



Global Positioning Systems Wing

GPS Program Update to 49th CGSIC Meeting

21 September 2009

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GPS User Equipment Group**



Outline

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



GPS Constellation

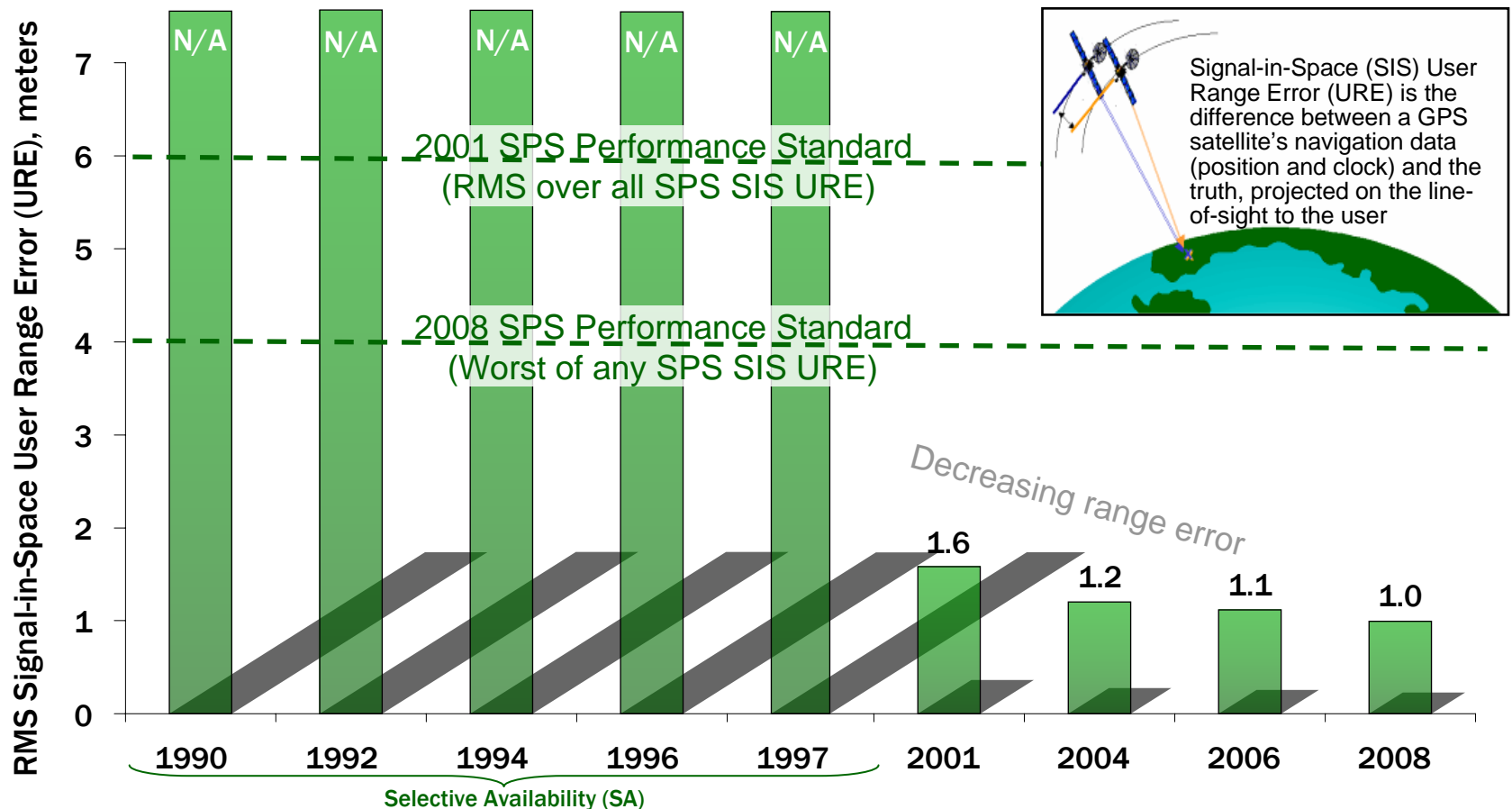
- **Very robust constellation**
 - 30 space vehicles currently set healthy
 - 11 GPS IIA
 - 12 GPS IIR
 - 7 GPS IIR-M
 - 1 GPS IIR-M waiting to be set healthy
 - 3 additional satellites in residual status
- **Global GPS civil service performance commitment met continuously since December 1993**





