TITLE:

U.S. SPACE-BASED PNT POLICY AND PROGRAM UPDATE

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Economy:

ALL

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Asia-Pacific Economic Cooperation

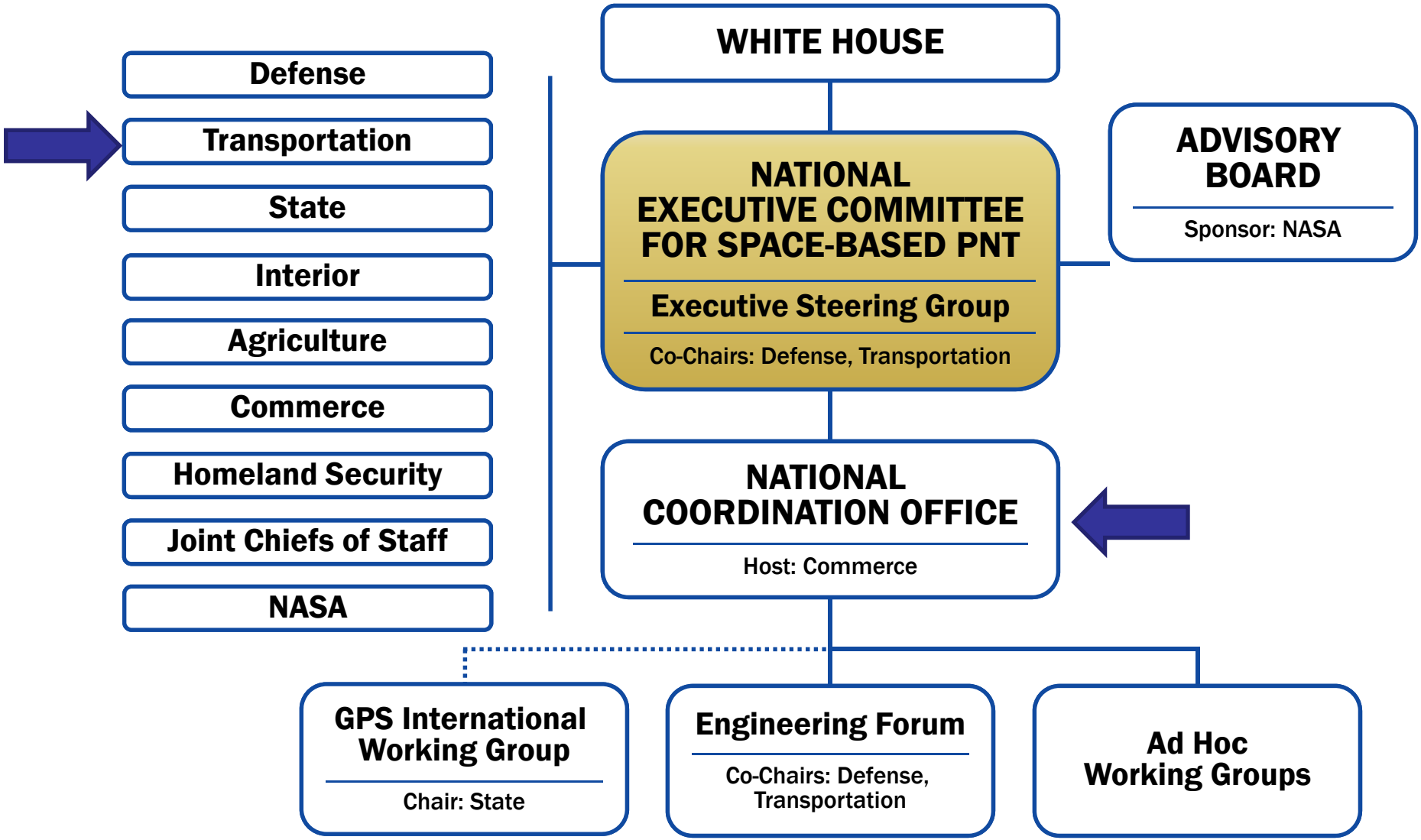
APEC CHINA 2014

Ministry of Transport
TE MANATŪ WAKA

Overview

- U.S. Space-Based PNT Policy
- International Interoperability
- Global Positioning System Status
- Ground System Modernization
- Space System Modernization
- CNAV Implementation Plans

