishes joint civil/military management
- **1997:** U.S. law provides civil GPS access free of direct user fees
- **2000:** President ends use of *Selective Availability*
- **2004:** President issues U.S. Policy on Space-Based PNT
- **2004:** Agreement signed on GPS-Galileo Cooperation
- **2007:** President announces *Selective Availability* eliminated from future GPS III satellites
- **2010:** New National Space Policy provides high-level PNT guidance





# U.S. Space-Based PNT Organizational Structure





# U.S. Space-Based PNT Policy



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

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**ASSURE SERVICE**

Provide uninterrupted availability of PNT services

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**MEET DEMANDS**

Meet growing national, homeland, economic security, and civil requirements, and scientific and commercial demands

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**LEAD MILITARILY**

Remain the pre-eminent military space-based PNT service

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**STAY COMPETITIVE**

Continue to provide civil services that exceed or are competitive with foreign civil space-based PNT services and augmentation systems

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**INTEGRATE GLOBALLY**

Remain essential components of internationally accepted PNT services

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**LEAD TECHNICALLY**

Promote U.S. technological leadership in applications involving space-based PNT services

# President Obama's Space Policy

## June 2010



- Provide continuous worldwide access for peaceful uses, free of direct user charges
- Encourage compatibility and interoperability with foreign GNSS services
- Operate and maintain constellation to satisfy civil and national security needs
  - *Foreign PNT may be used to strengthen resiliency*
- Invest in domestic capabilities and support international activities to detect, mitigate and increase resiliency to harmful interference

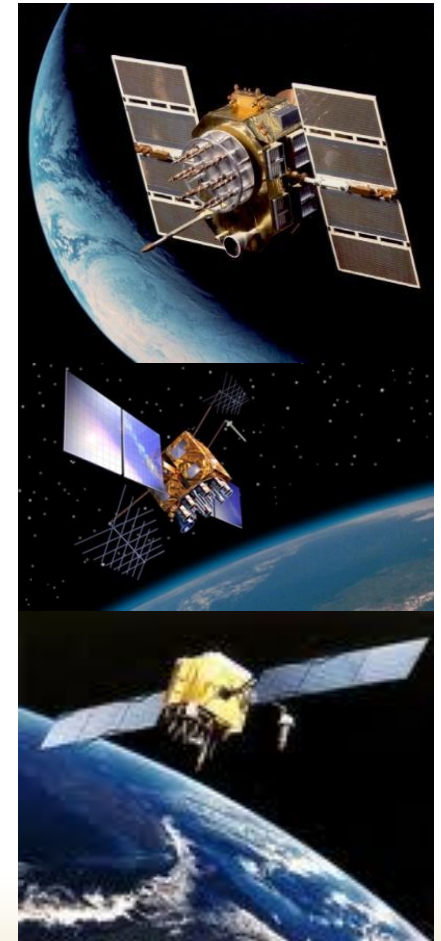


# GPS Constellation Status



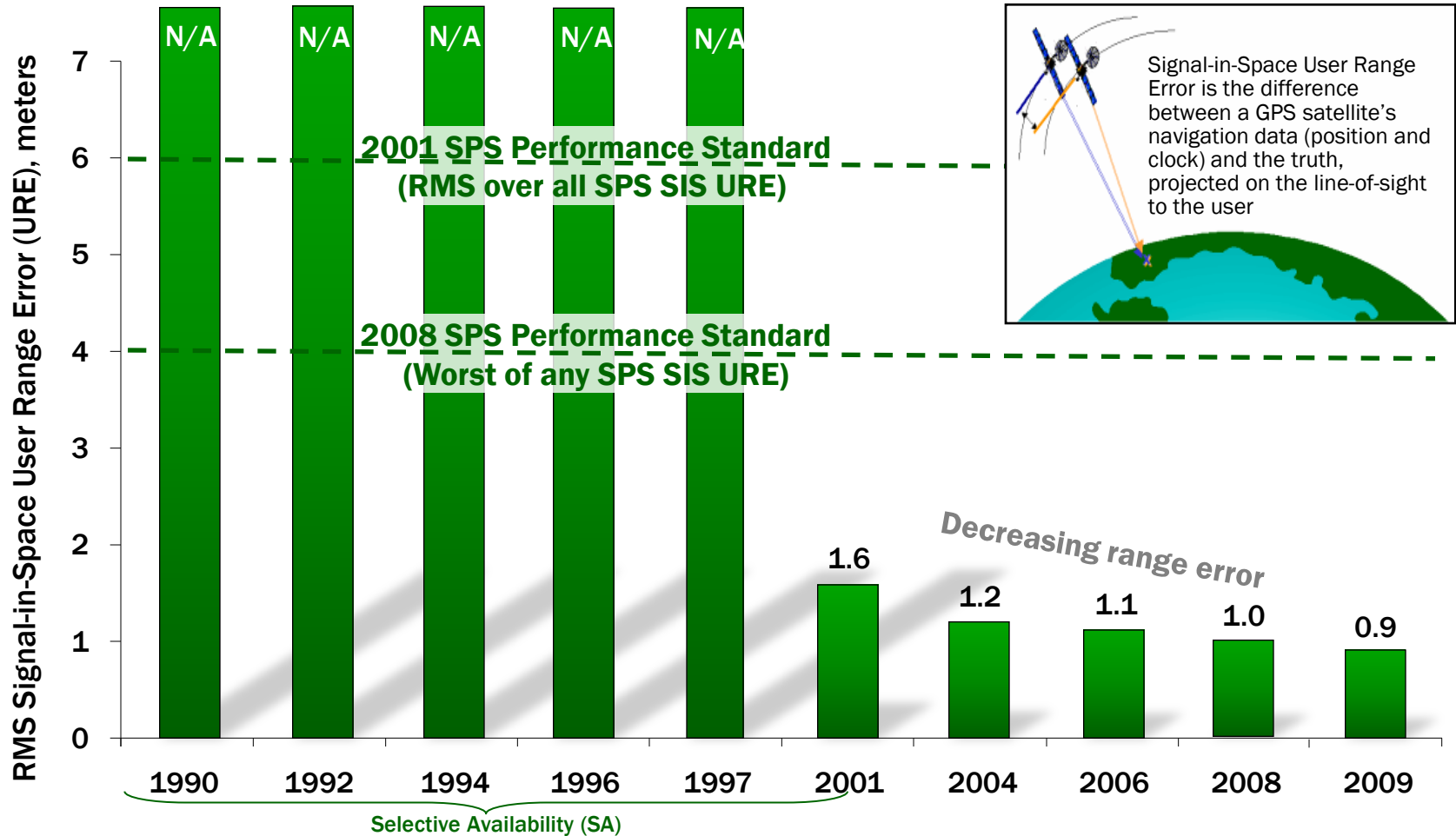
## *Baseline Constellation = “24 Expandable”*

