

U.S. Space-Based Positioning, Navigation and Timing Policy and Program Update

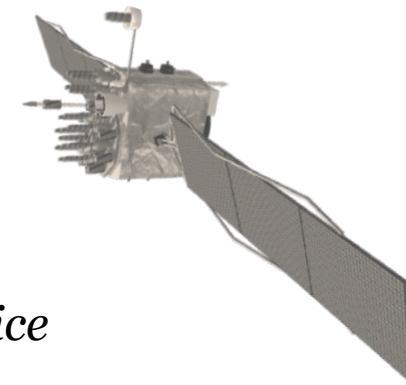
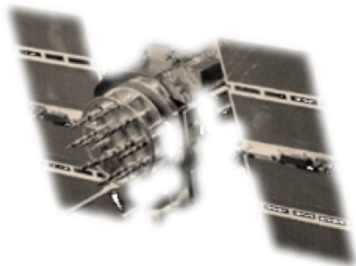
*9th Meeting of the International
Committee on GNSS*

Prague, Czech Republic

10 November 2014

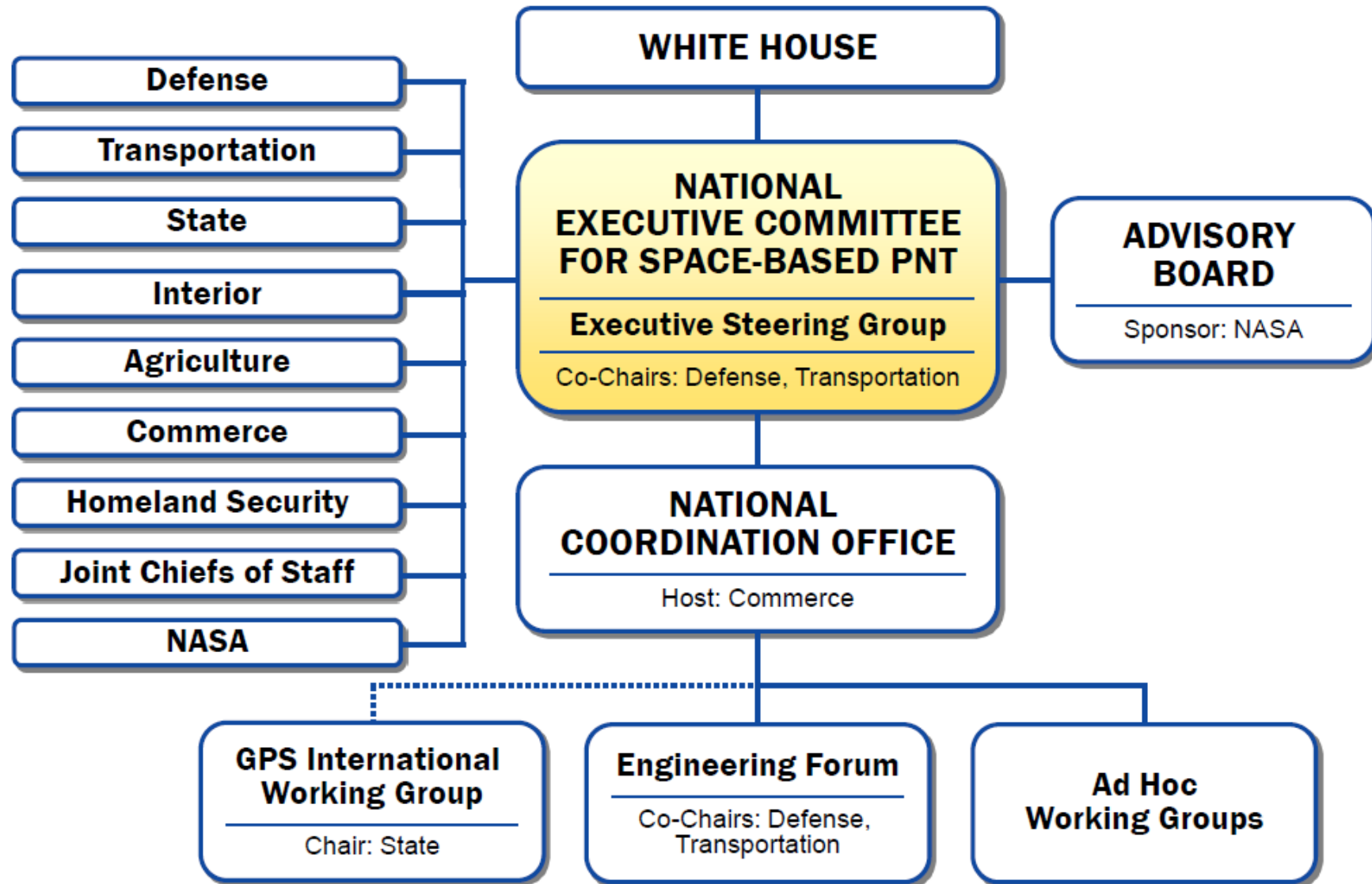
Harold W. Martin III

*Director, National Coordination Office
United States of America*





National Space-Based PNT Organization





U.S. Policy



- Provide continuous worldwide access for peaceful uses, free of direct user charges
- Encourage compatibility and interoperability with foreign GNSS services and promote transparency in civil service provisioning
- Operate and maintain constellation to satisfy civil and national security needs
 - *Foreign PNT services may be used to complement services from GPS*
- Invest in domestic capabilities and support international activities to detect, mitigate and increase resiliency to harmful 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
- Ensure a level playing field in the global marketplace

*Pursue through Bilateral
and Multilateral Cooperation*



