



Global Positioning Systems Wing

GPS Program Update to 48th CGSIC Meeting

15 September 2008

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Outline

- **Constellation Status**
- **System Performance**
- **GPS Modernization**
- **International Cooperation**
- **Support to Civil Users**
- **Upcoming Events**



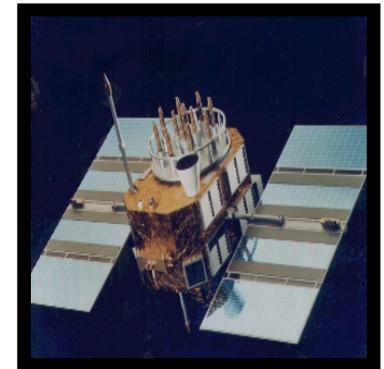
Recent Successes

- **Operational Control Segment (OCS)**
 - Architecture Evolution Plan (AEP)/Launch & Early Orbit, Anomaly Resolution & Disposal Operations (LADO) switch over – Sep 07
 - Alternate Master Control Station fully functional at VAFB, CA
- **Next Generation Operational Control Segment (OCX)**
 - Awarded Phase A contracts to Northrop Grumman & Raytheon, Nov 07
- **GPS IIR(M)**
 - 3 Successful launches since Oct 07
- **GPS IIIA**
 - Awarded to Lockheed Martin Space Systems Company (Newton, PA), May 08



GPS Constellation

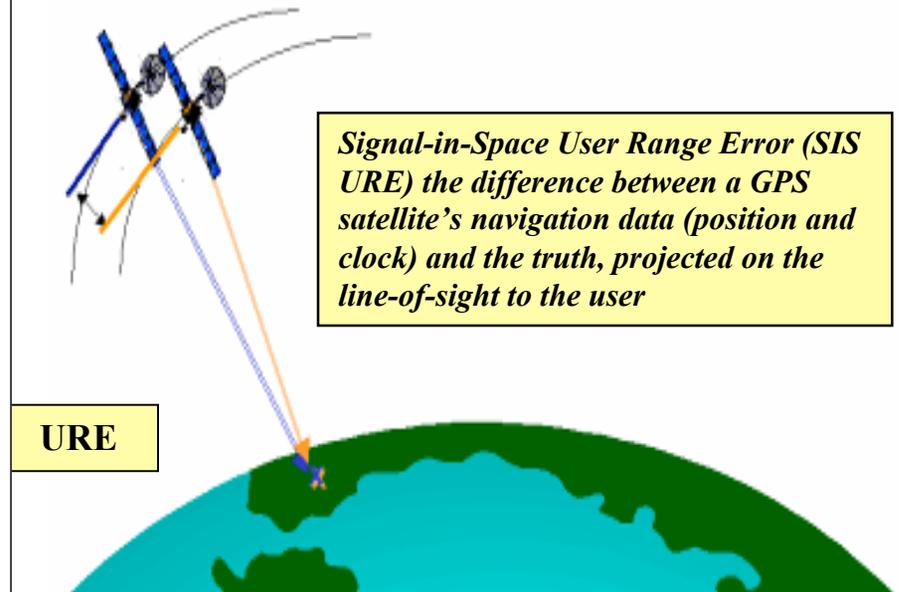
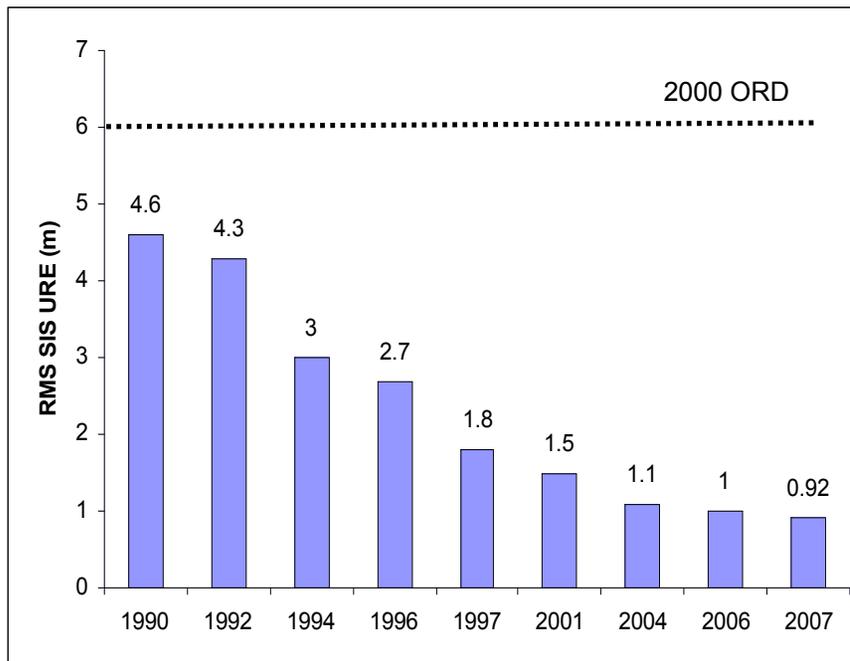
- **29 space vehicles currently in operation**
 - 11 GPS IIA
 - 12 GPS IIR
 - 6 GPS IIR-M
 - Transmitting new second civil signal (L2C)
- **Continuously assessing constellation health to determine launch need**
 - 2 Block IIR(M) satellites remaining
- **Global GPS civil service performance commitment met continuously since December 1993**