- Very robust constellation; exceeds user requirements
- **31 satellites** currently in operation
  - 11 GPS IIA
  - 12 GPS IIR
  - 7 GPS IIR-M
  - **1 GPS IIF (set “healthy” 26 Aug 2010)**
- 3 additional satellites in residual status
- 1 additional IIR-M in test status
- Global GPS civil service performance commitment met continuously since December 1993





# Current GPS Accuracy

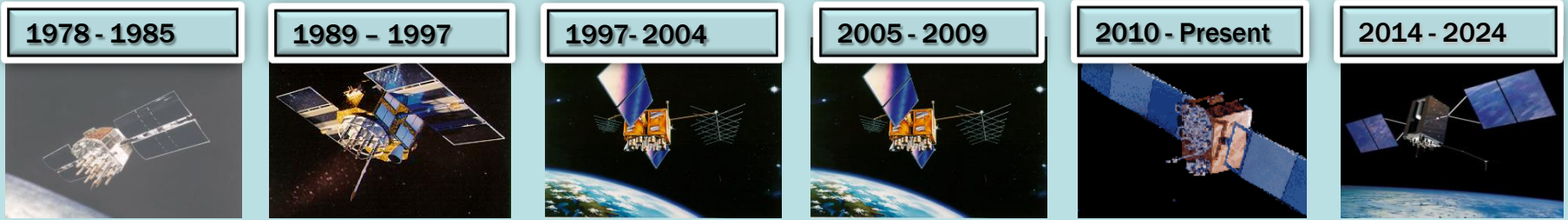


**System accuracy exceeds published standard**





# Modernization Path – GPS Space Segment



## 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

- Std Service
  - Single Frequency (L1)
  - C/A code navigation
  - Precise Service
  - Two frequencies (L1 & L2)
  - P (Y) -Code navigation
  - 7.5 Year Design Life

- 2<sup>nd</sup> Civil Signal L2 (L2C)
- Earth Coverage M-Code on L1/L2
- L5 Demo
- Anti-Jam Flex Power
- 7.5 Year Design Life

- 3<sup>rd</sup> Civil Signal L5
- Reprogrammable Nav Processor
- Increased Accuracy requirement
- 12 Year Design Life

- IIIA
  - Increased accuracy
  - Increased Earth Coverage power
  - 15 Year Design Life
  - 4<sup>th</sup> Civil Signal (L1C)
- IIIB
  - Real-time Communications
- IIIC
  - Navigation Integrity
  - Spot Beam for AJ

**Increasing Space System Capabilities – Increasing Civil User Benefits**

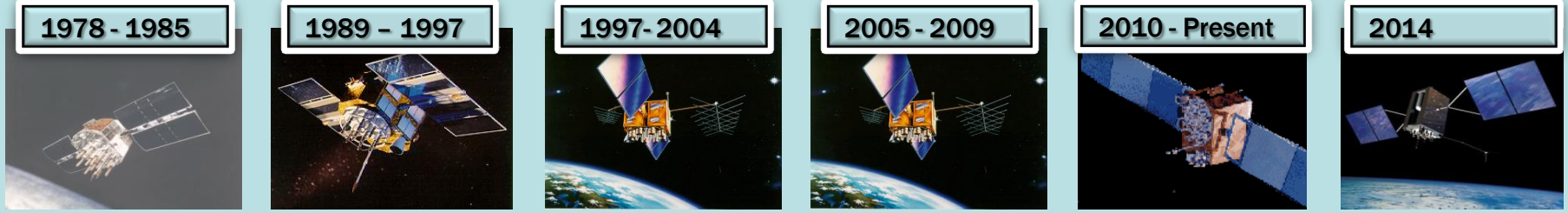


# GPS Operational Control Segment (OCS)





# Modernization Path - GPS Control Segment



**Block I**

**Block II/IIA**

**Block IIR**

**Block IIR-M**

**Block IIF**

**Block III**

## Legacy Control System

- Master Control System (MCS)
- Tracking, Telemetry & Control (TT&C)
- L1 & L2 Monitoring
- Satellite health and welfare monitoring
- GPS signal performance monitoring ( P(Y) code only)
- Satellite navigation payload analysis

## Architecture Evolution Plan (AEP)

- Distributed System
  - Launch, Anomaly, Disposal Ops (LADO)
- Increased capacity for signal monitoring
  - IIR, IIR (M), IIF
- Increased worldwide commanding capability
  - New MCS/AMCS
  - Flex Power

## OCX

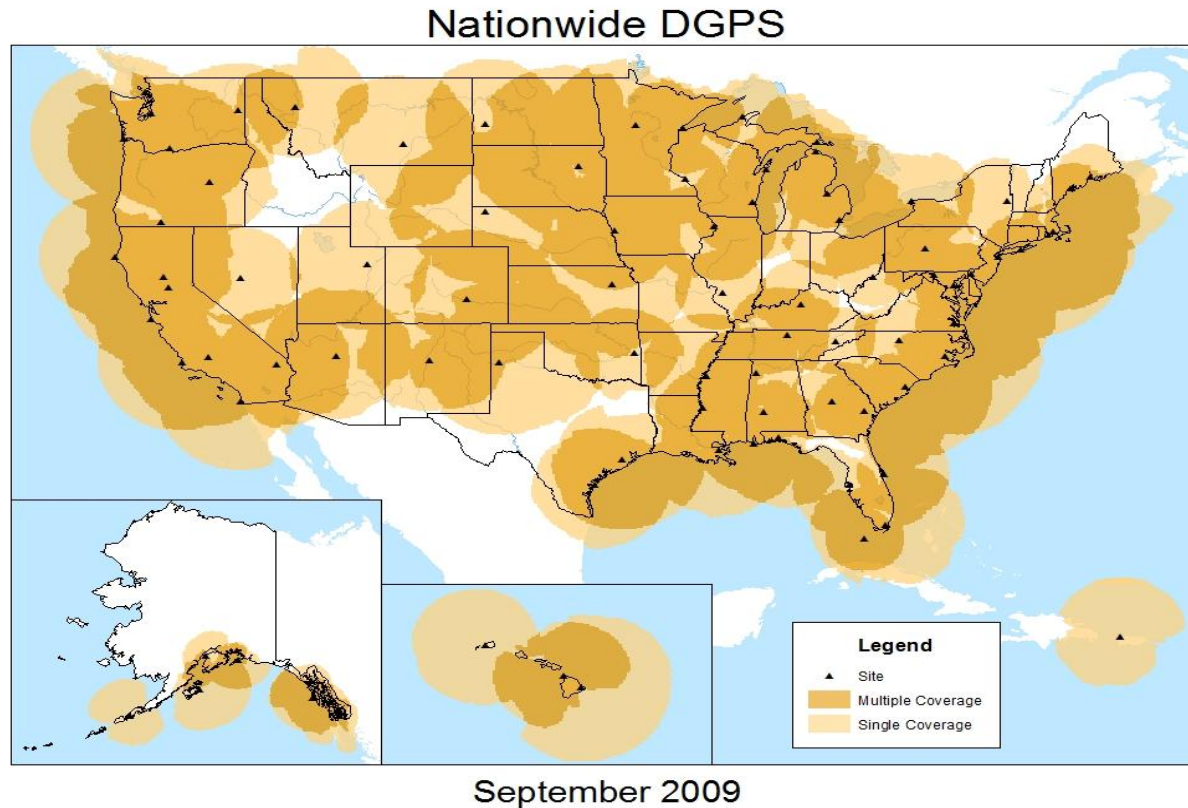
- Net Centricity
- Control for GPS III
- Monitors all GPS signals
  - Legacy plus L1C, L2C and L5
  - Flex Power
  - Real-Time C2