Keys to Successful U.S. Program



- Policy Stability
- Transparency
- Program Stability
- Sustained Performance and Credibility
- Continuous Improvement

Policy stability and transparency improve industry confidence and investment

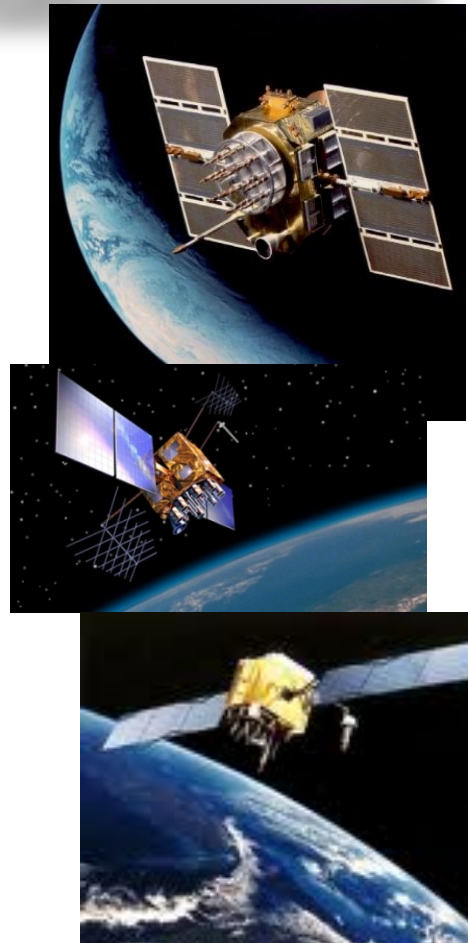


GPS Constellation Status



*30 Operational Satellites
(Baseline Constellation: 24+3)*

- Robust constellation
 - 4 GPS IIA, 12 GPS IIR, 7 GPS IIR-M, 7 GPS IIF
 - 8 Additional satellites in residual/test status, and 1 in early orbit test (IIF-8)
- Global GPS civil service performance commitment met continuously since December 1993
 - Best performance 46.6 cm User Range Error (URE) 8 Jun 2013; best weekly average 58.7 cm URE 18 Aug 14
 - Performance improving as new satellites replace older satellites





GPS IIF Launches in 2014



- IIF-8 Successfully Launched on 29 October 2014
 - Satellite Vehicle Number 69
 - PRN 03
- SVN 64 launched 20 Feb 2014
- SVN 67 launched 16 May 2014
- SVN 68 launched 01 August 2014



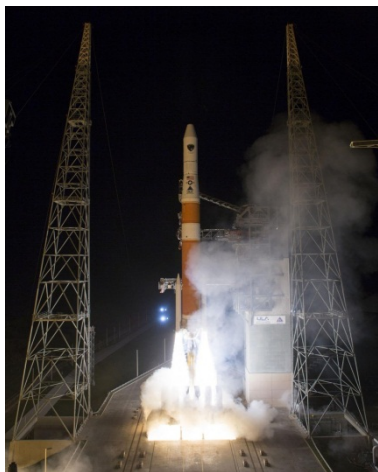
Most GPS launches in a single year since 1993