National Space-Based PNT Organization



U.S. National Space Policy 2010

- Provide continuous worldwide access to GPS for peaceful uses, free of direct user charges
- Open, free access to information necessary to use civil GPS and augmentations
- Encourage global compatibility and interoperability with GPS and its augmentations
- ***Other States' GNSS services may be used to complement GPS services***
- Invest in domestic capabilities and support international activities to detect, mitigate and increase resiliency to harmful interference

U.S. policy on civil GPS access has been stable and consistent for 30 years

PNT Critical Infrastructure Resiliency

- Critical Infrastructure sector dependencies on satellite navigation assessed 2010-2012
  - Communications (e.g. cellular phone tower synchronization)
  - Energy (e.g. power grid synchronization)
  - Emergency Services (e.g. location)
  - Transportation Systems (NextGen)

  http://www.gps.gov/news/2013/05/2013-05-NRE-public-summary.pdf
- February 2013 Presidential Policy Directive 21 and Executive Order 13636 address critical infrastructure
- Ongoing U.S. interagency activities are addressing the need for *critical infrastructure resiliency* due to the critical infrastructure sectors increasing reliance upon GPS/GNSS for PNT services

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International Committee on GNSS (ICG)

- Established under the umbrella of the United Nations, promotes cooperation on matters of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services
- Members include: GNSS Providers (U.S., EU, Russia, China, India, Japan), Other States of the United Nations, International organizations/ associations
- **Multi-GNSS Monitoring Subgroup approved Jun 2012**
  - **Identifying service parameters that should be monitored**
  - **identifying monitoring methods and level of monitoring**
  - **Potential mechanism to support APNT**
- 8th ICG met in Dubai, UAE Nov 9-14, 2013
- 9th ICG Nov 10-14, 2014 in Prague, Czech Republic http://www.oosa.unvienna.org/oosa/SAP/gnss/icg.html

ICG Cooperation Objectives

- Ensure **compatibility** – ability to use multiple States' GNSS services separately or together without interfering with each individual service or signal to achieve radio frequency compatibility
- Achieve **interoperability** – ability to use multiple States' GNSS services together to provide the user better capabilities than would be achieved by relying solely on one service or signal
  - Primary focus is on common L1C and L5 signals
- Principle of t**ransparency**: every GNSS provider should publish documentation that describes: signal and system information, the policies of provision and the minimum levels of performance offered for its open services
- Consider the perspective of various user applications and equipment manufacturers
- Ensure a level playing field in the global marketplace

Pursue through Bilateral and Multilateral Cooperation

U.S. Position on GNSS Intellectual Property

- United States has a longstanding commitment to provide civil open service signals, and technical information necessary to develop and build equipment to use these signals, available worldwide to users at no direct cost (principle of transparency)
- All intellectual property for U.S. GPS civil signal designs and their broadcast from GPS are in the public domain
- Encourage other GNSS providers to make their signals available in same manner
- Those entities that wish to patent technologies or techniques that are specific to receiver design and application development are free to do so
- Approach maximizes private sector innovation and has promoted new applications and great economic benefits

GNSS Spectrum Challenges

- 2010 & 2013 Presidential Memorandums
  - 500 MHz broadband initiative, with sharing
- LightSquared, Dish, Globalstar
  - Multiple broadband companies with filings near GPS
- National Advanced Spectrum & Communications Test Network (NASCTN)
  - Facilitate and Coordinate: testing and evaluation of spectrum sharing capabilities
- GPS Adjacent Band Compatibility Assessment
  - DOT/FAA determining adjacent band power limits as a function of frequency separation

Spectrum Protection Challenges Continue for GPS/GNSS and Have National-Level Attention

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GPS IIF-5 Launch

- Satellite Vehicle Number 64 (PRN 30)
- Launched 20 February 2014 aboard a Delta IV booster
- Preparing for PNT operations

GPS IIF Status

- 5 total GPS IIFs on orbit
  - Enhanced GPS clock performance
  - Transmits the L5 signal in addition to the L1, L2 and L2C signals