**Increasing Control Segment Capabilities - Increasing Civil User Benefits**



# Nationwide Differential GPS



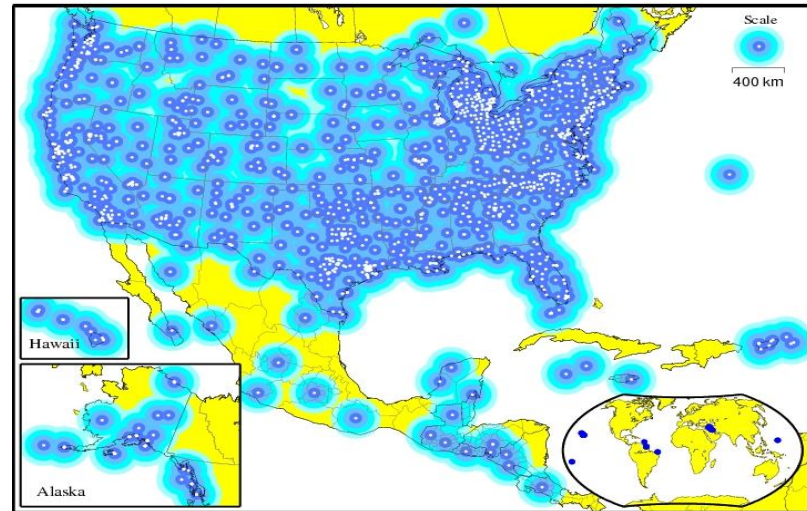
- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries



# National Continuously Operating Reference Stations (CORS)



- Enables highly accurate, 3-D positioning
  - Centimeter-level accuracy
  - Tied to National Spatial Reference System
- 1,300+ sites operated by 200+ public, private, academic organizations



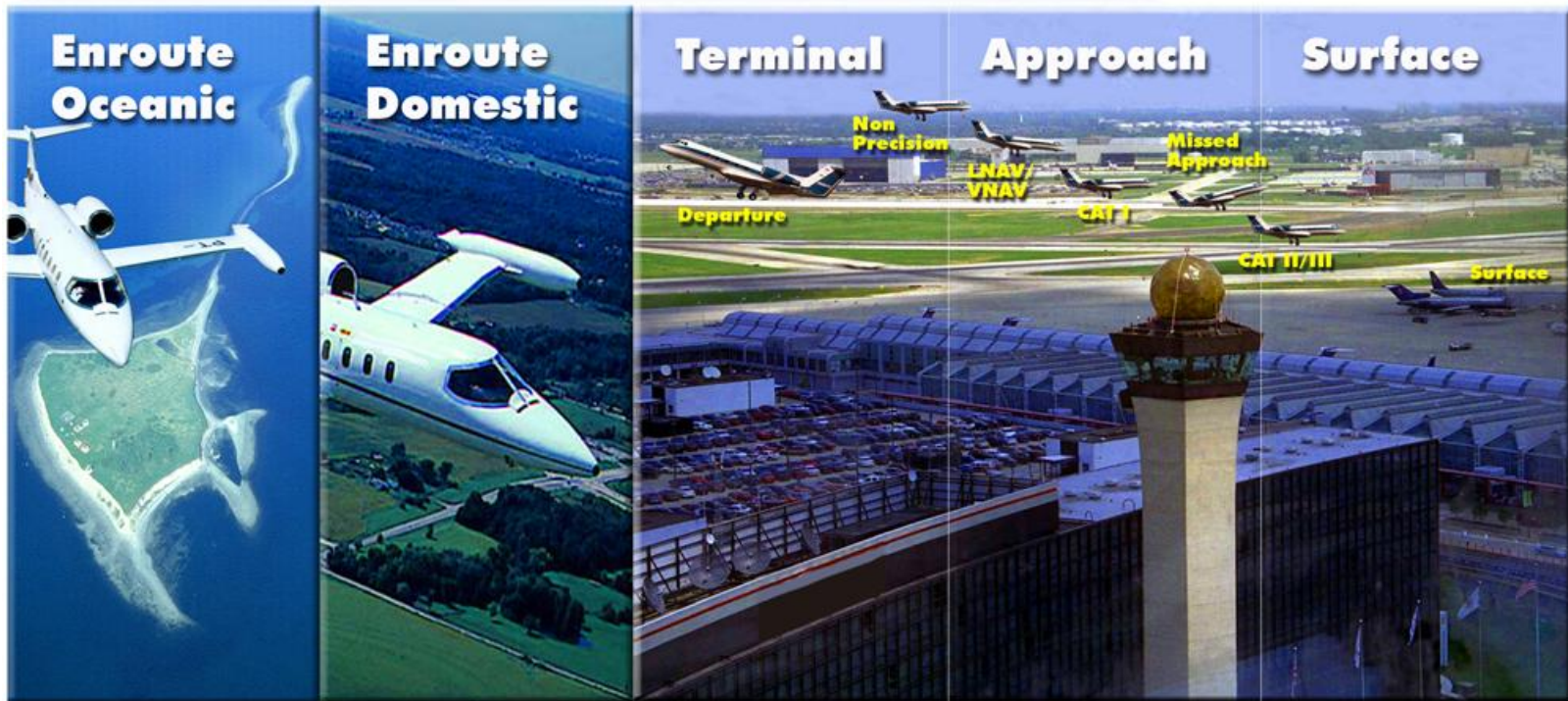
- NOAA's Online Positioning User Service (OPUS) automatically processes coordinates submitted via the web from around the world
- OPUS-RS (Rapid Static) declared operational in 2007
- NOAA considering support for real-time networks