GPS IIF Status



- 8 total GPS IIFs on orbit
- 4 more GPS IIFs in the pipeline
 - SVs 10, 11, and 12 are in storage
 - SV-9 is in production testing



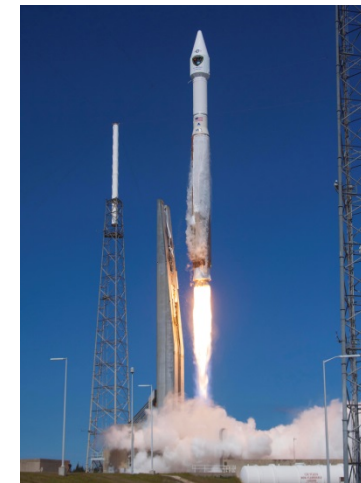
20 Feb: IIF-5



16 May: IIF-6



1 Aug: IIF-7



29 Oct: IIF-8



GPS Modernization Program



Legacy GPS IIA/IIR

- Single Frequency (L1)
- Coarse acquisition (C/A) code
- Y-Code (L1Y & L2Y)

GPS IIR-M

- 2nd Civil Signal (L2C)
- M-Code (L1M & L2M)

GPS IIF

- 3rd civil signal (L5)
- 2 Rb + 1 Cs Clocks
- 12 year design life

GPS III

- 4th civil signal (L1C)
- 4x better User Range Error than IIF
- Increased availability
- Increased integrity
- 15 year design life



Legacy OCS

- Mainframe system
- Command & Control
- Signal monitoring

AEP

- Distributed architecture
- Increased signal monitoring
- Security
- Accuracy
- Launch and disposal ops

OCX Block 0

- Launch & On-Orbit Checkout of GPS III

OCX Block 1

- Transition to OCX for all GPS command and control operations

Increasing System Capabilities - Increasing User Benefit



GPS III and OCX Status



- GPS III
 - L1 C/A, L1C, L2C, L5; L1/L2 P(Y), L1/L2M
 - SVO7/08 contract awarded 31 Mar 14
 - SVO1 navigation payload panel began space environment testing at Lockheed Martin's Colorado facility Sep 14
 - SVO1 available for launch starting 2016
- Next Generation Operational Control System (OCX)
 - Modernized command & control system with M-Code and modern civil signal monitoring
 - OCX Block 0 supports launch & checkout for GPS III and is in integration & test
 - OCX Block 1 will support transition from OCS in 2018
 - Successfully completed 4 GPS III launch exercises



Monitor Station



Ground Antenna



Modernized Civil GPS Capabilities



- Second civil signal “L2C”
 - Designed to meet commercial needs
 - Available since 2005 without data message
 - Currently 14 satellites broadcasting L2c



Third civil signal “L5”

- Designed to meet transportation safety of life requirements
- Uses Aeronautical Radio Navigation Service band
- Currently 7 satellites broadcasting L5

- Fourth civil signal “L1C”
 - Designed for GNSS interoperability
 - Specification developed in cooperation with industry
 - Improved tracking performance