- 7 more GPS IIFs in the pipeline
  - 1 processing at Cape for launch
  - 5 complete & in storage
  - 1 completing production

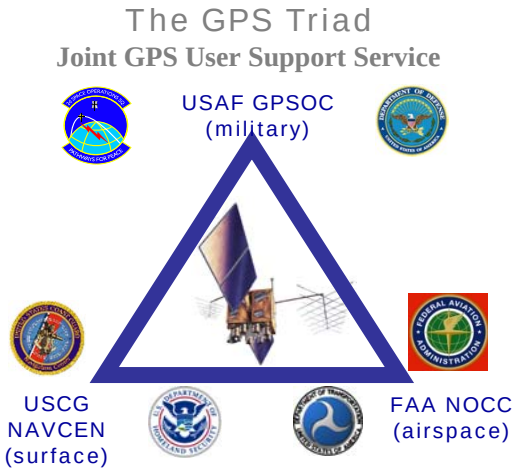
GPS Constellation Status

37 Satellites (30 Operational)
as of 30 Mar 2014
"Expandable 24" configuration (27 slots)

- 7 Block IIA
- 12 Block IIR
- 7 Block IIR-M
- 4 Block IIF
- 1 Block IIF in post launch checkout
- 1 in test (SVN 49/PRN 6) and set unusable
- 5 additional satellites in residual status
- Continuously assessing c0nstellation health to determine launch need

GPS Civil Commitment

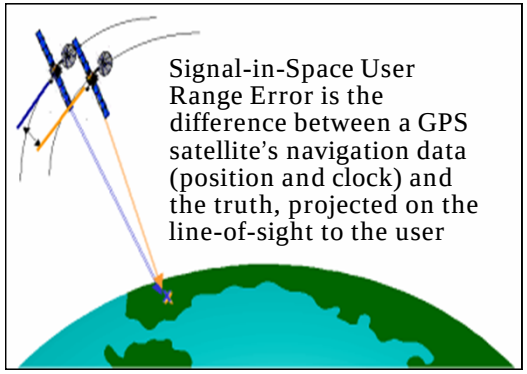
- Global GPS civil service performance commitments met continuously since Dec 1993
- Extensive International and Civil Cooperation
  - Agreements with international customers
  - Public Interface Working Group
  - Published Performance Standards
  - About 2 billion civil/commercial users
- GPS embedded in all facets of life
  - Aviation, Emergency Services, Timing, Agriculture, Rescue, Automotive, Tracking, Science, Military, Robotics/Control Systems



Standard Positioning Service (SPS) Signal-in-Space Performance

2001 Standard Positioning Service (SPS) Performance Standard (PS)

(RMS over all SPS SIS URE)



Signal-in-Space User Range Error is the difference between a GPS satellite's navigation data (position and clock) and the truth, projected on the line-of-sight to the user

2008 Standard Positioning Service (SPS) Performance Standard (PS)

(Worst of any SPS SIS URE)