Current GPS Accuracy

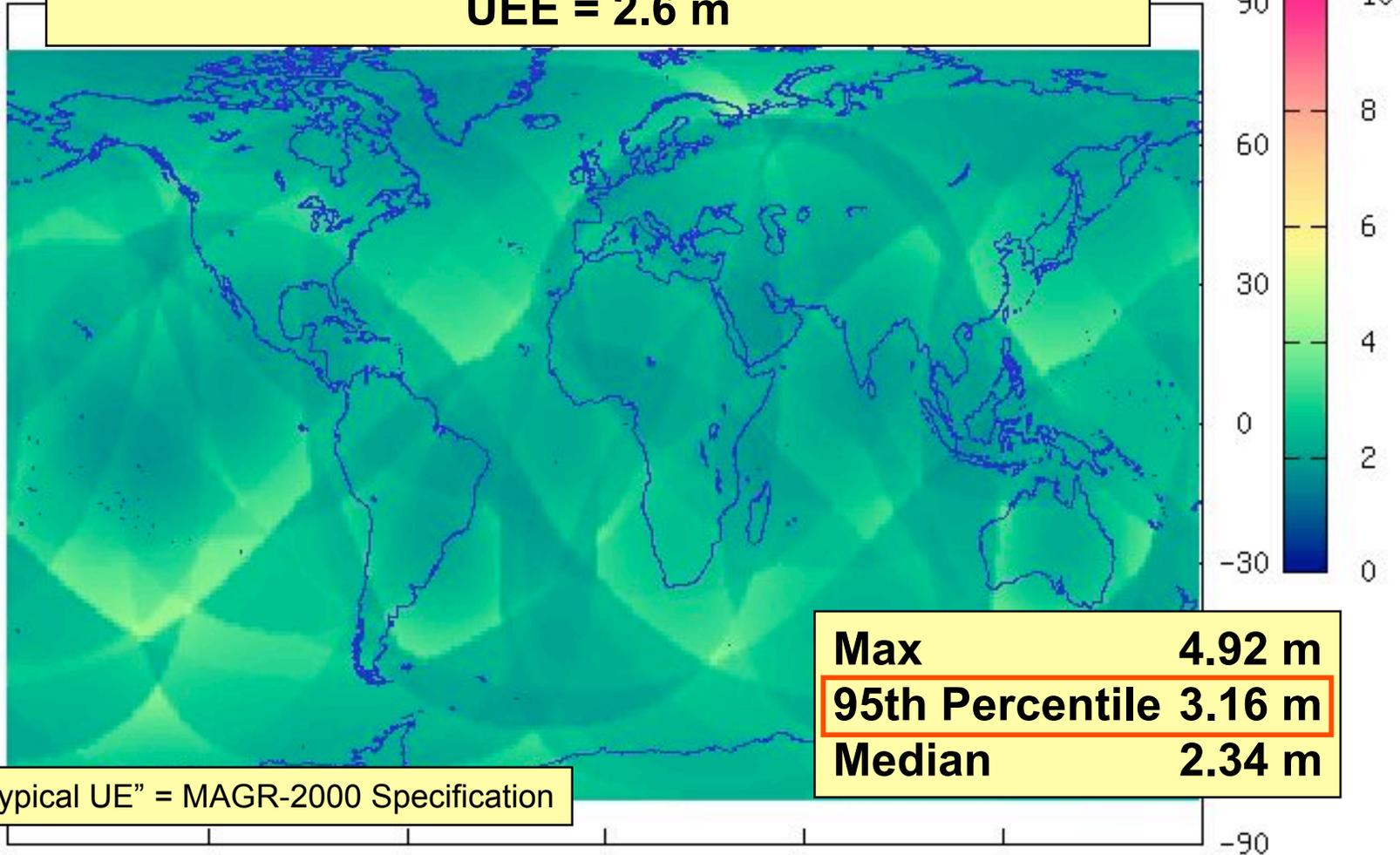
- **Signal-In-Space (SIS) User Range Error (URE)**
 - One-year RMS as of June 08: 0.92 meters
- **Zero Age-Of-Data (AOD) URE**
 - One-year RMS as of June 08: 0.22 meters