Current GPS Accuracy

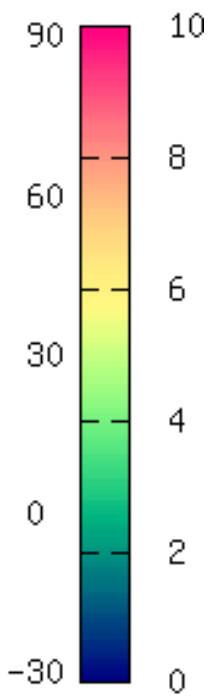
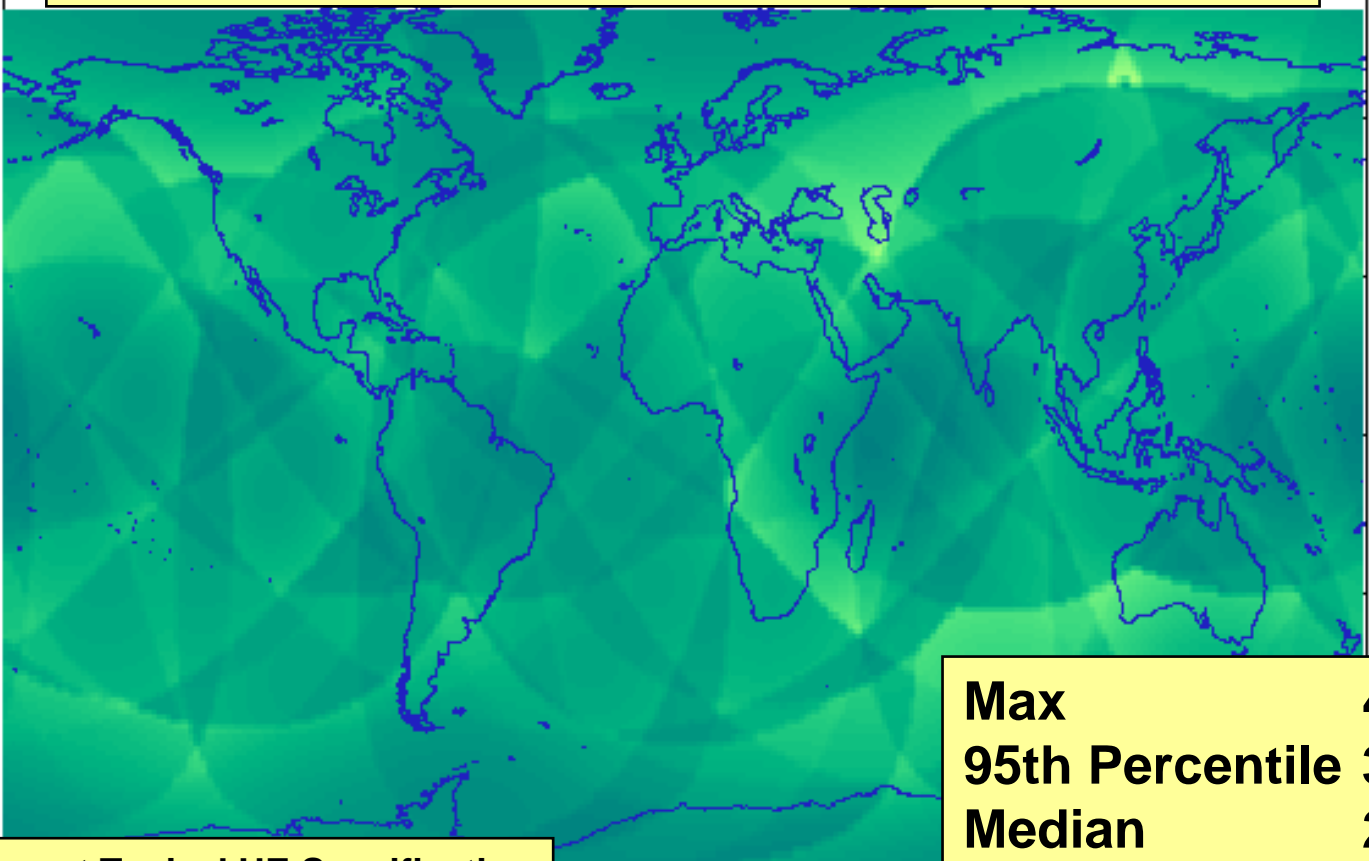
- **SPS Signal-in-Space (SIS) User Range error (URE)**
 - One-year RMS through August 2009: 1.04 meters
- **SPS Zero Age-of-Data (AOD) URE**
 - One-year RMS through August 2009: 0.53 meters