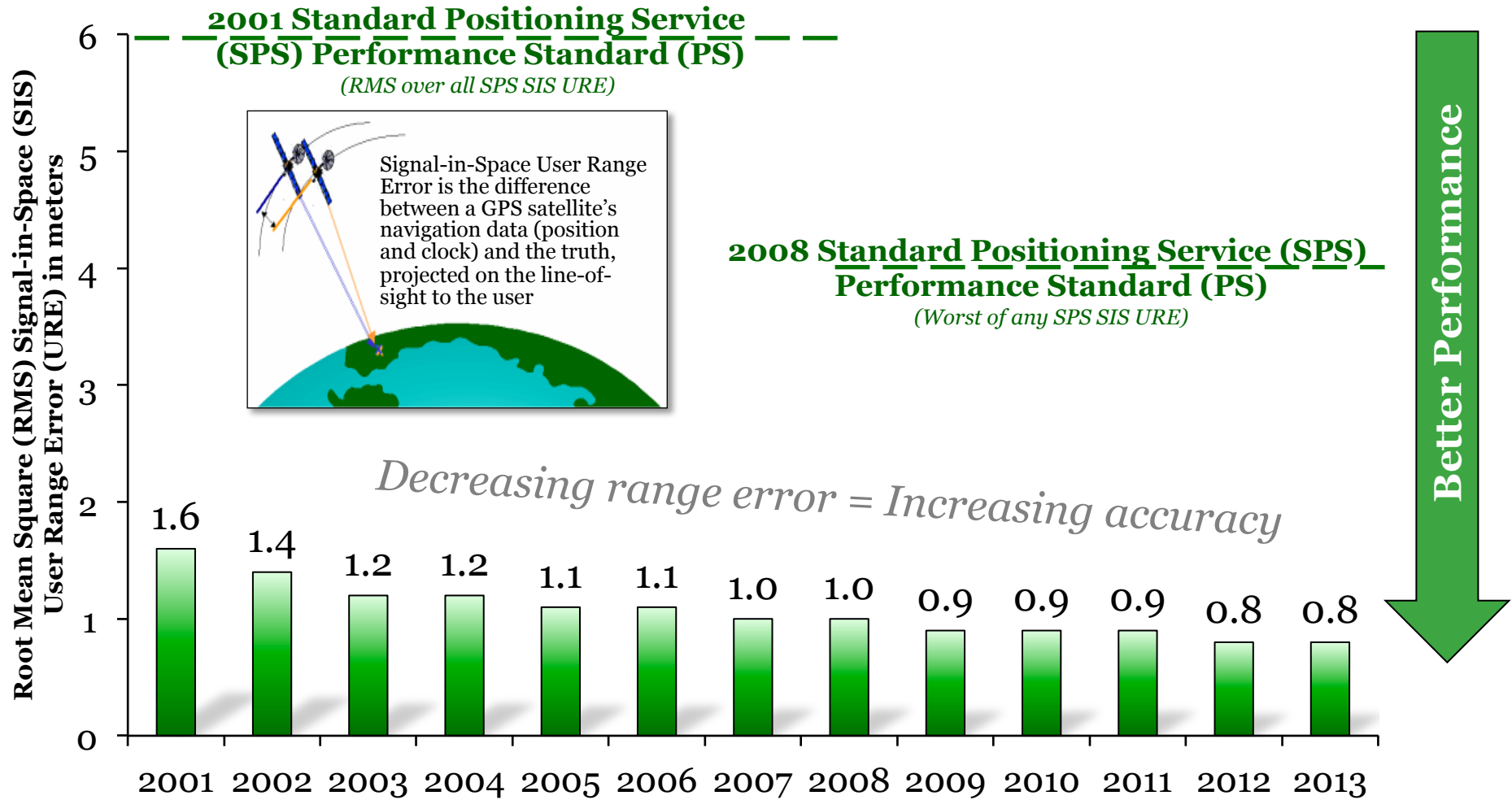


Urban Canyons

Improved
performance in
challenged
environments



GPS Signal-in-Space Performance



System accuracy better than published standard



CNAV Implementation



- First-Ever pre-operational Civil Navigation (CNAV) message broadcast on L2C began 28 April 2014
 - Signal set Healthy, but use at own risk
 - Part of GPS modernization program announced in 1999
- CNAV message also broadcast since 28 Apr on L5
 - L5 message set ‘unhealthy’ until sufficient monitoring capability established (signal verification)

