

Space and Missile Systems Center



Global Positioning Systems Directorate

GPS Program Update to
ION GNSS+ 2014

10 Sep 2014

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Deputy Director, GPS Directorate



Global Positioning Systems Directorate

SPACE AND MISSILE SYSTEMS CENTER

Mission:

Acquire, deliver and sustain reliable GPS capabilities to America's warfighters, our allies, and civil users



Col Bill Cooley



Deliver and Sustain Global Navigation and Timing Service

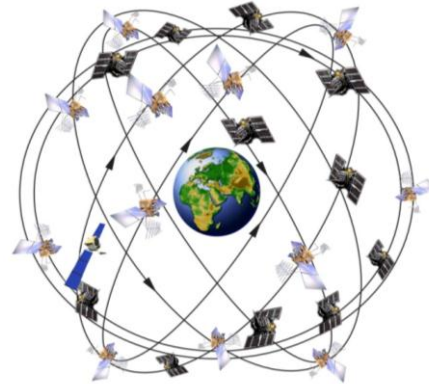


GPS Overview

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Civil Cooperation

- 1+ Billion civil & commercial users
- Search and Rescue
- Civil Signals
 - L2C (2nd Civil Signal)
 - L5 (Safety of Life)
 - L1C (International)



Department of Defense

- Services (Army, Navy, AF, USMC)
- Agencies (NGA & DISA)
- US Naval Observatory
- PNT EXCOMS
- GPS Partnership Council

Maintenance/Security

- All Level I and Level II
 - Worldwide Infrastructure
 - NATO Repair Facility
- Develop & Publish ICDs Annually
 - ICWG: Worldwide Involvement
- Update www.GPS.gov Webpage
- Load Operational Software on over 1 million SAASM Receivers
- Distribute PRNs for the World
 - Including 90 for GNSS

Spectrum

- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements
- Adjacent Band Interference

39 Satellites/ 31 Set Healthy
Baseline Constellation: 24 Satellites

Satellite	Quantity	Avg Life	Oldest
GPS IIA	5	20.1	23.8
GPS IIR	12	12.7	17.1
GPS IIR-M	7	7.9	8.9
GPS IIF	7	1.63	4.3
Constellation	31	10.4	23.8

AS OF: 27 AUG 14

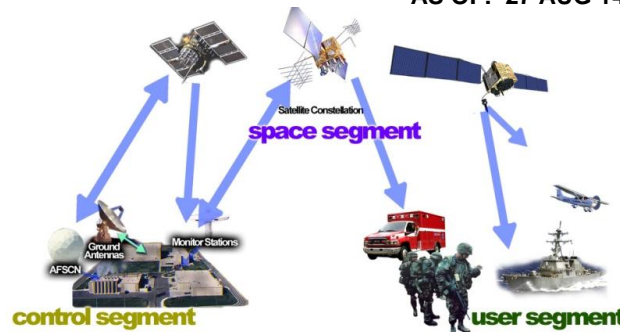


Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

- U.S. Coast Guard



International Cooperation

- 57 Authorized Allied Users
 - 25+ Years of Cooperation
- GNSS
 - Russia - GLONASS
 - Europe - Galileo
 - China - BeiDou
 - Japan - QZSS
 - India - IRNSS



GPS Constellation

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- Robust constellation
 - 31 space vehicles currently in operation
 - 5 GPS IIA, 12 GPS IIR, 7 GPS IIR-M, 7 GPS IIF
 - 7 additional satellites in residual status, 1 in test status
- Extensive International and Civil Cooperation
 - Agreements with 57 international customers
 - 1 billion+ civil/commercial users
 - Countless applications...and growing
- Global GPS civil service performance commitment met continuously since Dec 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