Snapshot: Typical UE

Horizontal Position Error at 2009-03-13 12:00:00
UEE = 2.6 m



Max	4.71 m
95th Percentile	3.02 m
Median	2.37 m

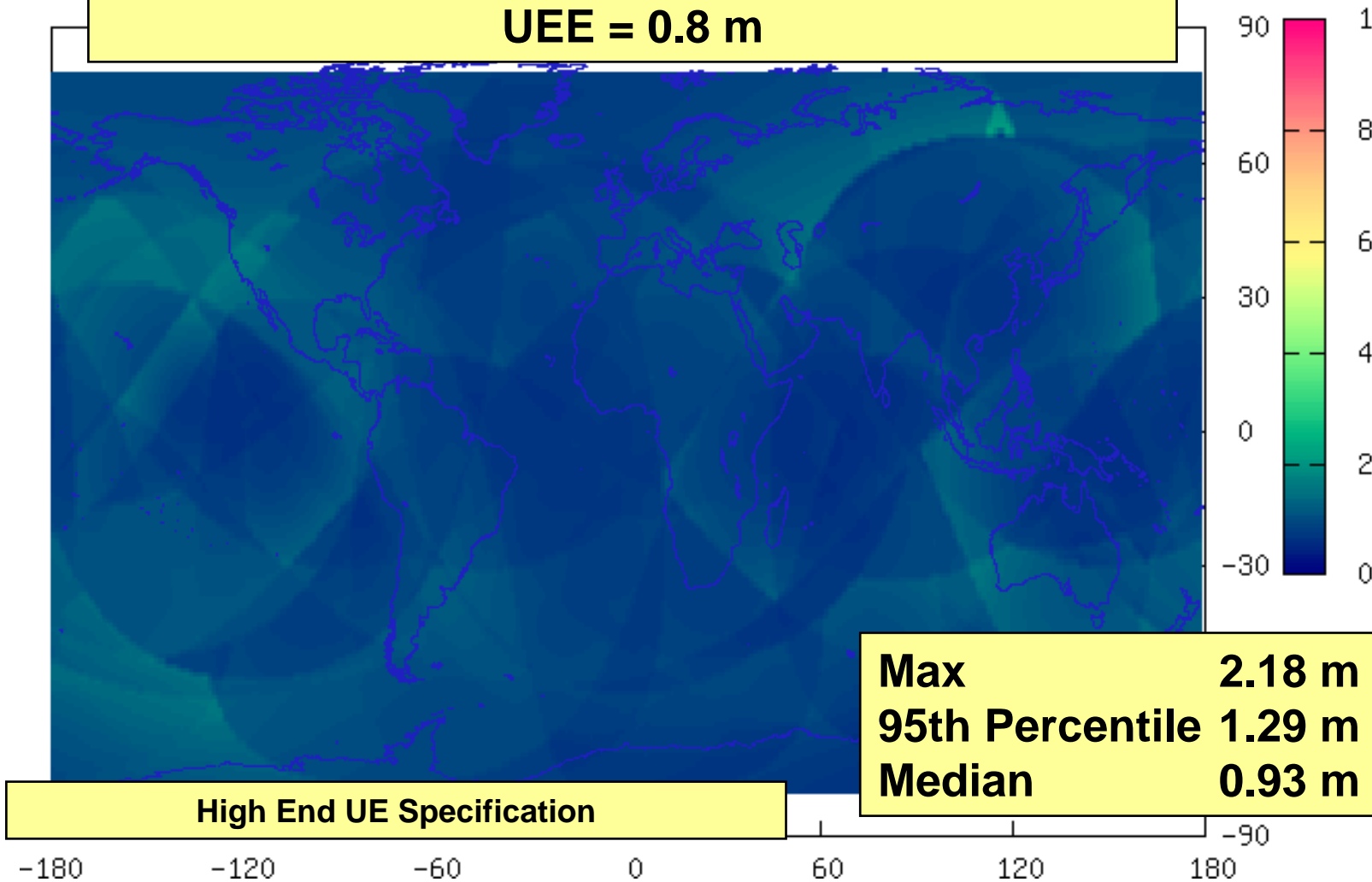
Current Typical UE Specification

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



Snapshot: High End UE

Horizontal Position Error at 2009-03-13 12:00:00
UEE = 0.8 m





Recent Successes

Space Segment

- **SVN 49 launched in March 09**
 - L5 demo payload secured frequency filing
 - Signal distortion investigation still underway
 - ION panel session Wednesday on SVN-49
- **SVN 50 launched in August 09**
 - Set healthy
 - Completed GPS Delta II launches
- **GPS IIF completed Pathfinder testing**
- **GPS IIF-1 completed thermal vacuum test & mission assurance review**
- **GPS IIIA completed Preliminary Design Reviews**