# U.S. GPS Augmentation Programs Designed for Aviation



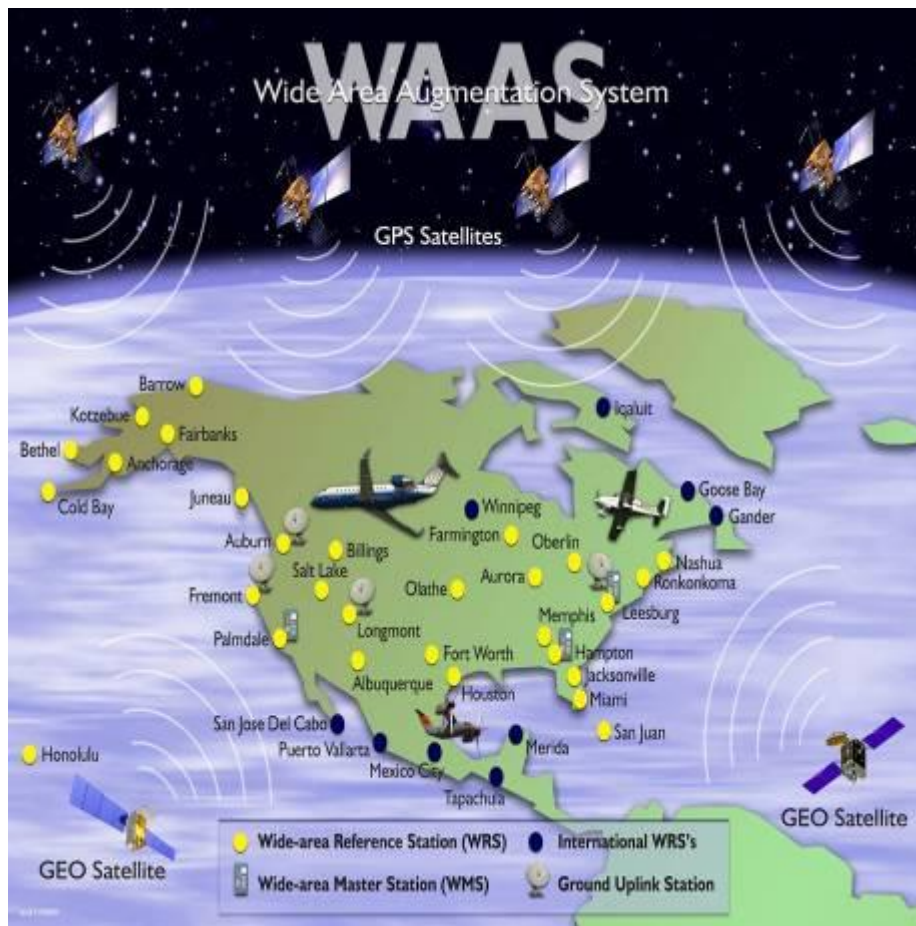
## WAAS



## GBAS



# Wide Area Augmentation System (WAAS) Architecture



**38 Reference Stations**



**3 Master Stations**



**6 Ground Earth Stations**



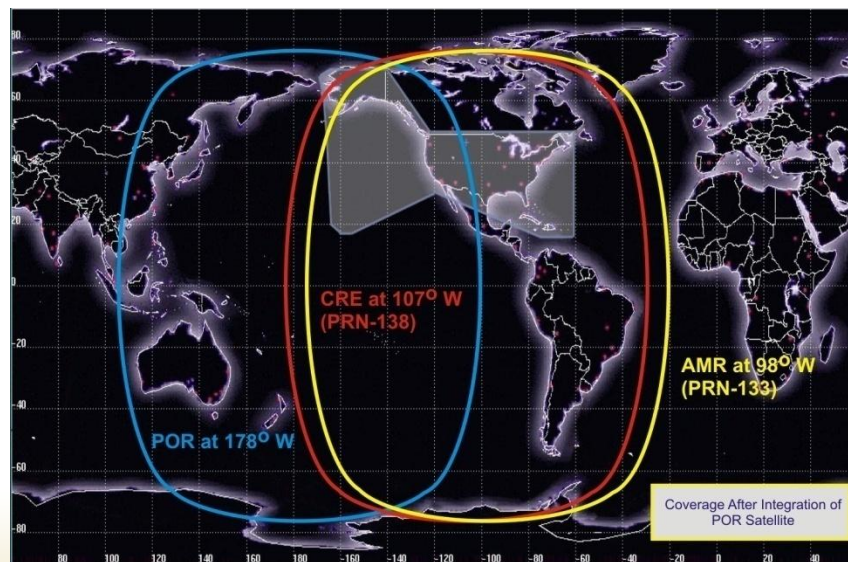
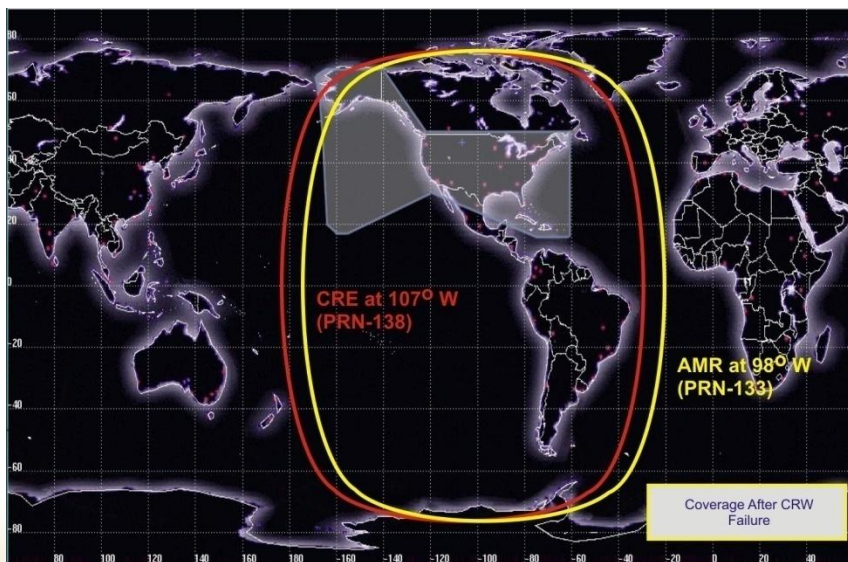
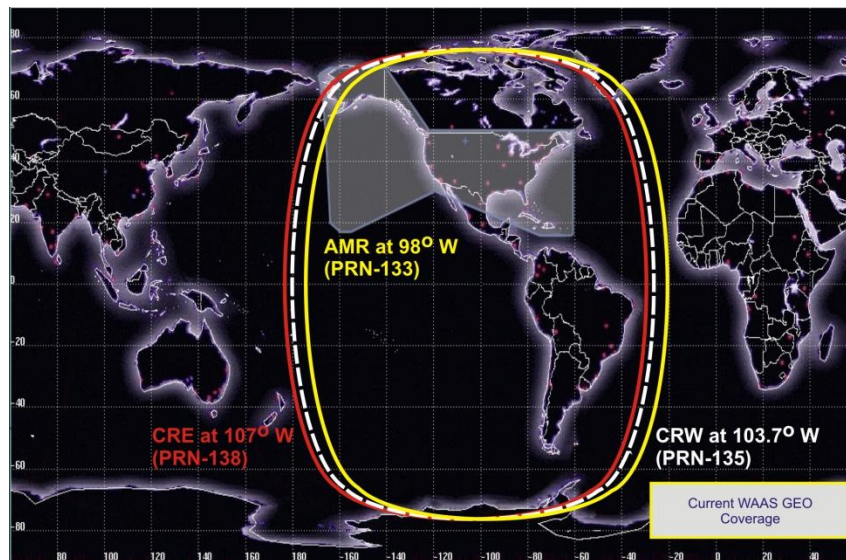
**3 Geostationary Satellite Links**