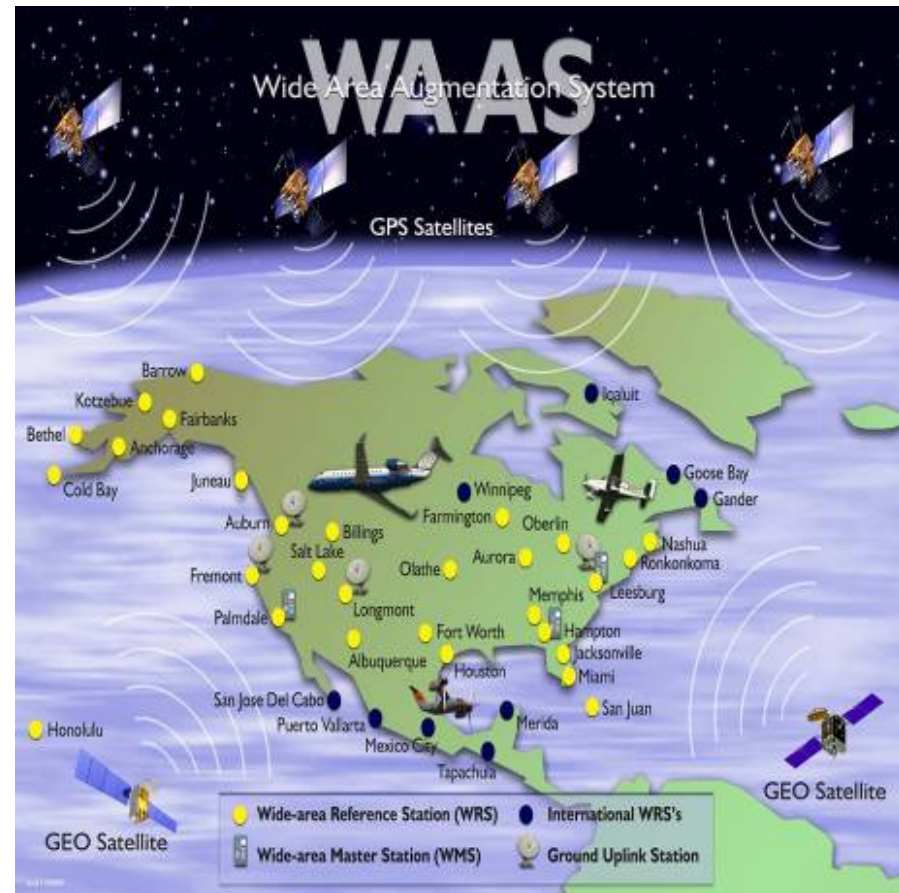
Civil signal messages on-line now



Wide Area Augmentation System (WAAS) Architecture



- A combination of ground-based and space-based systems that augment the GPS Standard Positioning Service (SPS)
- Provides the capability for increased availability and accuracy in position reporting, allowing more time for uniform and high quality air traffic management.
- Provides navigation service for all classes of aircraft during all phases of flight - including en route navigation, departures, arrival and landing



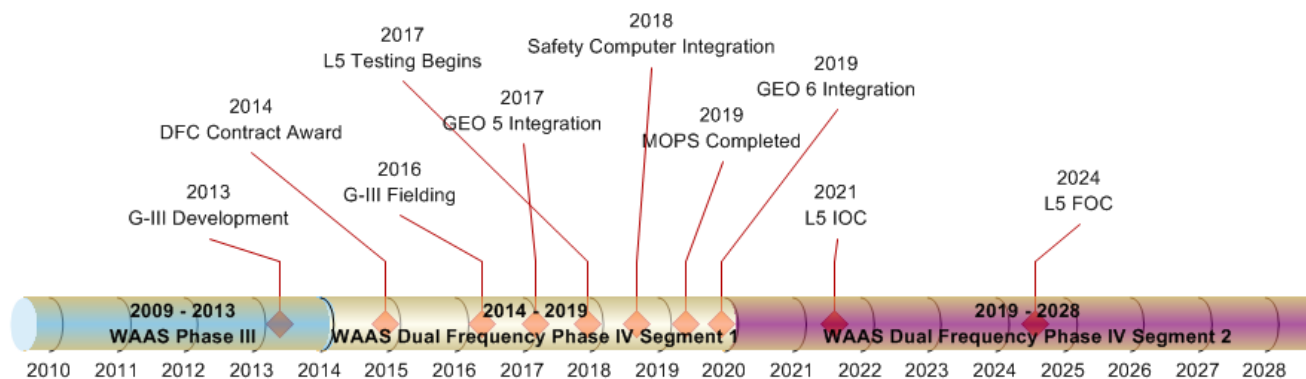
Sponsor: Federal Aviation Administration