Snapshot: Typical UE

Horizontal Position Error at 2008-09-10 16:55:00
UEE = 2.6 m



| | |
|------------------------|---------------|
| Max | 4.92 m |
| 95th Percentile | 3.16 m |
| Median | 2.34 m |

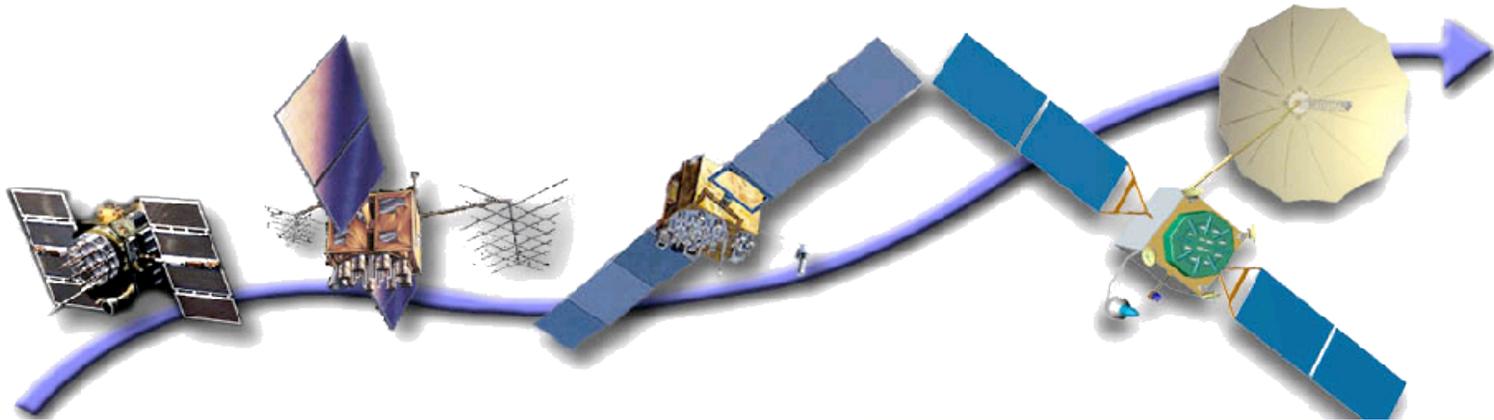
“Typical UE” = MAGR-2000 Specification

-180 -120 -60 0 60 120 180 -90

Median 2.34 m 95 Percentile 3.16 RMS 2.44 m Max 4.92



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 anti-jam power
- Assured availability
- Navigation surety
- Controlled integrity
- Increased security
- System survivability



GPS Modernization – New Civil Signals

- **Second civil signal “L2C”**
 - Designed to meet commercial needs
 - Higher accuracy through ionospheric correction
 - 1st launch: Sep 2006 (GPS IIR-M); 24 satellites: ~2016
- **Third civil signal “L5”**
 - Designed to meet demanding requirements for transportation safety-of-life
 - Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
 - 1st launch: ~ 2009 (GPS IIF); 24 satellites: ~2018
- **Fourth civil signal “L1C”**
 - Designed with international partners for GNSS interoperability
 - Begins with GPS Block III
 - 1st launch: ~2014; 24 satellites: ~2021



Second Civil Signal (L2C)

- **Designed to meet commercial needs**
 - Higher accuracy via ionospheric correction
 - Expected to generate over \$5B in user productivity benefits
- **Available since 2005**
- **On 24 satellites by 2016**



Benefits existing professional receivers



Increases accuracy for consumers



Supports miniaturization, possible indoor use



Third Civil Signal (L5)

- **Designed to meet demanding requirements for transport safety**
- Uses highly protected Aeronautical Radionavigation Service (ARNS) band
- **May also enable global, centimeter-level accuracy using new techniques**
- **Opportunity for international interoperability**
- **Demonstration signal to be launched in October 2008**
- **24 satellites by 2018**





Fourth Civil Signal (L1C)



