GPS and Worldwide GNSS Interoperability

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Overview

- **U.S. Space-Based PNT Policy**
- GPS & U.S. 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. 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

30 Operational Satellites
(Baseline Constellation: 24)

- 11 Block IIA
- 12 Block IIR
- 8 Block IIR-M (7 operational)
  - Transmitting new second civil signal
  - 1 GPS IIR-M in on-orbit testing
- First Block IIF-1 launched 27 May 2010
  - 12 Block IIF satellites are planned
- GPS continues to meet/exceed civil service performance commitments

GPS Block IIF Status

Key Milestones Current Forecast

- 1st IIF launch 27 May 2010

Program Description

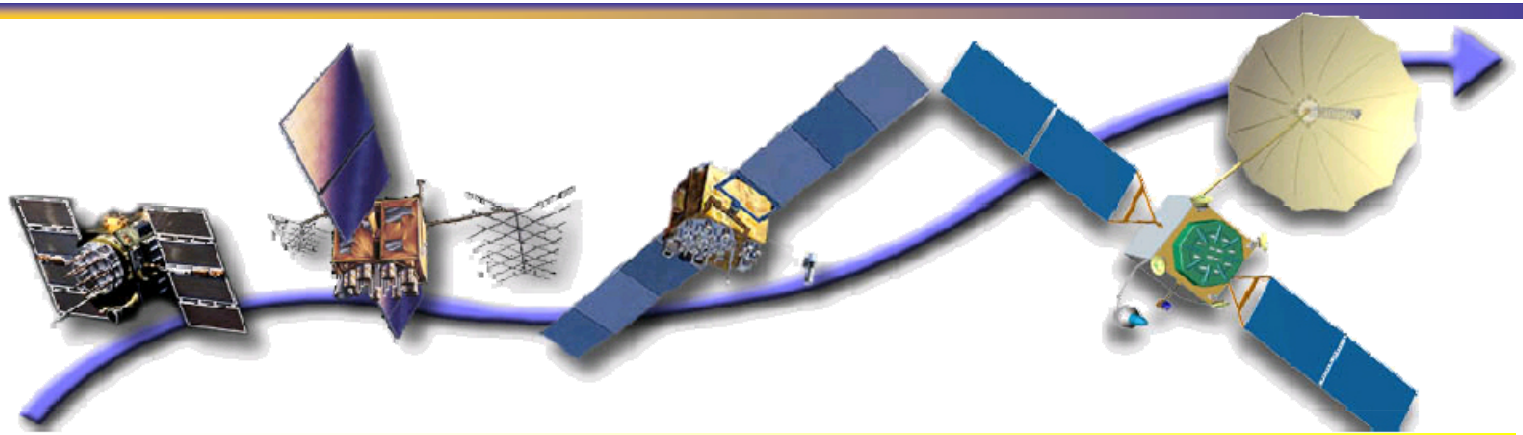
- 2 Rubidium + 1 Cesium clock
- 12 year design life
- Launch options: Atlas V or Delta IV
- Satellite launch weight < 3720 lb
- SPS signals: L1C/A, L2C, L5
- PPS signals: L1-L2P(Y), L1-L2M

Program Status

- SV1 launch successful
- SV2 launched schedule Winter 2010

SV1 launch
Atlas V

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

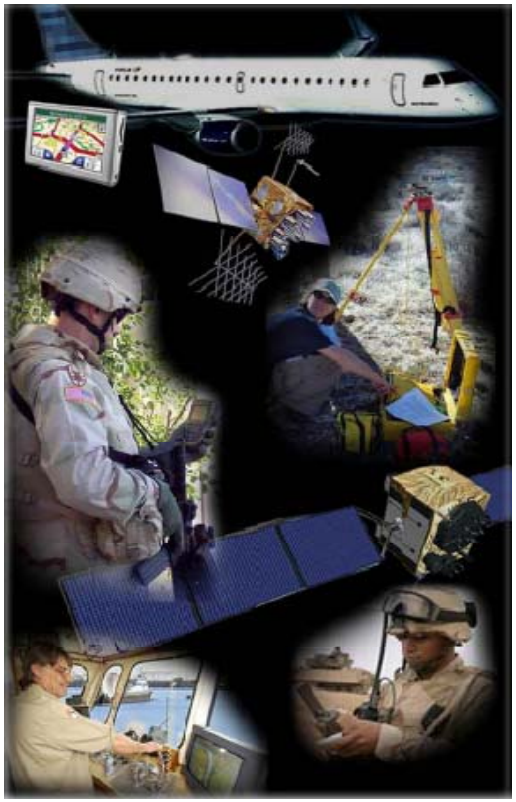
- **3rd civil signal (L5)**
- Anti-jam flex power