WAAS Status



- Phase IV: Dual Frequency (L1, L5) Operations (2014 – 2044)
 - Improved availability/continuity during severe solar activity
 - Transition from use of L2 to L5 in WAAS reference stations
 - Support sustainment of WAAS GEOs
 - Infrastructure modifications to support L1/L5 users
 - Continue to support single frequency users
 - Evaluate Multi-Constellation utility



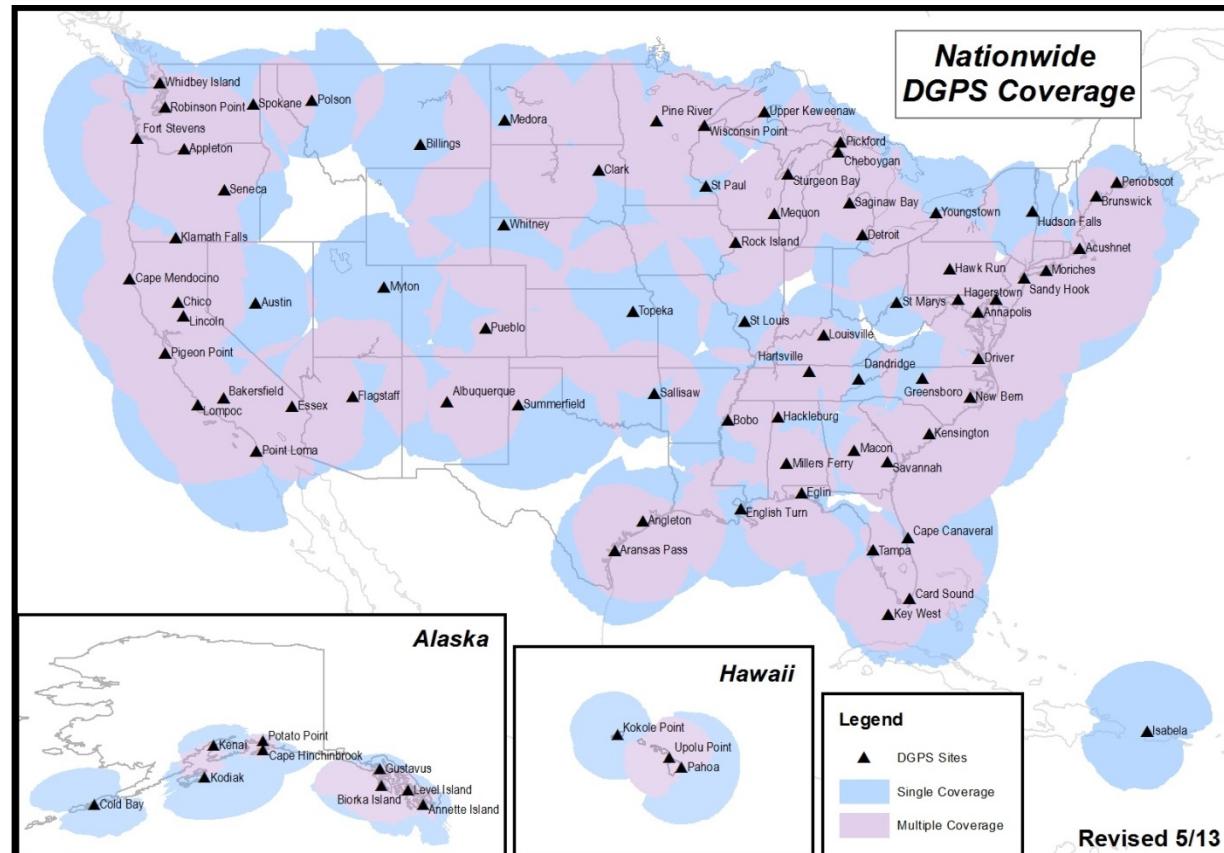


Nationwide Differential GPS (NDGPS)



Sponsors: U.S.
Coast Guard &
Department of
Transportation

- 80+ sites
- Broadcasts GPS correction signals
- Improved accuracy & integrity





Assessment of Future of NDGPS



- Joint U.S. Coast Guard & Department of Transportation Federal Register Notice 16 April 2013
 - Assessment driven by many factors: from policy to technology
 - Asked how NDGPS is used, impact/alternatives if discontinued
 - Responses have been reviewed
- Current Activity: Identify and assess alternatives
 - Continuation/partial decommission/transfer/hybrid
- Decision timeline: No earlier than fall/winter 2014
 - Supports investment decisions in 2017
- Continue uninterrupted NDGPS service to users as currently provided until future decision reached
- Public/user community information/ involvement in decision processes and next steps