Better Performance

Decreasing range error = Increasing accuracy

System accuracy exceeds published standard

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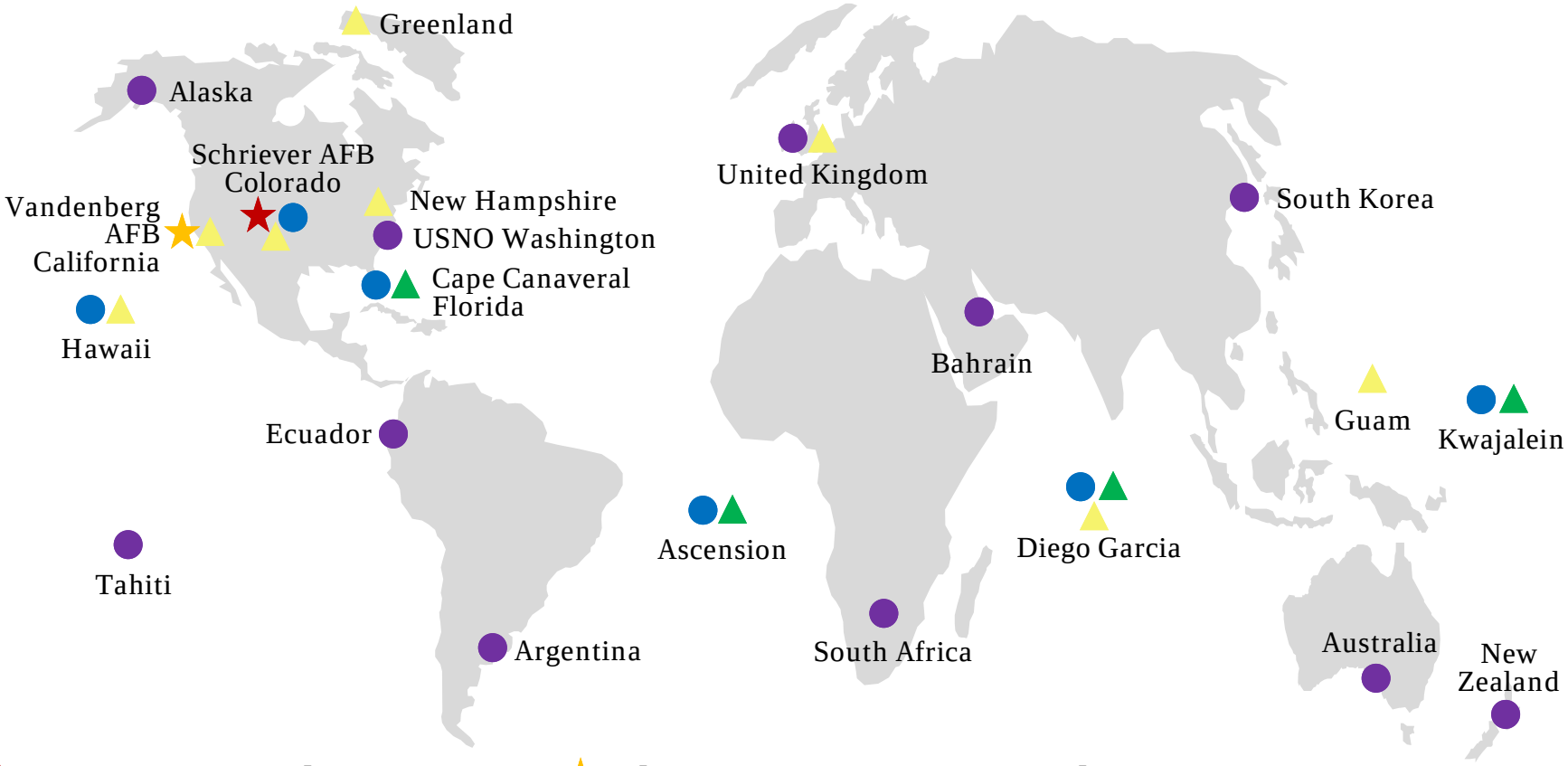
GPS Modernized Ground System

- Operational Control Segment (OCS) now flying GPS IIA/IIR/IIR-M/IIF constellation to provide L1 C/A
- Next Generation Operational Control System (OCX)
  - OCX Block 0 (2014) supports GPS III launch/checkout
  - OCX Block I (Operational capability projected in 2016)
    - Provides operational CNAV for L2C and L5
    - Command & control for GPS IIR/IIR-M/IIF/III
  - OCX Block II (Operational capability projected in 2017)
    - Delivers new L1C signal and M-Code
- OCX to GPS III Integration Status
  - Hardware in the Loop (HWIL) testing using OCX
  - Communicated with Ground Non-flight Satellite Testbed at Cape Canaveral
  - System Integration demonstrations underway for key system interactions

Monitor Station

Ground Antenna

GPS Operational Control Segment



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GPS Modernization Program

Increasing System Capabilities ◆ Increasing User Benefit

GPS IIA/IIR

<u>Basic GPS</u>

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

GPS IIR-M, IIF

<u>GPS IIR-M</u> – Basic GPS plus:

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

<u>GPS IIF</u> – GPS IIR-M capability plus:

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

GPS III

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

Modernized Civil GPS Capabilities

2nd Civil Signal (L2C)