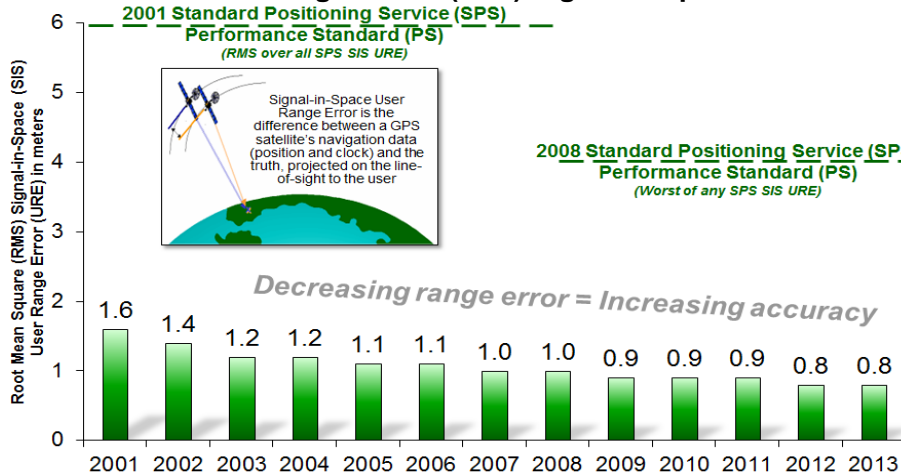




GPS Signal in Space Performance

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



Better Performance



Mining and Construction



Precision Agriculture

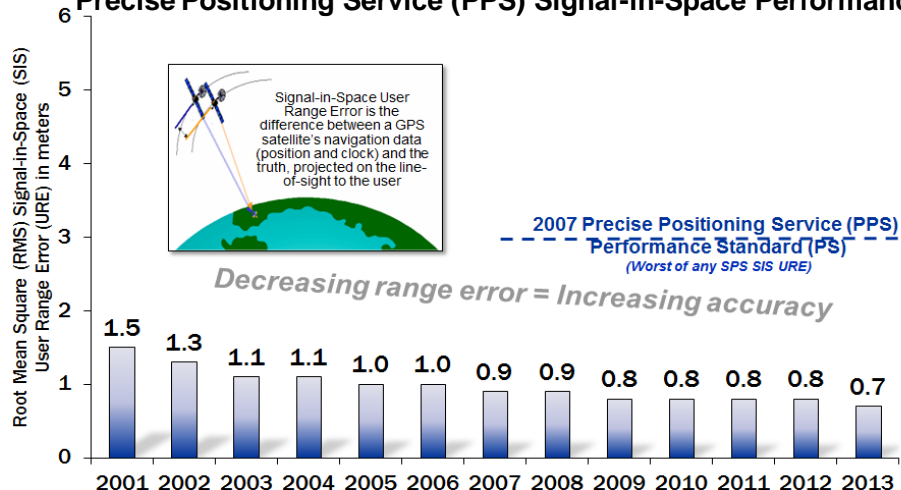


Aviation



Wildlife Research

Precise Positioning Service (PPS) Signal-in-Space Performance



Better Performance



Precision Navigation



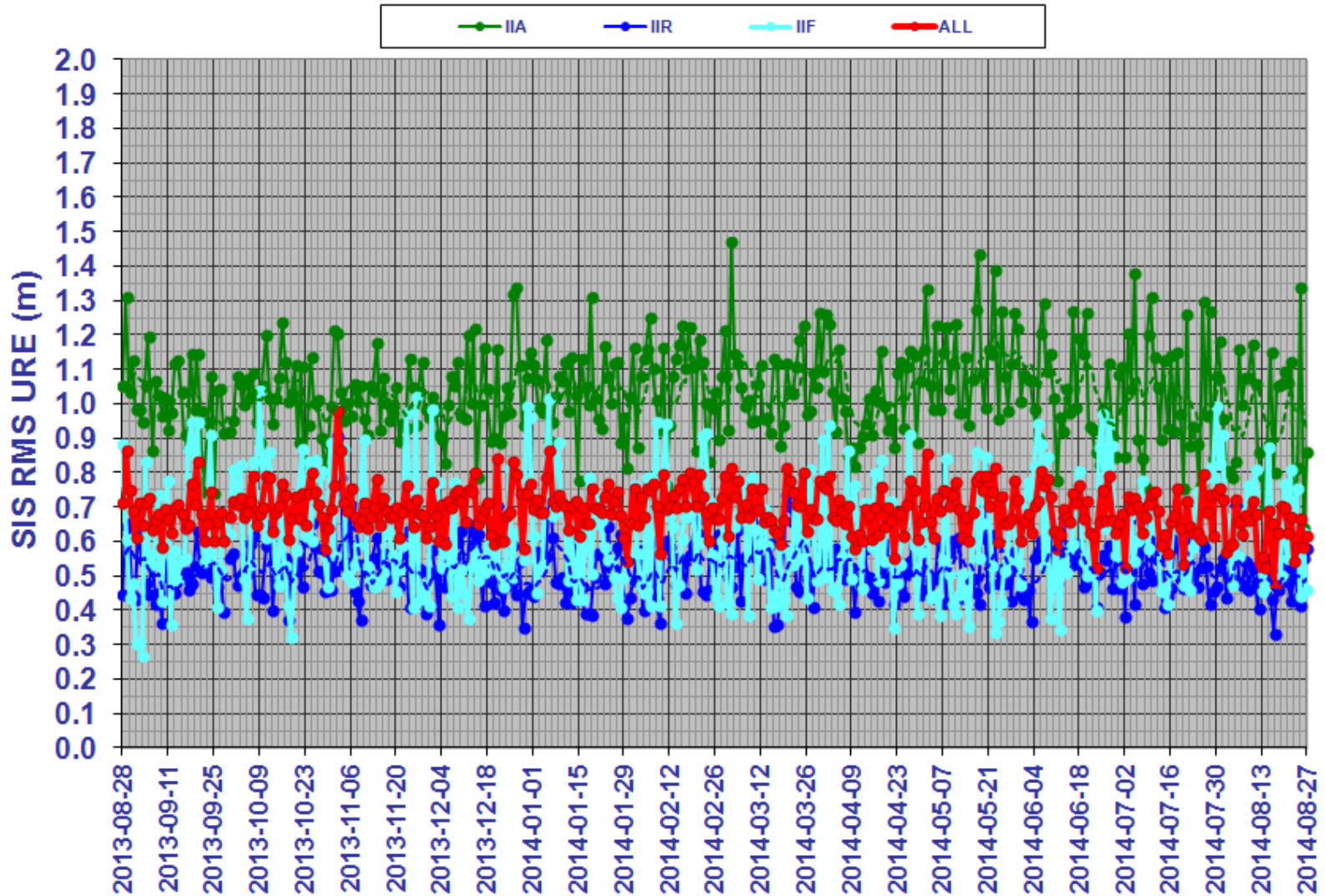
System accuracy exceeds published standard



GPS Performance – Past 12 Months

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As-Broadcast SIS vs JPL Real Time





GPS IIA/IIR/IIR-M Status

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- 19 GPS IIR and GPS IIR-M satellites are on orbit
 - Current backbone of the GPS constellation
 - SIS URE of 0.53 meters (1-yr performance Aug 2014); (1.04m for GPS IIA and 0.64m for GPS IIF)
- Excellent life expectancy
 - GPS IIA performing well past design life (2.5x on avg)
 - GPS IIR/IIR-M solar array capacity far exceeds specified Mean Mission Duration
 - No GPS IIR/IIR-M clock failures to date
 - GPS IIR/IIR-M battery life extension implemented, yielding avg 1-2 years additional life per satellite





GPS IIF Status

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- What a year!
- Launched GPS IIF-5 on 21 Feb 14
 - Satellite Vehicle Number 64, PRN 30
- Launched GPS IIF-6 on 15 May 14
 - Satellite Vehicle Number 67, PRN 6
- Launched GPS IIF-7 on 1 Aug 14
 - Satellite Vehicle Number 68, PRN 9
- 7 total GPS IIFs on orbit
 - Continued demonstration of Flex Power capability
- 5 more GPS IIFs in the pipeline
 - SV-8 scheduled for launch in Oct 2014
 - SVs 10, 11, and 12 are in storage
 - SV-9 is in production testing
 - Improved Rubidium clocks on SVs 3 and 5-12