Under trees

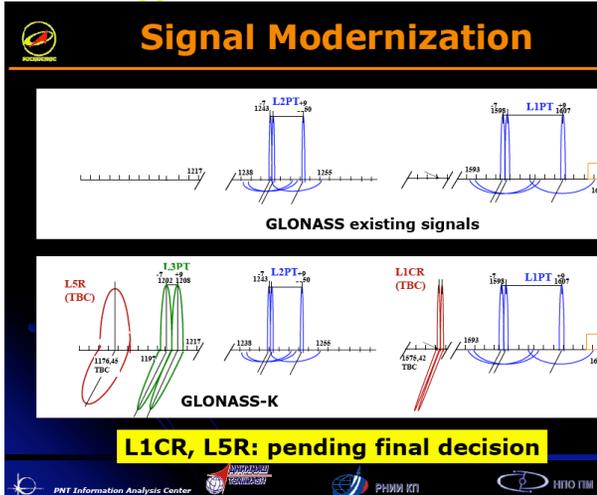


Urban Canyons

- **Designed with international partners for interoperability**
- **Modernized civil signal at L1 frequency**
 - More robust navigation across a broad range of user applications
 - Improved performance in challenged tracking environments
 - Original signal retained for backward compatibility
- **Launches with GPS III in 2014**
- **Transmitted from 24 satellites by ~2021**

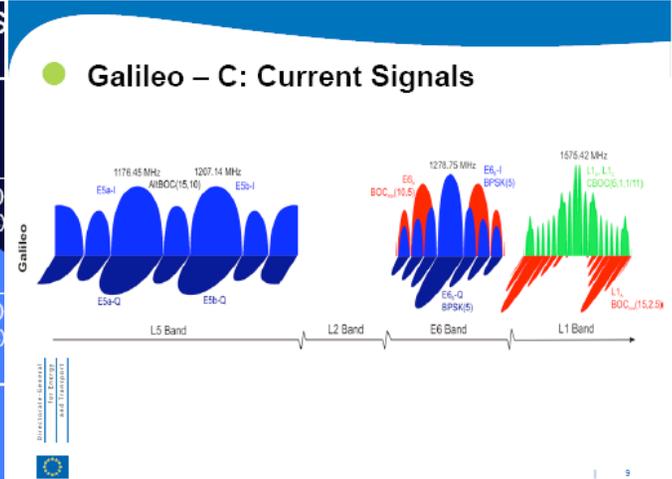


International GNSS Coordination



IRNSS SERVICES & CENTRE FREQUENCIES

| Service Type | Signals | Frequency Band |
|------------------------------|------------|-------------------------------------|
| Standard Positioning Service | 1 MHz BPSK | L5 (1176.45 MHz) S (2492.08 MHz) |
| Precision Service | BOC(5,2) | L5 (1176.45 MHz) S (2492.08 MHz) |



GLONASS

1.3 Signals

| Signal | Carrier frequency (MHZ) | bandwidth (MHZ) | PRN code chip rate (Mcps) | Signal modulation | Navigation data bit rate (bps) |
|--------|-------------------------|-----------------|---------------------------|-------------------|--------------------------------|
| B1 | 1561.098 | 4.092 | 2.046 | QPSK | I: 500 NGSO: 50 Q: 500 |
| B1-2 | 1589.742 | 4.092 | 2.046 | QPSK | |
| B2 | 1207.14 | 24 | 10.23 | QPSK | |
| B3 | 1268.52 | 24 | 10.23 | QPSK | |
| B1-BOC | 1575.42 | 16.368 | 1.023 | MBOC (6, 1, 1/11) | 50 |
| B2-BOC | 1207.14 | 30.69 | 5.115 | BOC (10, 5) | |
| B3-BOC | 1268.52 | 35.805 | 2.5575 | BOC (15, 2.5) | |
| L5 | 1176.45 | 24 | 10.23 | QPSK | |

Compass

GNSS descriptions from ICG web site: www.unoosa.org

4. Planned Signals

Planned Signal List for QZSS

| Generic Signal Name | Center Frequency | Notes |
|---------------------|------------------|---|
| L1-C/A | 1575.42MHz | ■ GPS interoperable signals |
| L1C | | ■ Compatibility and interoperability with existing and future modernized GPS signals |
| L2C | | |
| L5 | | |
| L1-SAIF* | 1575.42MHz | ■ Compatibility with GPS-SBAS ■ WDGPS |
| LEX | 1278.75MHz | ■ Experimental Signal with higher data rate message (2Kbps) ■ Compatibility with Galileo E6 signal |

*L1-SAIF: L1-Submeter-class Augmentation with Integrity Function

QZSS

GPS is actively coordinating with other GNSS on compatibility and interoperability issues in increasingly crowded frequency bands