**2 Operational Control Centers**



# WAAS Geo Satellites







# GPS/WAAS Performance



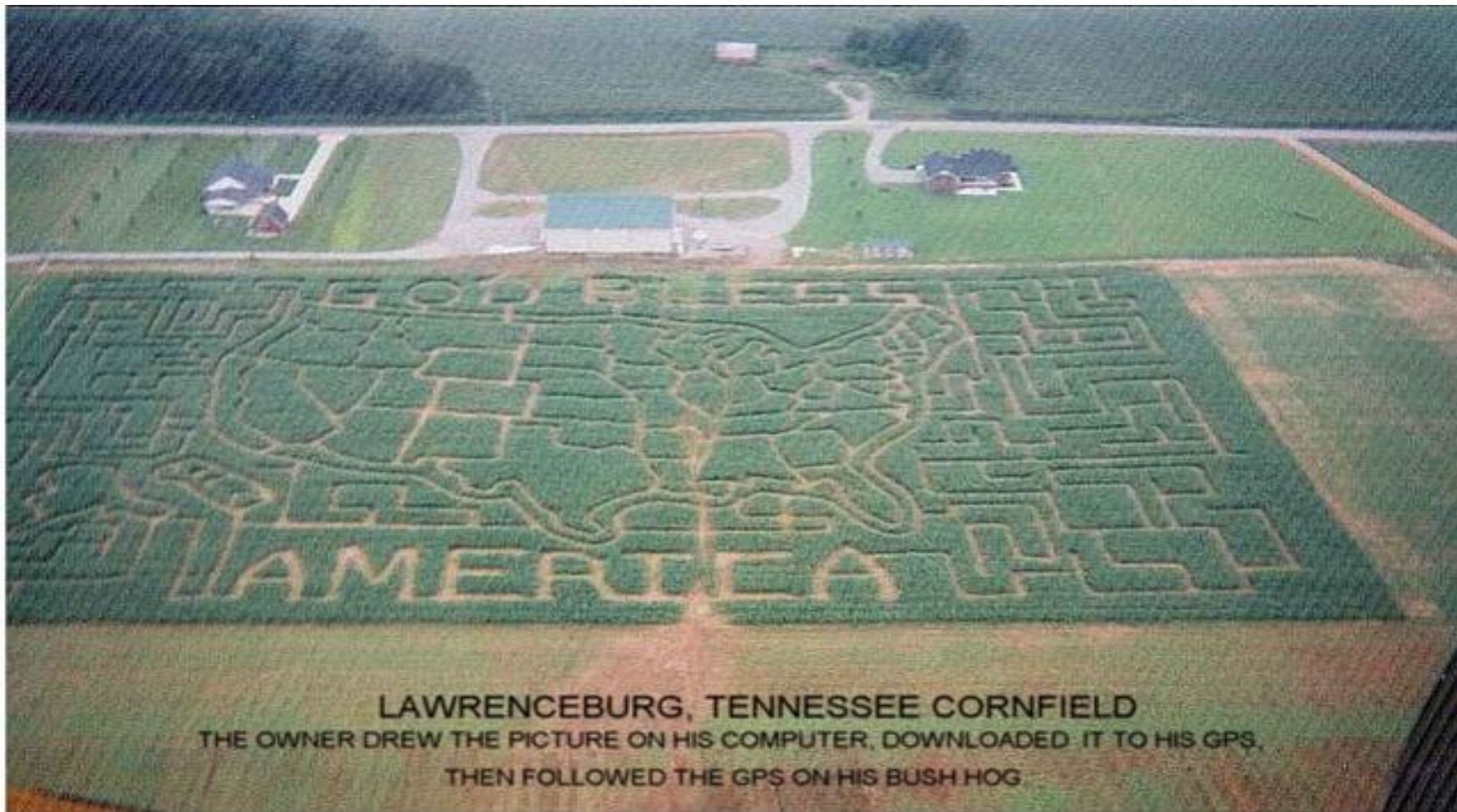
	<b>GPS Standard</b>	<b>GPS Actual</b>	<b>WAAS LPV-200 Standard</b>	<b>WAAS Actual</b>
<b>Horizontal 95%</b>	<b>36 m</b>	<b>2.74 m</b>	<b>16 m</b>	<b>1.08 m</b>
<b>Vertical 95%</b>	<b>77 m</b>	<b>*3.89 m</b>	<b>4 m</b>	<b>1.26 m</b>

*\* Use of GPS vertical not authorized for aviation without augmentation (SBAS or GBAS)*

*WAAS Performance evaluated based on a total of 1,761 million samples (or 20,389 user days)*