GPS III Status

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- Newest block of GPS satellites
 - 4 civil and 4 military signals:
L1 C/A, L1C, L2C, L5; L1/L2 P(Y), L1/L2M
 - First satellites to broadcast common L1C signal
 - Three improved Rubidium atomic clocks
- SV07/08 contract awarded 31 Mar 14
- Navigation Payload Panel in acceptance testing
- GPS III Non-Flight Satellite Testbed accomplished launch processing at Cape Canaveral; reduced risk for integration & test and launch processing
- GPS III SV01 available for launch starting Jan 2016



Lockheed-Martin (Waterton, CO) – Prime



Ground Segment Status

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- Current system Operational Control Segment (OCS)
 - Flying GPS constellation on Architecture Evolution Plan (AEP) and Launch & Early Orbit, Anomaly, and Disposal Operations (LADO) software systems
 - Cyber security enhancements in progress
- Next Generation Operational Control System (OCX)
 - Modernized command & control system with M-Code, modern civil, signal monitoring, info assurance infrastructure and improved PNT performance
 - OCX Block 0 supports launch & checkout for GPS III and is in integration & test; Raytheon (Aurora, CO) - Prime
 - OCX Block 1 supports transition from OCS in 2018
 - Successfully completed 3 GPS III launch exercises



Monitor Station



Ground Antenna



GPS Modernization – New Civil Signals

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- Second civil signal “L2C”
 - Designed to meet commercial needs
 - Available since 2005 without data message
 - Phased roll-out of CNAV message
 - Currently 14 SVs broadcasting L2C



- Third civil signal “L5”
 - Designed to meet transportation safety-of-life requirements
 - Uses Aeronautical Radio Navigation Service band
 - Currently 7 SVs broadcasting L5



- Fourth civil signal “L1C”
 - Designed for GNSS interoperability
 - Specification developed in cooperation with industry
 - Launches with GPS III in 2016
 - Improved tracking performance