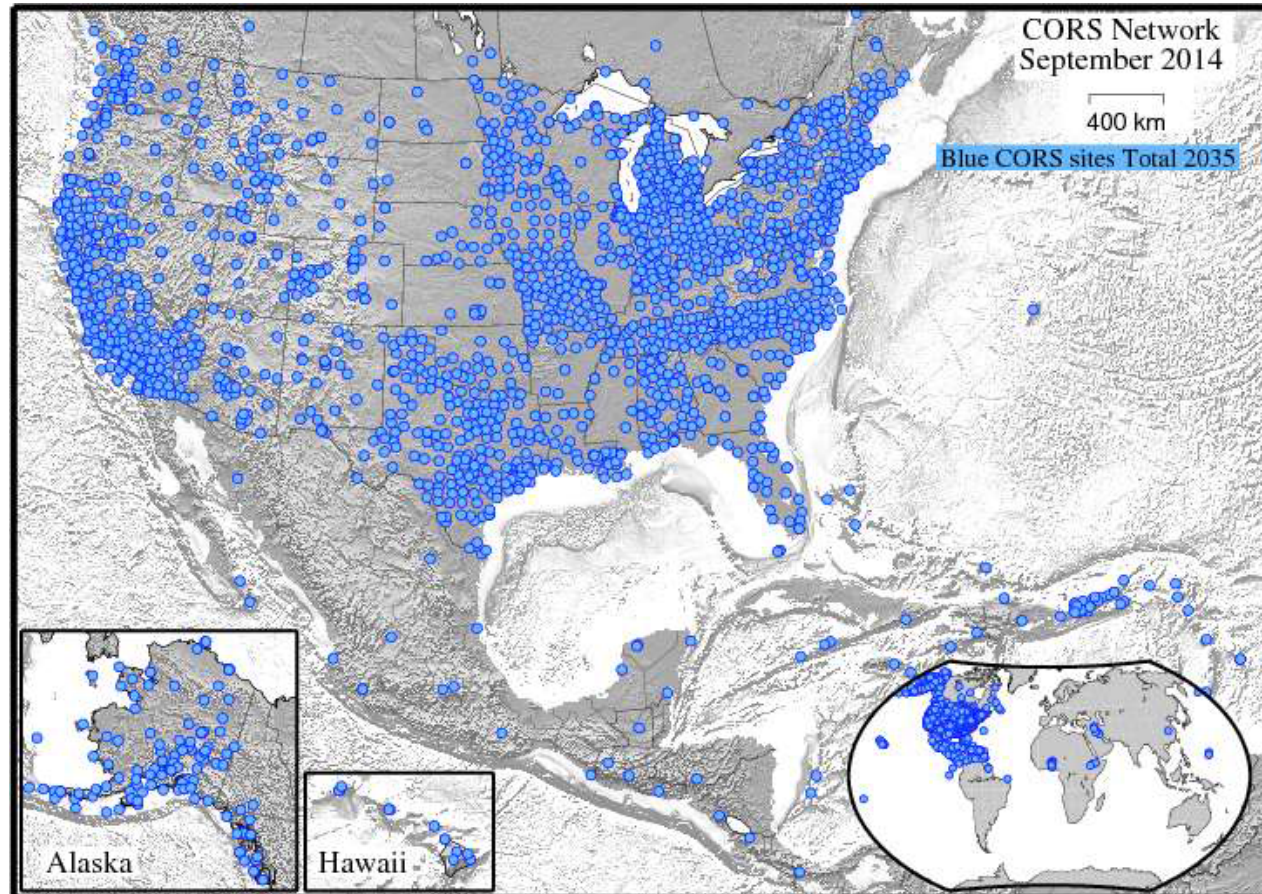


National Continuously Operating Reference Stations (CORS)



Sponsor: National Oceanic and Atmospheric Administration

- 2,030+ sites
- Operated by 200+ Fed, State, City, Private, Educ. organizations
- Enables highly accurate, post processed 3-D positioning