# Precision Agriculture



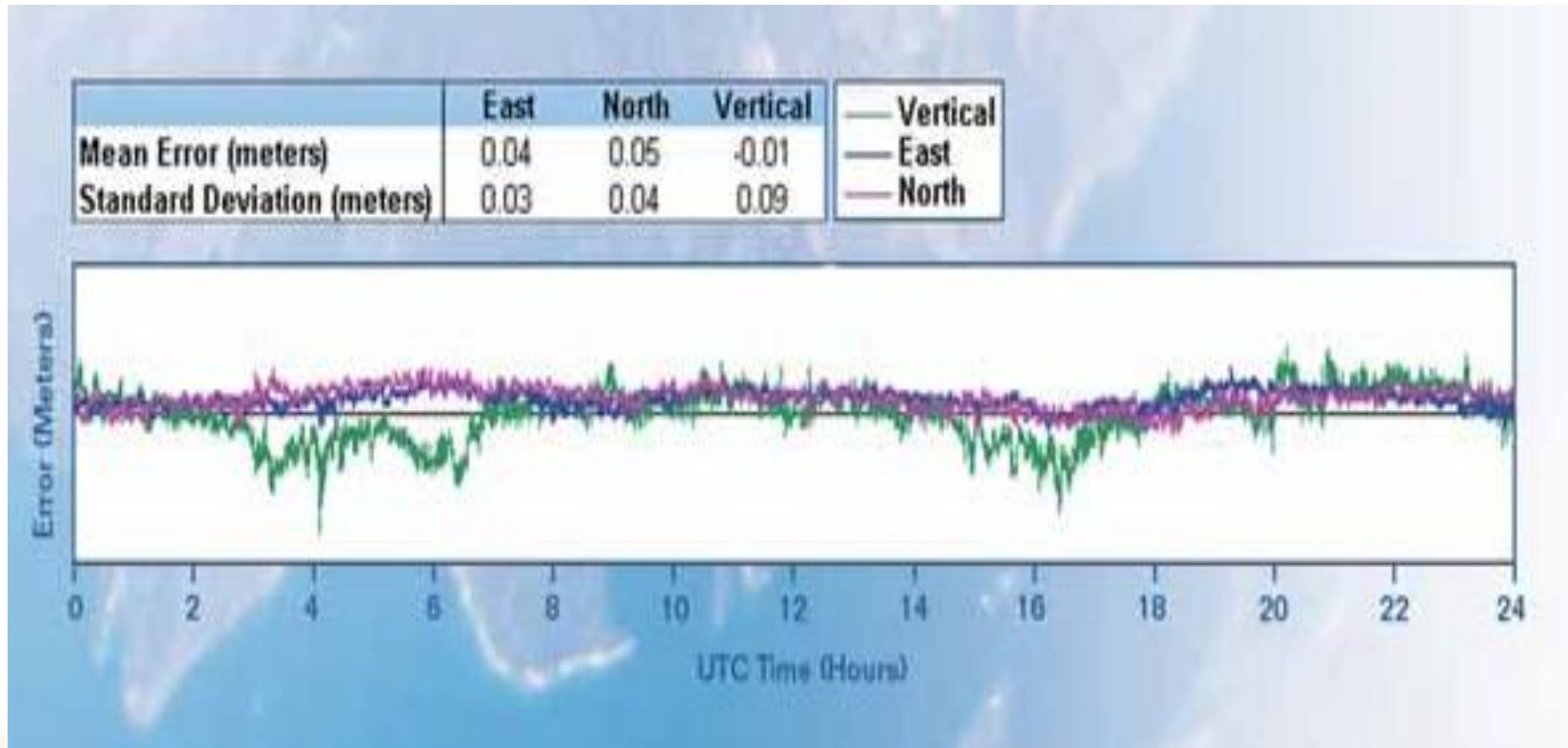


# Achieving Precision Accuracy



## NavCom / Starfire Receiver

- 20 cm horizontal accuracy
- 30 cm vertical accuracy (2 sigma - 95%)