Urban Canyons

Improved
performance in
challenged
environments

Early CNAV test conducted in Jun 2013



CNAV Pre-Operational Deployment

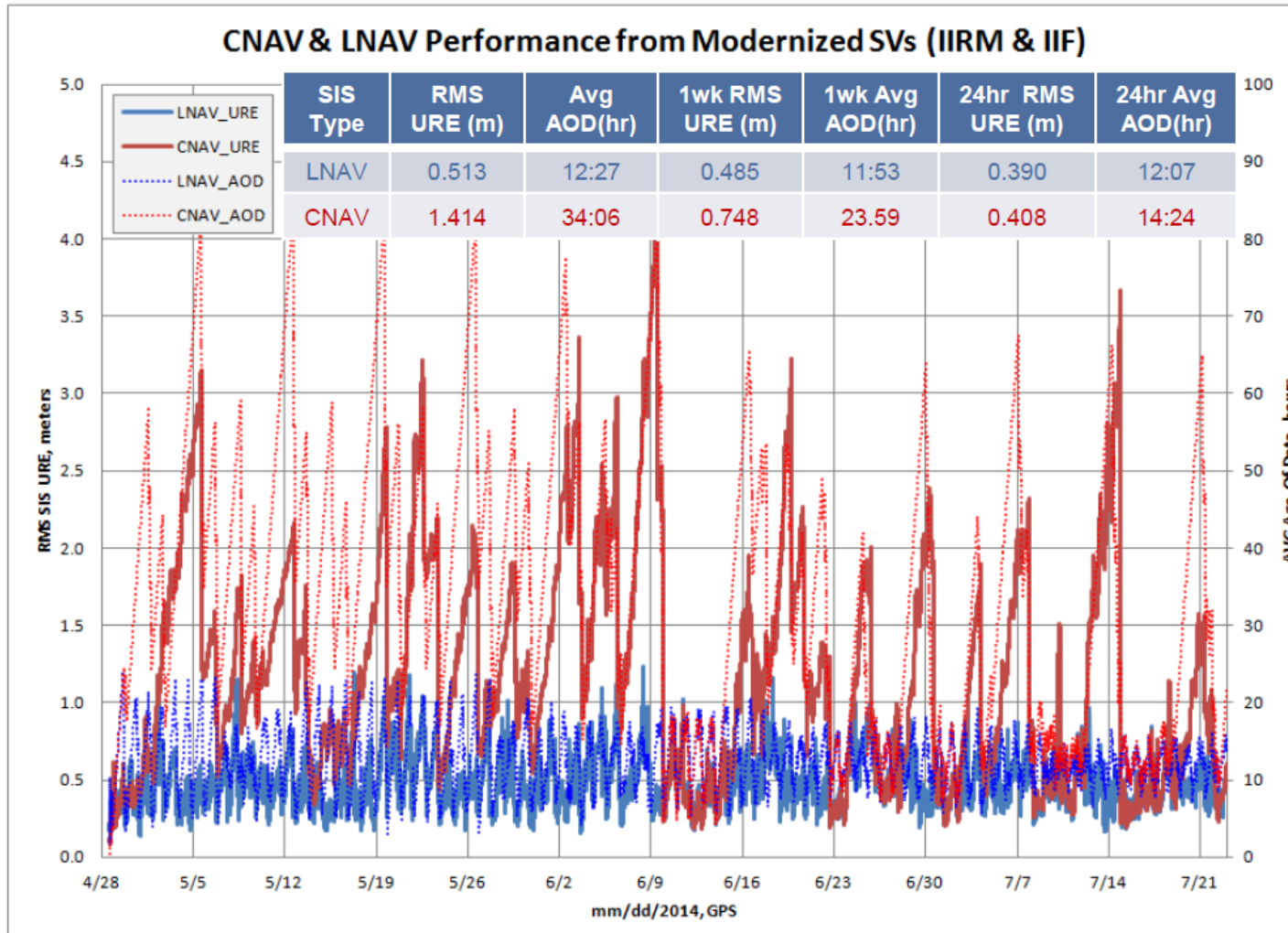
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- Initiated continuous CNAV message broadcast (L2C & L5) on 28 Apr 14
- CNAV Data message uploaded twice a week initially; with daily uploads expected by Dec 2014
- Position accuracy not guaranteed during pre-operational deployment of CNAV signals; “use at own risk”
 - L2C message currently set “healthy”
 - L5 message set “unhealthy” until sufficient monitoring capability established (signal verification)
- Expected Performance for users:
 - During first 24 hours after upload, CNAV performs as LNAV
 - Expect divergence between CNAV & LNAV as CNAV data ages until next CNAV upload



L2CNAV Upload Performance

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CNAV Performance Within Expectations