Block III

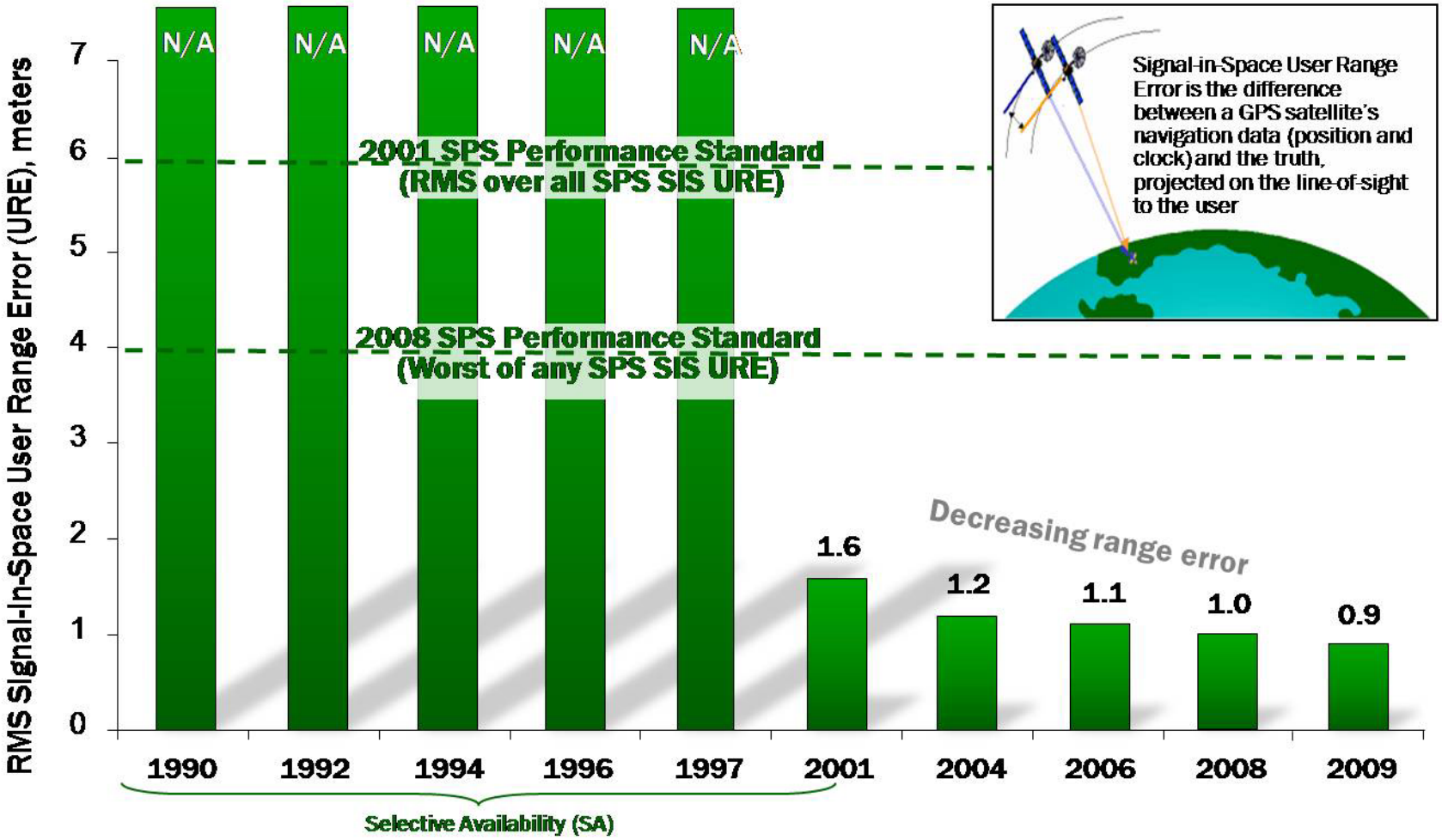
- Backward compatibility
- **4th civil signal (L1C)**
- Increased accuracy
- Increased integrity