# The World of Space-Based Positioning, Navigation and Timing



## Global Constellations

- GPS (US)
- GLONASS (Russia)
- Galileo (EU)\*
- Compass (China)\*

## Regional Constellations

- QZSS (Japan)
- IRNSS (India)\*

## GPS Service Monitoring

- CORS
- IGS
- Civil Signal Monitoring \*

## Space-Based Augmentations

- WAAS (US)
- EGNOS (EU)
- MSAS (Japan)\*
- GAGAN (India)\*

## Terrestrial Augmentations

- GBAS
- NDGPS
- GDGPS

## National Backup Systems

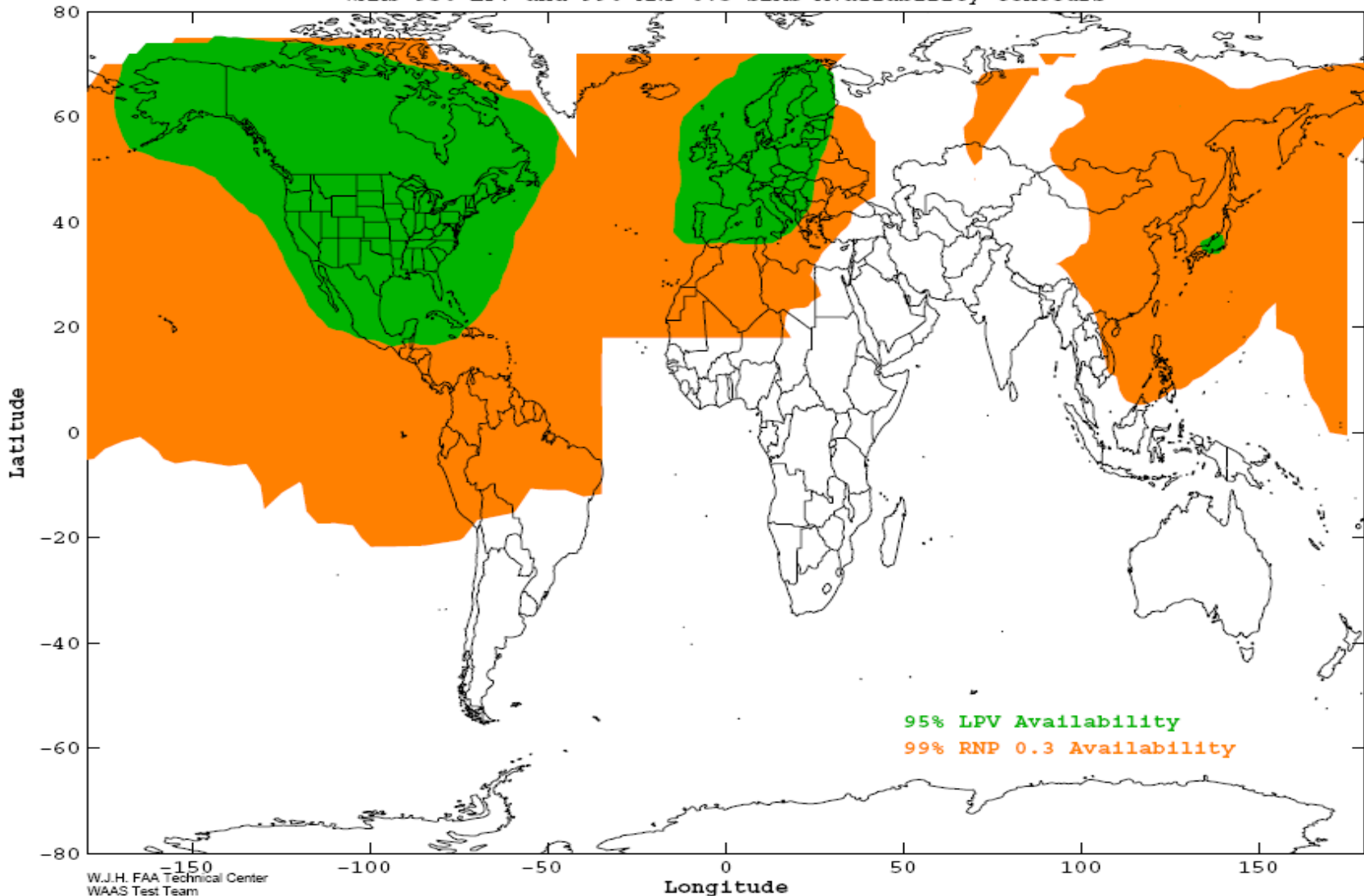
**Future\***



# Global SBAS Coverage



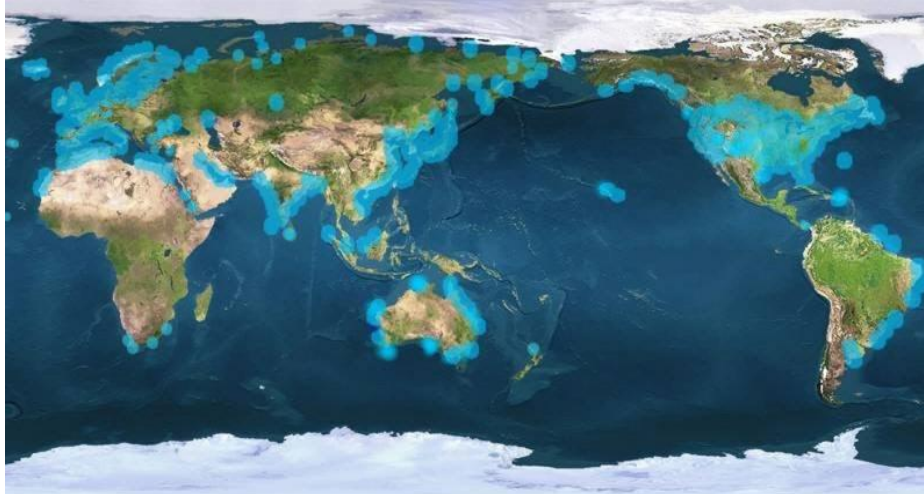
WAAS 95% LPV and 99% RNP 0.3 SBAS Availability Contours



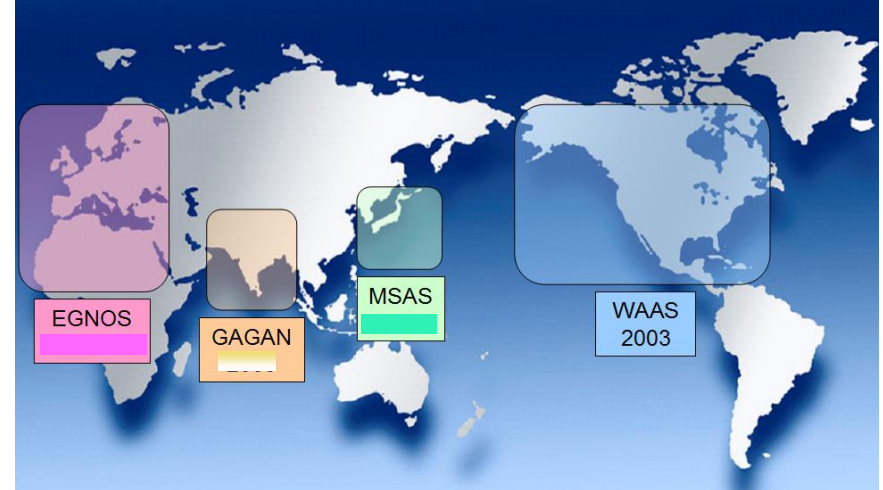
W.J.H. FAA Technical Center  
WAAS Test Team