Recent Successes (Cont'd)

Ground Segment

- Delivered new version of OCS (AEP 5.5) to final regression testing with SAASM capability
- Completed successful OCX, SDR, Modernized Capability Demo and RFP release





Recent Successes (Cont'd)

System

- Deploying L2C message Type 0 capability for GPS IIRM to support testing of civil UE testing
- Civil Monitoring Performance Specification (CMPS) – 30 Apr 09
- L1C phase relationship configuration established
 - L1C components will be in phase with L1 P(Y)-code





IIF Pathfinder (May – Sep 2009)



- IIF-2 shipped to Cape for risk mitigation
- All transport procedures proven successful
- All mechanical activities performed to plan and facility interfaces verified
- Consolidated System Testing checked all interfaces to OCS AEP and LADO
- Cut IIF-1 critical path to launch by 2 months and reduced schedule risk
- Best Practice for future GPS programs





GPS IIF Performance

Tech Performance Measure	Requirement	Current Status
L1 C/A User Rec. Pwr.	> -158.5 dBW	-156.9
L1 P(Y) User Rec. Pwr.	> -161.5 dBW	-159.9
L1 M User Rec. Pwr.	> -158 dBW	-156.3
L2 C User Rec. Pwr.	> -160 dBW	-159.60
L2 P(Y) User Rec. Pwr.	> -161.5 dBW	-160.96
L2 M User Rec. Pwr.	> -161 dBW	-160.56
L5 User Rec. Pwr.	> -154.9 dBW	-154.1
Mean Mission Duration	> 9.9 years	10.86
SV Reliability	> 0.61	0.76090

GPS IIF is meeting or exceeding all specified requirements



GPS IIF Summary

- **GPS IIF available for launch in November 2009**
- **New/improved capabilities for civil and military users**
- **Reliable sustainment of GPS constellation over the coming years**
- **Partnership between GPSW and Boeing continues to focus on mission success**





Modernization

Satellites

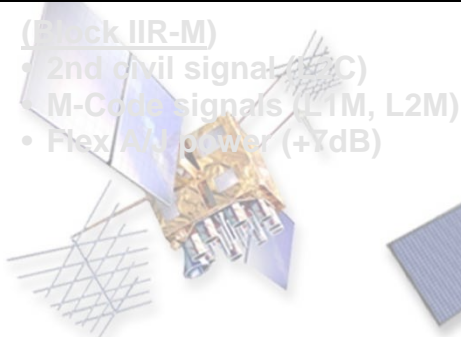
Legacy (Block IIA/IIR)

- Basic GPS
- C/A civil signal (L1C/A)
- Std Pos. Service
- Precise Pos. Service
 - L1 & L2 P(Y) nav
- NDS



(Block IIR-M)

- 2nd civil signal (L2C)
- M-Code signals (L1M, L2M)
- Flex A/J power (+7dB)



(Block IIF)

- 3rd civil signal (L5)



GPS III (Block III)

- Increased accuracy
- Increased A/J power (up to 20 dB)
- Signal integrity
- Search and Rescue
- Common Galileo OS & GPS (L1C)

Control Systems

Legacy

- TT&C
- L1 & L2 monitoring

Upgraded (AEP)

- GPS IIF TT&C
- SAASM



OCX Blk 1 (Modernized)

- Flexible Architecture
- Mission Ops for all SVs
- Control 1 new signal (L2C, L5, or M-Code)
- Control Flex Power
- Signal Integrity Monitoring

OCX Blk 2

- LADO ops for all SVs
- All new signals (including L1C)

OCX Blk 3&4 (GPS III B/C)

- Manage Spot Beam
- NAVWAR, GNOC
- Mission Planning
- Effects-Based Ops

User Equipment

Legacy

- Man Pack
- MAGR, PLGR
- RCVR-3A, 3S
- OH, UH
- FRPA, CRPA



Upgraded

- DAGR • GAS-1
- CSEL • MAGR2K
- GB-GRAM



MGUE (Modernized)

- Anti-Jam, Anti-Spoof
- Military exclusivity
- Handheld / Anti-Tamper
- Gnd & Avionics embed
- Auto OTA Rekeying