GPS GNSS Coordination Activities

- **Galileo**
 - Ongoing technical working groups
 - Signed major agreement in 2004, including common civil L1 signal
- **QZSS**
 - Ongoing technical working groups
- **GLONASS**
 - Ongoing technical working groups
 - Signed joint statement in 2006 promoting GLONASS/GPS interoperability
- **Compass**
 - Ongoing ITU coordination meetings
- **IRNSS**
 - Ongoing technical working groups



Performance Standards

- **The AF, DoD, and U.S. Government are committed to being good stewards of GPS**
- **GPS Performance Standards define the levels of performance the U.S. Government commits to provide GPS users**
 - Precise Positioning Service Performance Standard for military users
 - Standard Positioning Service Performance Standard for civil users
 - Revised SPS PS to be released end of September 2008
- **SPS PS available on US Coast Guard Navigation Center website: <http://www.navcen.uscg.gov/>**

GPS Committed to Maintaining & Improving Services For All Users



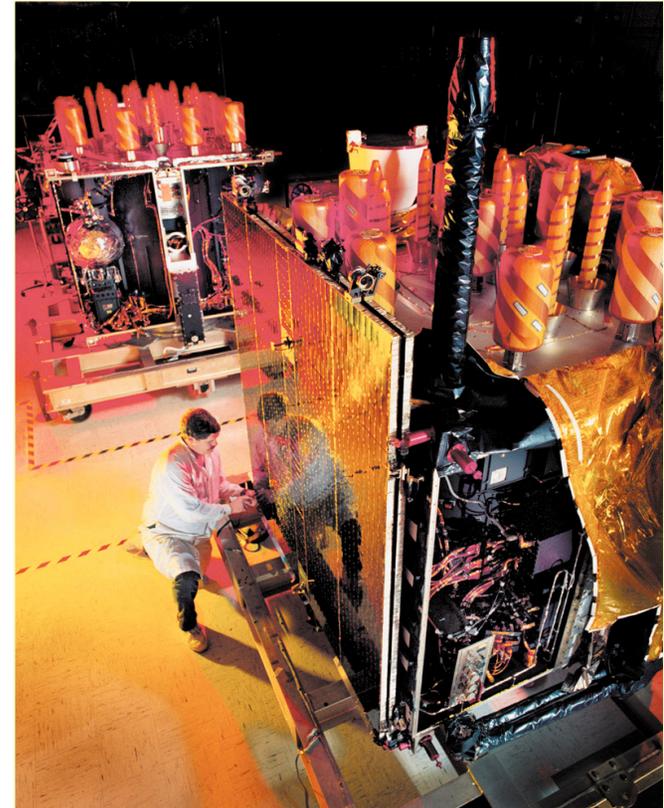
Support to Civil Issues via NPEF

- **National Space-Based PNT Systems Engineering Forum (NPEF) created by US National Policy for Space-based PNT in 2004**
- **Permanent technical forum, co-chaired by FAA and GPSW**
- **Define technical issues and make recommendations**
- **Major study in 2007 and 2008: “Assess Dual Frequency GPS Use and Military Flexible Signal Power implementation”**
 - Civil codeless/semi-codeless users and backward compatibility
 - Extensive coordination with FAA, NASA, NOAA, DOC, DOT, other agencies
 - Primary Findings
 - Over 300,000 civil semi-codeless users world wide
 - GPS will continue enabling codeless/semi-codeless GPS access until December 31, 2020
 - Details available at: www.space.commerce.gov/gps/semicodeless/



FY09 Planned Events

- **Space Segment**
 - Three launches planned in FY09: IIRM-20, IIRM-21 and IIF-1
 - L5 demo payload on IIRM-20
- **Current Ground Segment**
 - Support for IIF launch and operations
 - Support to SAASM UE and functions
 - Remote site equipment upgrade
 - Position Training Emulator release
- **Next Generation Ground Segment**
 - OCX Modernized Capability Engineering Model (MCEM) demonstration
 - OCX System Design Review with two contractors and down-select
- **User Segment**
 - MGUE Phase A testing





L5 Demo Payload on GPS IIR-20

- **Purpose is to secure GPS L5 ITU-R filing**
- **Will not affect primary or secondary missions**
- **Signal is not intended for navigation**
- **Dataless IS-GPS-705 Q5 modulation**
- **PRN 63**
- **Scheduled for launch into slot B2**



Summary

- **GPS has continuously met its commitments to all users since FOC**
- **GPS has had multiple operational and acquisition successes in the past year**
- **Modernization of all GPS Segments is on track**

Maintaining And Improving GPS Services For All Users Is Job #1