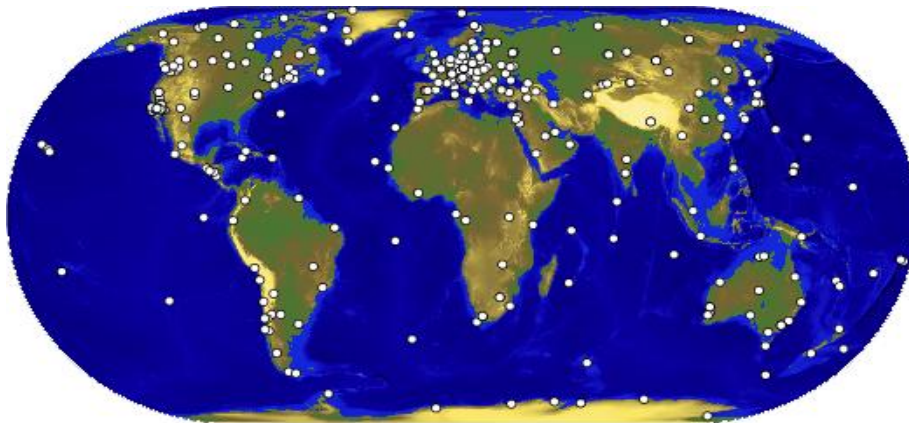
# International Augmentations



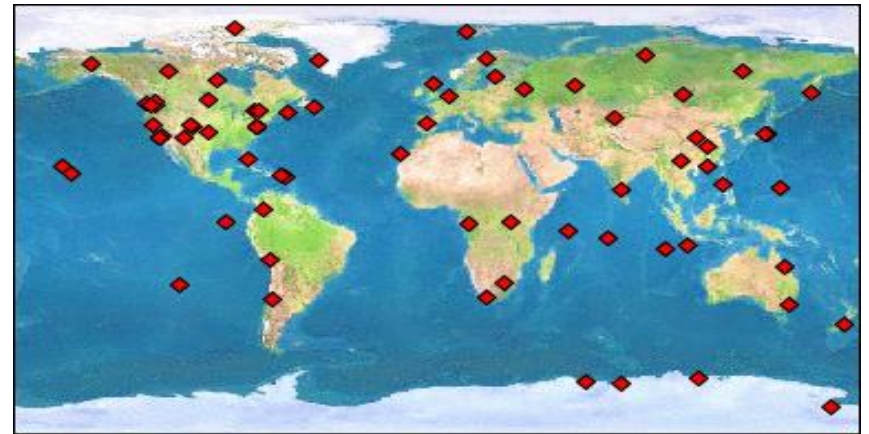
**Differential GPS Networks**



**Satellite-Based Augmentation Systems**



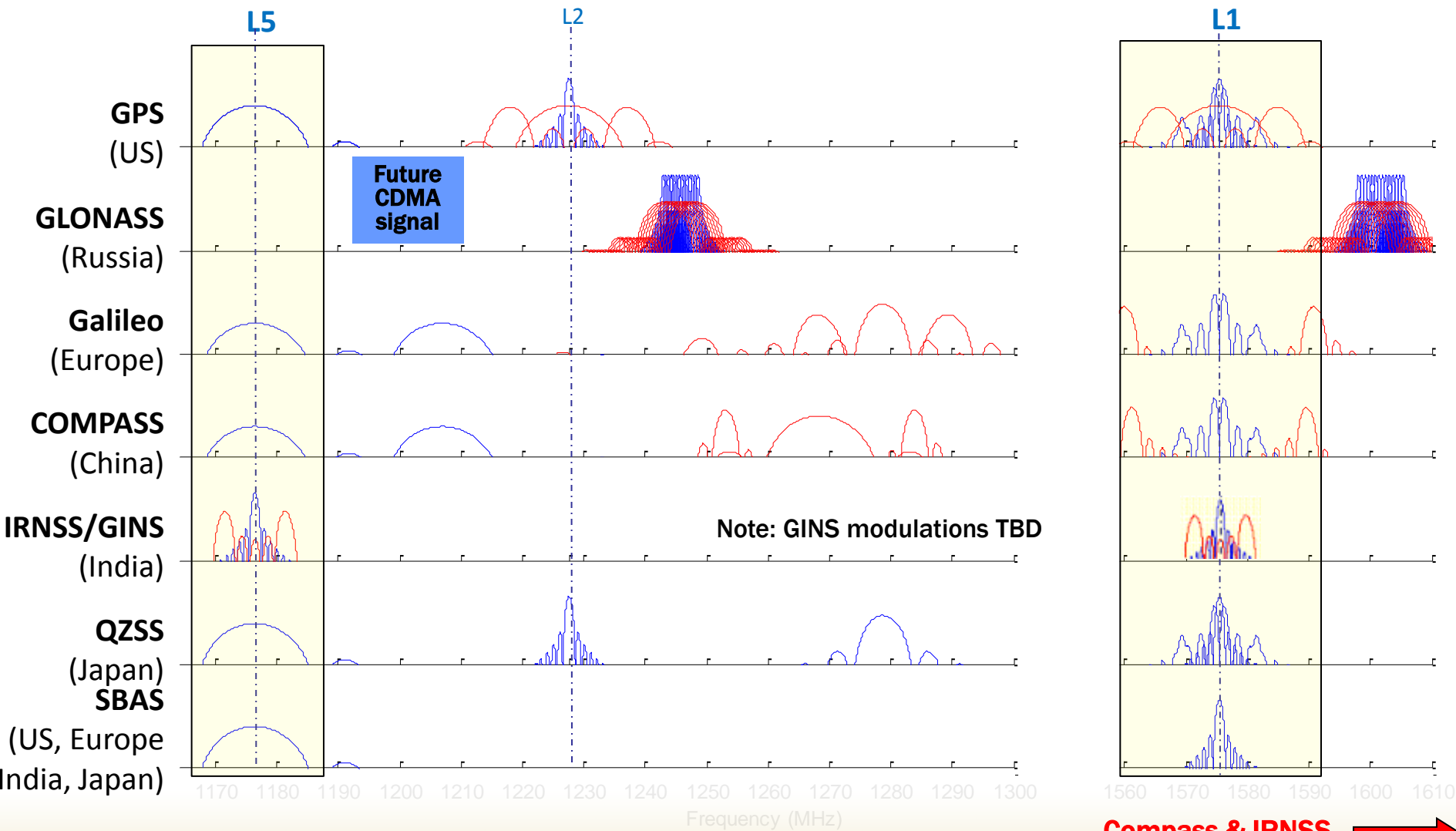
**International GNSS Service**



**Global Differential GPS System**



# Current International Signal Plans



**Compass & IRNSS  
In S-band** 



# 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**
  - Permits U.S use of foreign PNT to increase resiliency
- **International cooperation is a priority**
  - Compatibility and interoperability are critical





# For Additional Information...



Global Positioning System - Windows Internet Explorer

http://www.gps.gov/spanish.html

English | Español | Français | 普通话 | العربية

## SISTEMA DE POSICIONAMIENTO GLOBAL

### Al Servicio del Mundo

**E**l Sistema de Posicionamiento Global (SPG) es un sistema de radionavegación de los Estados Unidos de América, basado en el espacio, que proporciona servicios fiables de posicionamiento, navegación, y cronometría gratuita e ininterrumpidamente a usuarios civiles en todo el mundo. A todo el que cuente con un receptor del SPG, el sistema le proporcionará su localización y la hora exacta en cualesquiera condiciones atmosféricas, de día o de noche, en cualquier lugar del mundo y sin límite al número de usuarios simultáneos.

El SPG se compone de tres elementos: los satélites en órbita alrededor de la Tierra, las estaciones terrestres de seguimiento y control, y los receptores del SPG propiedad de los usuarios. Desde el espacio, los satélites del SPG transmiten señales que reciben e identifican los receptores del SPG; ellos, a su vez, proporcionan por separado sus coordenadas tridimensionales de latitud, longitud y altitud, así como la hora local precisa.

Hoy están al alcance de todos en el mercado los pequeños receptores del SPG portátiles. Con esos receptores, el usuario puede determinar con exactitud su ubicación y desplazarse fácilmente al lugar a donde desea trasladarse, ya sea andando, conduciendo, volando o navegando. El SPG es

**INFORMACIÓN SOBRE EL SISTEMA**

- El Sistema de Posicionamiento Global
- Ampliaciones al SPG

**APLICACIONES**

- Cronometría
- Carreteras y Autopistas
- Espacio
- Aviación
- Agricultura
- Navegación Marítima
- Vías Férreas

[GPS.gov](http://GPS.gov)

National Executive Committee for Space-Based Positioning, Navigation, and Timing - Windows Internet Explorer

http://mendiculus.nos.noaa.gov/

## SPACE-BASED POSITIONING NAVIGATION & TIMING

NATIONAL EXECUTIVE COMMITTEE

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U.S. Policy

Charter

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USA.gov

The National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) is a U.S. Government organization established by **Presidential directive** to advise and coordinate federal departments and agencies on matters concerning the Global Positioning System (GPS) and related systems.

The National Executive Committee is chaired jointly by the Deputy Secretaries of Defense and Transportation. Its membership includes equivalent-level officials from the Departments of State, the Interior, Agriculture, Commerce, and Homeland Security, as well as the Joint Chiefs of Staff and NASA. Components of the Executive Office of the President participate as observers to the National Executive Committee, and the FCC Chairman participates as a liaison.

A National Coordination Office located in Washington, D.C., provides day-to-day staff support to the National Executive Committee. It consists of an interagency staff headed by Director Michael Shaw. The National Coordination Office is a point of contact for inquiries regarding PNT policy.

An Advisory Board provides independent advice to the National Executive Committee through its sponsor agency, NASA.

Several working groups support the National Executive Committee through staff-level, interagency

Get GPS status info and other user support at the **Navigation Center**

Learn more about the uses of space-based PNT at [www.GPS.gov](http://www.GPS.gov)

**National Executive Committee featured in Inside GNSS**

### What's New at PNT.gov

Presentations from APG Meetings

- Presentation from GPS Partnership Council
- Request for Public Comments on Semi-Codesless GPS
- Presentations from ENC-GNSS 2008
- Presentations from CGSIC Toulouse

More Releases...

[PNT.gov](http://PNT.gov)



# Contact Information



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