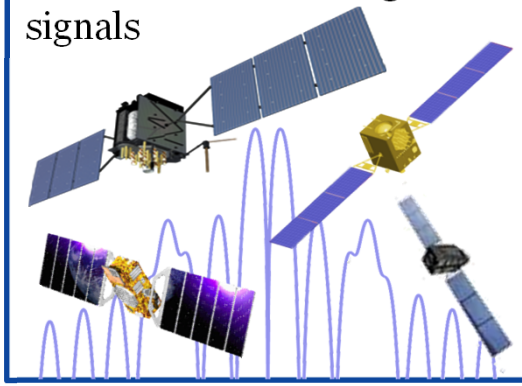
Provide dual-frequency civil navigation and extend GPS availability in challenged environments

3rd Civil Signal (L5)

Provide dual-frequency and/or triple-frequency civil navigation and safety-of-life signals

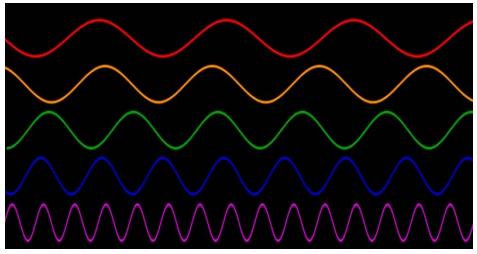
4th Civil Signal (L1C)

Provide internationally harmonized civil navigation signals



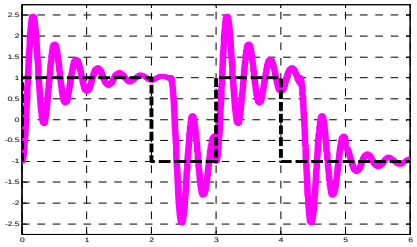
Precision Carrier-Phase Tracking

Dataless pilot channels for precision carrier phase lock loop tracking



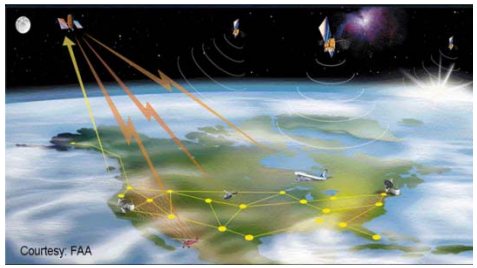
Monitored Integrity

On-board monitoring for clock anomalies, ground monitoring for signal malformation anomalies



External Augmentations

Extend GPS accuracy and integrity for safety-of-life applications



Modernized Civil GPS Capabilities

- Second civil signal "L2C
  - Designed to meet commercial needs
  - Available since 2005 without data message
  - Currently 11 satellites broadcasting L2c

Third civil signal "L5"

- Designed to meet transportation safety of life requirements
- Uses Aeronautical Radio Navigation Service band
- Currently 4 satellites broadcasting L5

- Fourth civil signal "L1C"
  - Designed for GNSS interoperability
  - Specification developed in cooperation with industry
  - Launches with GPS III
  - Improved tracking performance

Urban Canyons

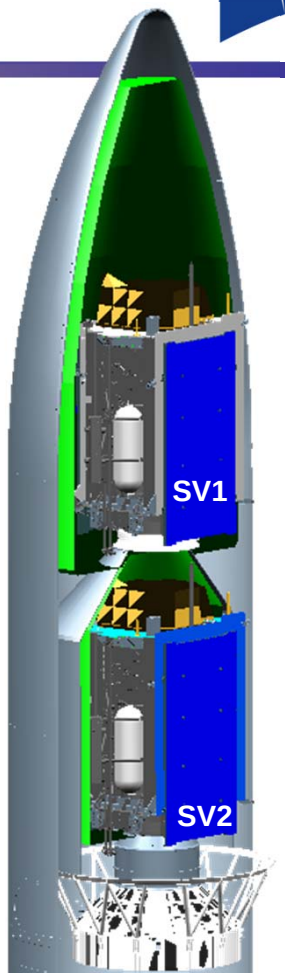
Improved performance in challenged environments