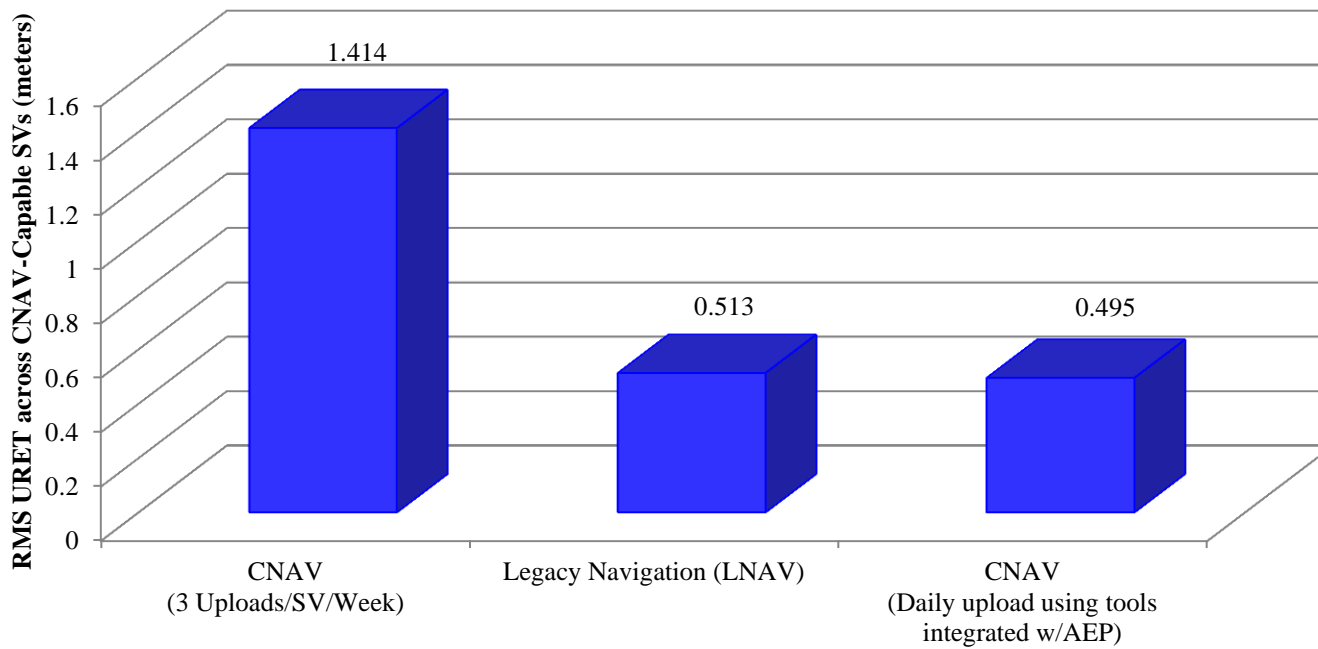


Effect of Upload Frequency on CNAV User Range Error

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- Improved tools reduce age of data & CNAV User Ranging Error (URE)
- Initial, twice-a-week upload (Apr 2014) drives high CNAV URE

RMS URE Driven by Upload Latency & Integration with AEP



Integrated Solutions Will Broadcast CNAV URE Comparable to Legacy in Dec 2014



GPS Summary

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- Modernized signal development in progress
 - 12 L2C, 5 L5 and 12 M-Code capable SVs on orbit
 - OCX will implement full C2 of L1/L2M, L2C, L5
 - Continuous L2C, L5 CNAV message broadcast began Apr 2014
 - Expect the first L1C SV launch in 2016
 - Continued progress to M-Code early use ~2018
- Modernization of all GPS Segments making progress but still with technical challenges commensurate with the advanced tech
- Working domestically, internationally and with Industry to simultaneously protect GNSS services and release spectrum for mobile services



Maintaining the world's "Gold Standard" PNT service is Job #1



Homepage for General Public

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GPS.GOV

Official U.S. Government information about the Global Positioning System (GPS) and related topics

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Lost Satellite Reception



FCC Proposes \$32K Penalty for User of GPS Jammer

On Aug 2, the FCC proposed a fine of nearly \$32,000 for an individual whose illegal use of a GPS jamming device on the highway outside Newark Airport interfered with an aviation safety system.

[LEARN MORE...](#)

Get Help with Incorrect Addresses, Maps, and Directions



Do GPS devices show your house or business in the wrong place? Are they sending trucks through your back alley? Don't blame the GPS satellites... contact the map makers! We'll tell you how. [LEARN MORE...](#)

New Additions to GPS.gov

- Aug 6: Presentations from APEC GIT/18 and IGNS 2013
- Jul 30: U.S.-Japan cooperation announcement
- Jun 26: Videos on WAAS and NextGen
- Jun 25: GPS national risk estimate fact sheet and updated summary
- Jun 13: Redesigned what's new and website history pages

[VIEW ALL WEBSITE UPDATES...](#)

Test Your GPS Knowledge

True or false? GPS satellites continuously

GPS User Support



Common Questions

- How do I stop GPS devices from giving wrong directions?
- What can I do about GPS maps directing traffic to my neighborhood?
- How do I report GPS service problems?