Civil Capability Improvements

- L2C
  - 24 operational satellites in 2016
  - Designed to meet commercial needs
  - Available since 2005
- L5
  - Designed to meet demanding requirements for transport safety
  - Uses highly protected Aeronautical Radionavigation Service (ARNS) band
  - 24 operational satellites in 2018
- L1C
  - 24 operational satellites in 2021
  - Modernized civil signal at L1 frequency
    - More robust navigation across a broad range of user applications
    - Original signal retained for backward compatibility
- Integrity Monitoring
  - GPS III integrity enhanced by SV reliability and on-board clock monitoring



SPS Signal in Space Performance



System accuracy exceeds published standard

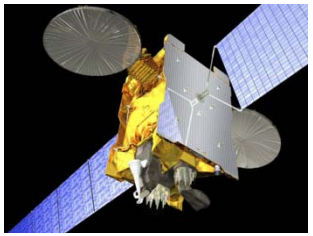
FAA GPS Augmentation Programs

Wide Area Augmentation System (WAAS) Architecture

38 Reference Stations

3 Master Stations

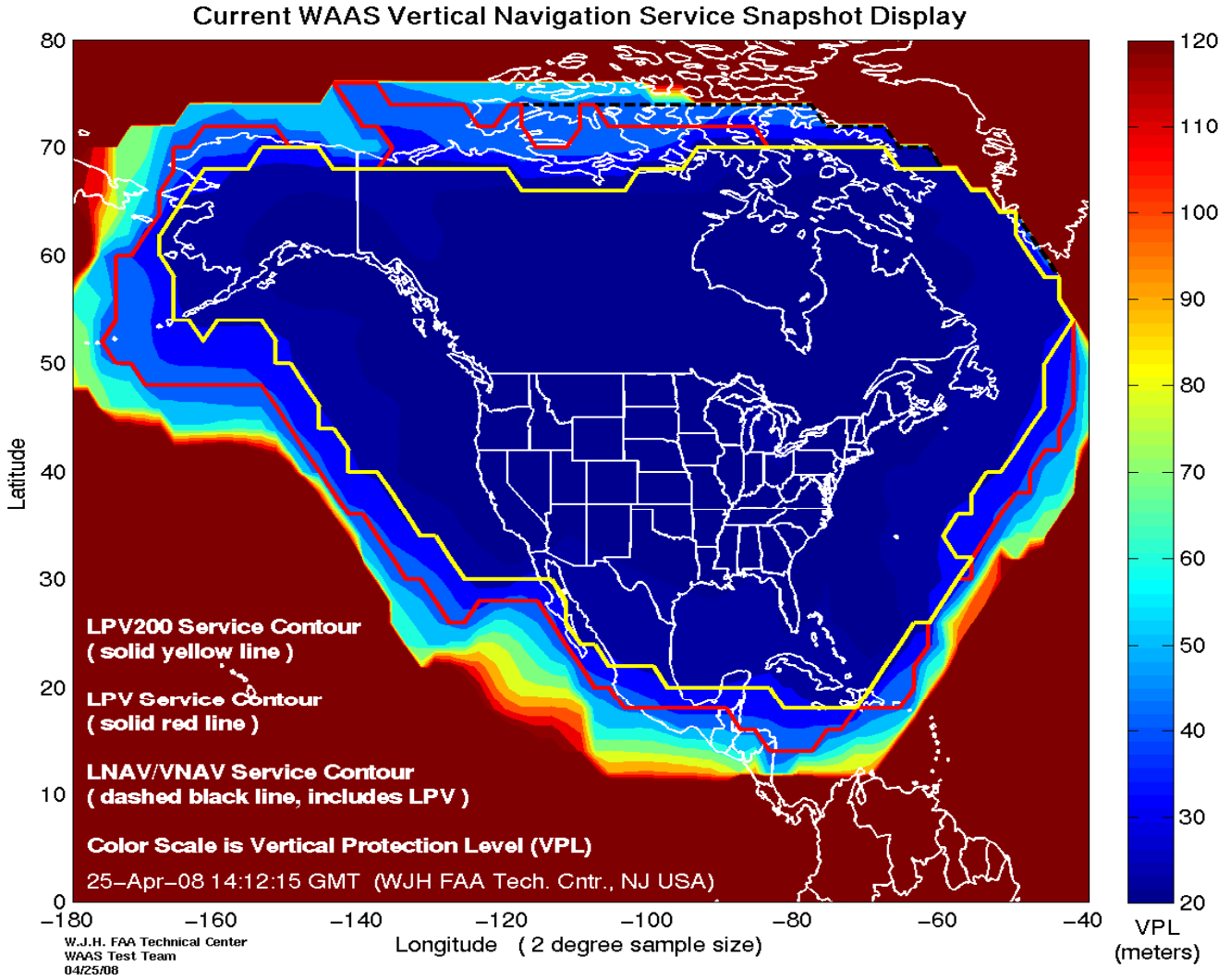
4 Ground Earth Stations



Geostationary Satellite Links

2 Operational Control Centers

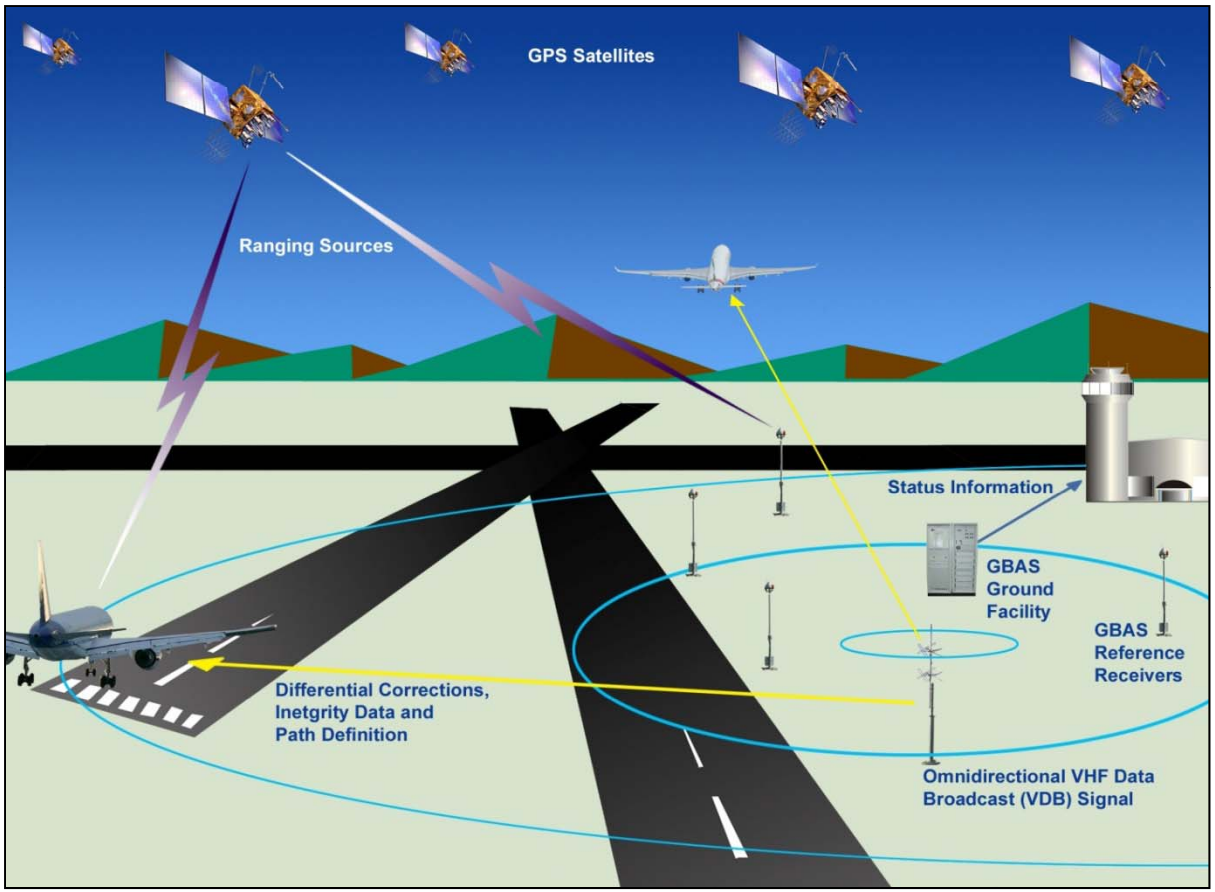
WAAS LPV Coverage



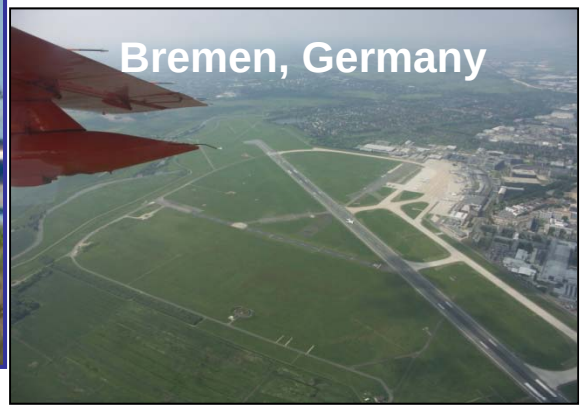
Note: Display does not account for Intelsat Galaxy 15 satellite anomaly

Local Area Augmentation System (LAAS)