GPS III Status

- Newest block of GPS satellites
  - First satellite to broadcast common L1C signal
  - Multiple civil and military signals; L1 C/A, L1 P(Y), L1M, L1C, L2C, L2 P(Y), L2M, L5
  - Three Rubidium clocks
- SV01 initial power turn-on 27 Feb 13
- GPS Satellite Simulator delivered to support OCX, 21 May 13
- GPS Non-Flight Satellite Testbed accomplished launch processing at Cape Canaveral; returned to factory
- Final elements of Navigation Payload are in acceptance test

Enabling Affordability & Capability

- Dual Launch significantly reduces costs
  - Studies indicate capability can be provided with minor changes in GPS III SV09+ production line
  - Reduces launch vehicle needs
  - Developing final requirements for dual payload adapter
- Future Size, Weight, Power (SWAP) considerations
  - Battery & Solar Array Efficiency, Star Tracker/ IMU, More Efficient Amplifiers, etc...
  - Allows SV09+ payload considerations
- New capability SV9+
  - Search and Rescue (SAR-GPS) -- formerly DASS
  - Laser retroreflectors



Notional Dual Launch Configuration on Atlas V

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L2C and L5 CNAV Messages

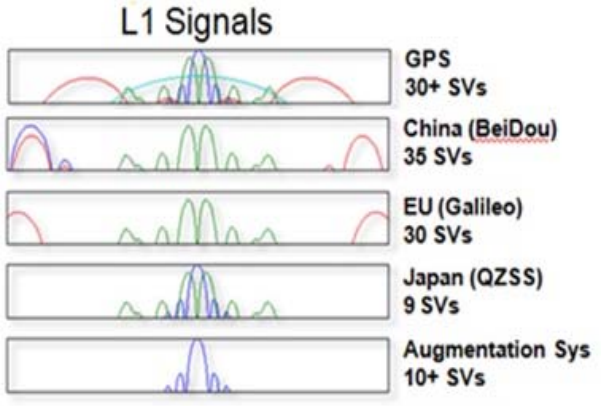
- June 2013 GPS CNAV testing publicized in advance through various PNT conferences and online at GPS.gov
- First CNAV live-sky test broadcast with civil input
  - Demonstrated CNAV messaging on GPS IIR-M & GPS IIF SVs (L2C, L5)
  - Focused on basic PNT functionality
- Broadcast populated messages for two weeks
  - Contents included: CNAV ephemeris, clock, almanac, and non-navigation message types
- Opportunity to identify or explore any CNAV message issues in order to implement fixes before operations
- CNAV message set unhealthy at conclusion of testing
- Further CNAV tests will be conducted to continue to troubleshoot before CNAV message is set healthy
- Interagency team focused on operational availability of L2C and L5 CNAV messages prior to OCX implementation

Civil Navigation Messages

- L2C and L5 will eventually replace civil need for semi-codeless access to military P(Y) signals
- All semi-codeless GPS users need to migrate to the new civil signals by Dec 31, 2020
- A Federal Register Notice (FRN) was published on 5 March 2014
- Seeks comment from the public and industry regarding plans by the United States Air Force to broadcast ***pre-operational*** L2C and L5 civil navigation (CNAV) messages from certain GPS satellites beginning in April 2014
- Comments accepted to the Department Of Transportation via the Federal eRulemaking Portal via: www.gps.gov/pros

GPS Interoperability Initiatives

- Demonstrated Civil Navigation message Type 35 in 2013
  - Supports foreign interoperability of L2C and L5
  - Tests GPS/GNSS Time Offset using defined protocols
    - GPS to Galileo
    - GPS to GLONASS
- Ongoing coordination with other GNSS providers
  - RF Compatibility to prevent interference between GNSS
  - Interoperability of Open Service (civil) signals
    - Benefits of multi-GNSS civil services
    - Use of GPS PRN codes
    - GPS PRN code assignment management and coordination



Keys to U.S. Program Success

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

Policy stability and transparency improve industry confidence and investment

Summary

- The U.S. supports free access to civilian GNSS signals and all necessary public domain documentation
  - GPS.gov -- official public resource for U.S. Government (USG) information about GPS and related topics
- 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

GPS continues to provide consistent, predictable, dependable performance

For Additional Information…

www.gps.gov

SPACE-BASED POSITIONING NAVIGATION & TIMING

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