The Global Differential GPS (GDGPS) System



Providing mission-critical, global real-time services, 24/7, since 2000

Sub-10 cm positioning accuracy globally

Customer-supported by industry, NASA, and DoD

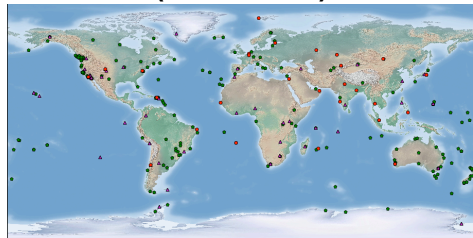
GNSS performance
Monitoring



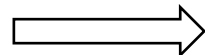
Precision Industrial
Positioning



Real-Time Tracking Network
(200+ sites)



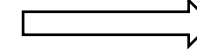
Measurements



Triple Hot Redundant Operation Centers



Products, Services



Personal
Geolocation

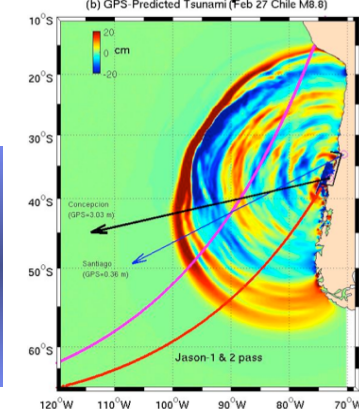


Core software for WAAS (U.S.), MSAS (Japan), GAGAN (India)

Software and testbed for Next Generation GPS Control Segment (OCX)

Multiple societal services

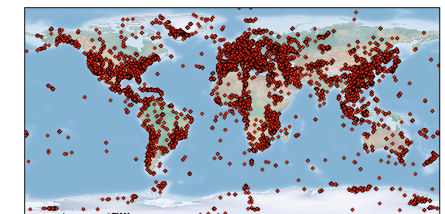
Earthquake monitoring
and tsunami prediction



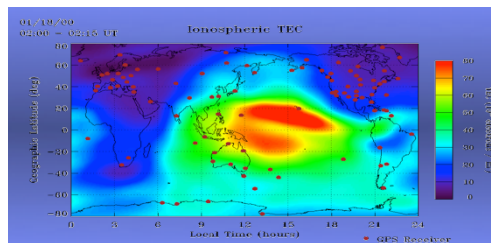
Repeat path interferometry
with UAV-SAR



Public positioning Service



Space weather monitoring



YEB - Oct 2014



Summary



- The U.S. supports free access to civilian GNSS signals and all necessary public domain documentation
- GPS is a critical component of the global information infrastructure
 - Compatible with other satellite navigation systems and interoperable at the user level
 - Guided at a national level as multi-use asset
 - Acquired and operated by the Air Force on behalf of the USG
- The U.S. policy promotes open competition and market growth for commercial GNSS
- Modernization milestones: Multiple launches and new Civil Navigation messages broadcast

GPS continues to provide continuously improving, predictable, dependable performance



Thank You !



Contact Information:

National Coordination Office for Space-Based PNT

1401 Constitution Ave, NW – Room 2518

Washington, DC 20230

Phone: (202) 482-5809

www.gps.gov

Official public resource for U.S. Government
information about GPS and related topics

Harold.Martin@gps.gov



Introduction



Bradford Parkinson, Ph.D.
U.S. National Space-Based PNT Advisory Board
Acting Chairman



Protect, Toughen, Augment (PTA) GNSS/PNT Services



- U.S./National Space-based PNT Advisory Board (the “**PNTAB**”)
 - ‘Citizen-based user group’ - US non-governmental plus international experts
 - Balanced to include members from all Major User Groups
 - Promotes transparency and fosters communications amongst all stakeholders
 - gives users a voice!
 - Provides Independent Recommendations to USG decision makers with a
Fundamental Purpose: Assured PNT
- ‘Current PNTAB activities :
 - Quantify **Economic Benefits** of GNSS and Inform Decision Makers
 - Make Recommendations to further Protect, Toughen and Augment GNSS (PTA). More details in ***Applications and Experts Seminar*** later today...

Recommendation to ICG-9: Other Global PNT service providers establish Advisory Boards with international participation to further understanding and collaboration.