- 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



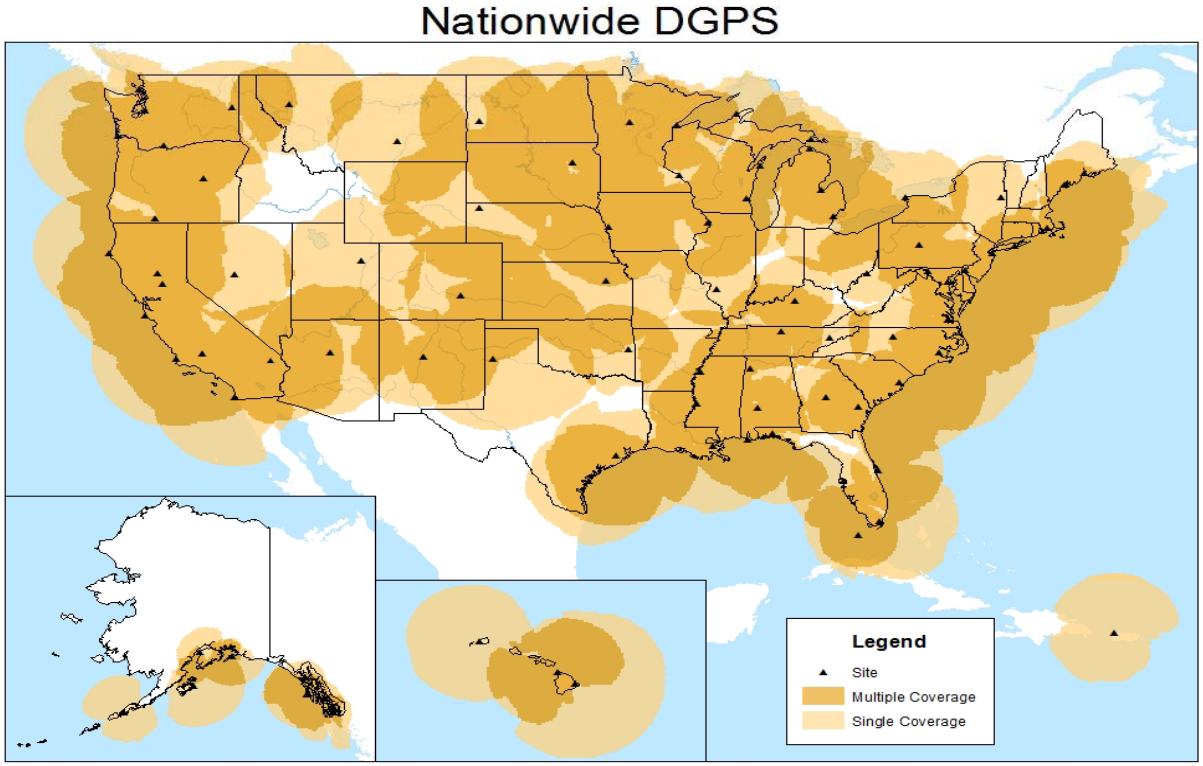
LAAS/GBAS International Efforts



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



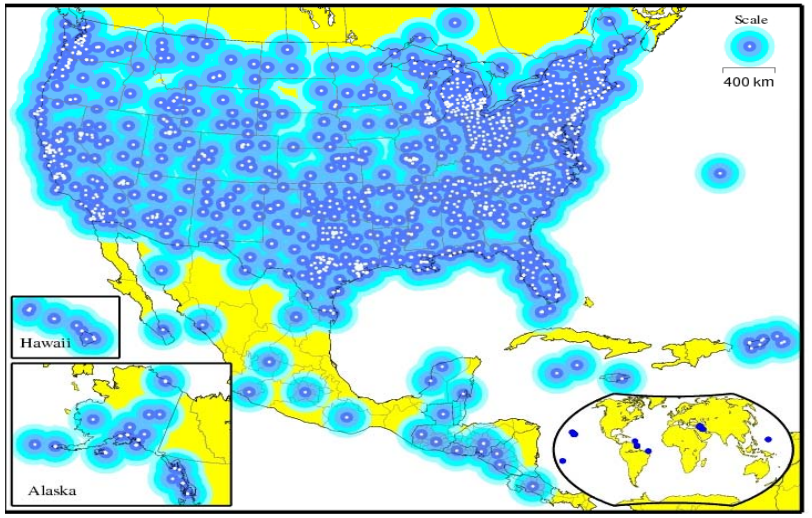
- Expansion of maritime differential GPS (DGPS) network to cover terrestrial United States
- Built to international standard adopted in 50+ countries

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 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

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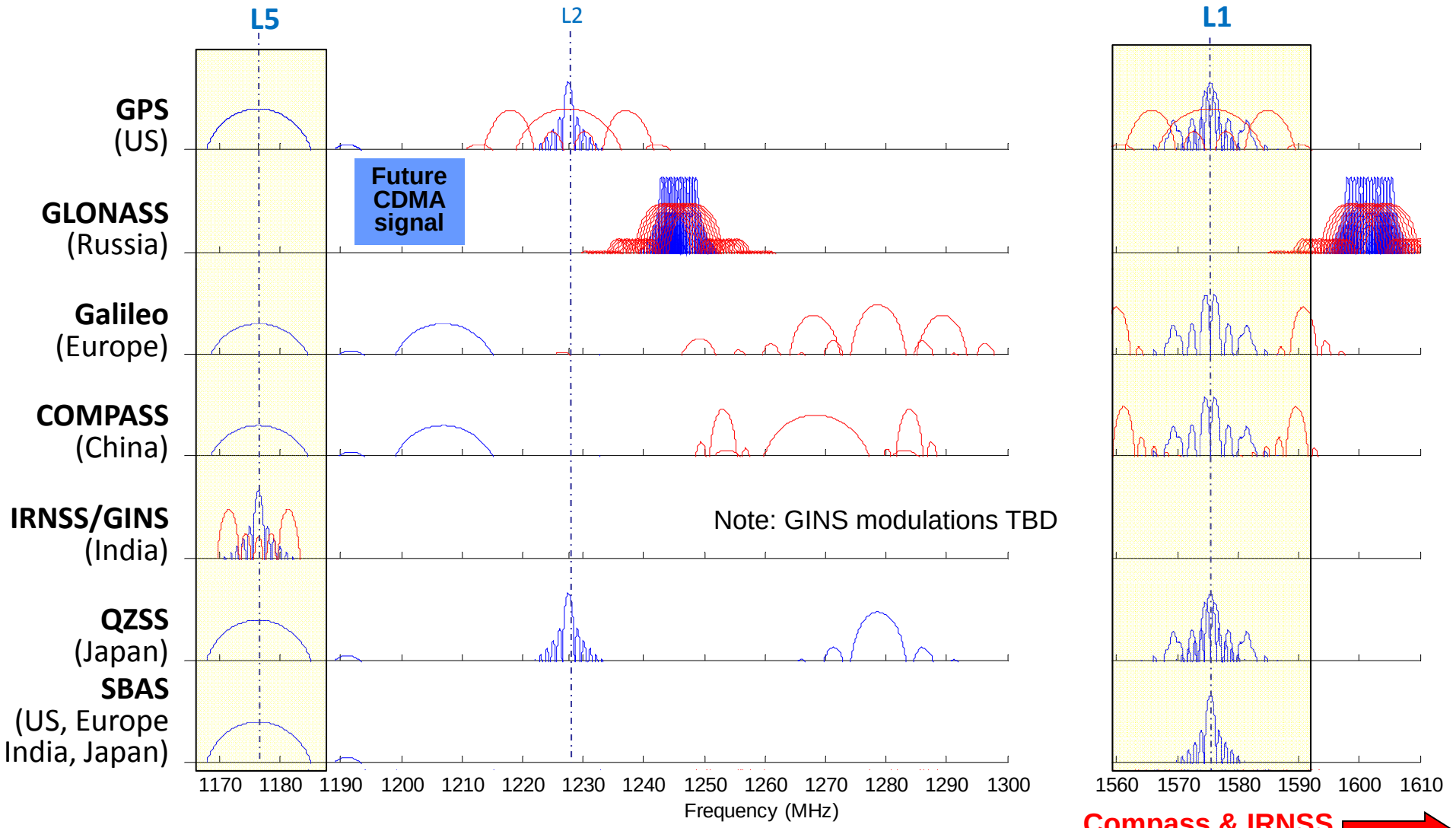
Planned GNSS

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

Current International Signal Plans



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

U.S. - Europe Cooperation

- 2004 U.S.-EU agreement provides foundation for cooperation
- Four working groups were set up under the agreement:
  - Technical, trade, next generation systems and security working groups
- Improved new civil signal (MBOC) adopted in July 2007
- Technical working group meetings, May 2010 in Brussels

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)

Additional Bilateral Cooperation

- U.S.-Japan Joint Statement on GPS Cooperation in 1998
  - Japan's 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. **Guam station completed!**
- U.S.-Russia Joint Statement issued in Dec. 2004
  - Negotiations for a U.S.-Russia Agreement on satellite navigation cooperation underway since late 2005
  - Working Groups on compatibility/interoperability, search and rescue
- U.S.-India Joint Statement on GNSS Coop. in 2007
  - Technical Meetings focused on GPS-India Regional Navigation Satellite System (IRNSS) compatibility and interoperability held in 2008 and 2009

International Committee on Global Navigation Satellite Systems (ICG)

- U.S. strongly supports ICG activities
  - U.S. hosted ICG-3 at Pasadena, California in 2008
  - U.S. contributes to UNOOSA to support ICG meetings and activities
- U.S. pleased with progress made at ICG-4 at St. Petersburg, Russia
  - Adoption of new principle on transparency for open services: **Every provider should publish documentation that describes signal and system information, policies of provision and minimum levels of performance for its open services**
- ICG-5 to be held in October 2010 in Turin, Italy

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

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