Cornerstones to the Future GPS are GPS III, OCX, & MGUE

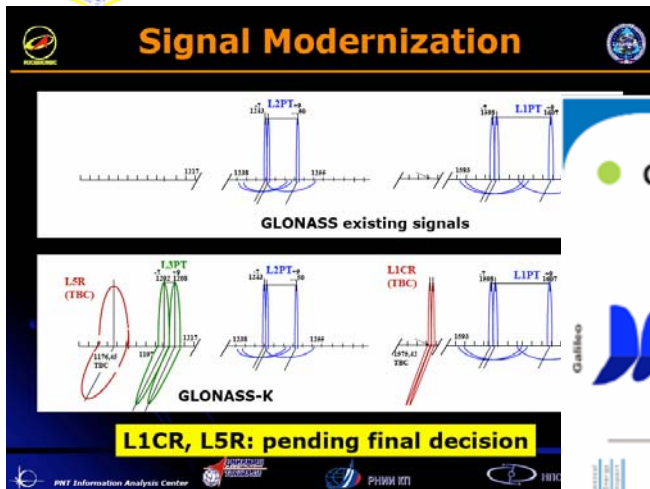


GPS Modernization – New Civil Signals

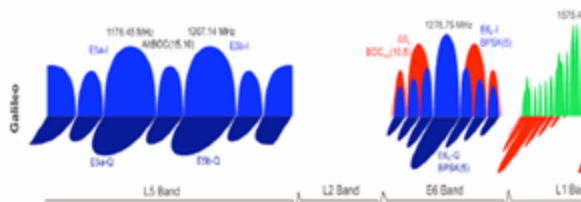
- **Second civil signal “L2C”**
 - Designed to meet commercial needs
 - Higher accuracy through ionospheric correction
 - 1st launch: Sep 2005 (GPS IIR-M); 24 satellites: ~2016
- **Third civil signal “L5”**
 - Designed to meet demanding requirements for transportation safety-of-life
 - 1st launch: ~ 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



International GNSS Coordination



Galileo – C: Current Signals



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 GSO: 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	50
B1-BOC	1575.42	16.368	1.023	MBOC (6, 1, 1/11)	
B2-BOC	1207.14	30.69	5.115	BOC (10, 5)	
B3-BOC	1268.52	35.805	2.5575	BOC (15, 2.5)	50
L5	1176.45	24	10.23	QPSK	

GLONASS

Galileo

Compass

4. Planned Signals

Planned Signal List for QZSS

Generic Signal Name	Center Frequency	Notes
L1-C/A	1575.42MHz	<ul style="list-style-type: none"> GPS interoperable signals Compatibility and interoperated existing and future modernized signals
L1C		
L2C	1227.6MHz	
L5	1176.45MHz	<ul style="list-style-type: none"> Compatibility with GPS-SBAS WDGPS
L1-SAIF ^a	1575.42MHz	
LEX	1278.75MHz	<ul style="list-style-type: none"> Experimental Signal with high rate message (2Kbps) Compatibility with Galileo E6

^aL1-SAIF: L1-Submeter-class Augmentation with Integrity Function

QZSS

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)

IRNSS



International Committee on Global Navigation Satellite Systems



Support to Civil Users

- **Resident Program Manager for Civil Applications**
 - DOT representative located within GPSW
- **Freely available, accurate, and stable documentation**
 - Standard Positioning Service Performance Standard (SPS PS)
 - Interface Control Documents (ICDs) / Interface Specifications (ISs)
 - Technical definitions for L1 C/A, L2C, L5, and L1C signals
- **Public Interface Control Working Groups (ICWGs)**
 - Insight, access, and influence to ICDs/Iss
- **Special manufacturer/user outreach**
 - Developing resolution plans for SVN-49 anomaly



Upcoming Events

- **Wednesday, 23 Sep 09**

- ION panel session dedicated to SVN-49 anomaly

- **Public Interface Control Working Groups (ICWGs)**

- Tuesday, 29 Sep 09

- ICWG for IS-GPS-200

- Wednesday, 30 Sep 09

- ICWG for IS-GPS-800

- Thursday, 1 Oct 09

- ICWG for IS-GPS-705

In Los Angeles

- **Early 2010**

- Launch of first IIF satellite



The Military GPS Challenge

- Bring advantages of commercial market to the joint and allied warfighter,
- and*
- Maintain the advantages of military exclusivity and resistance to electronic attack



COTS features



MIL advantages



Warfighter effectiveness

S



Solutions

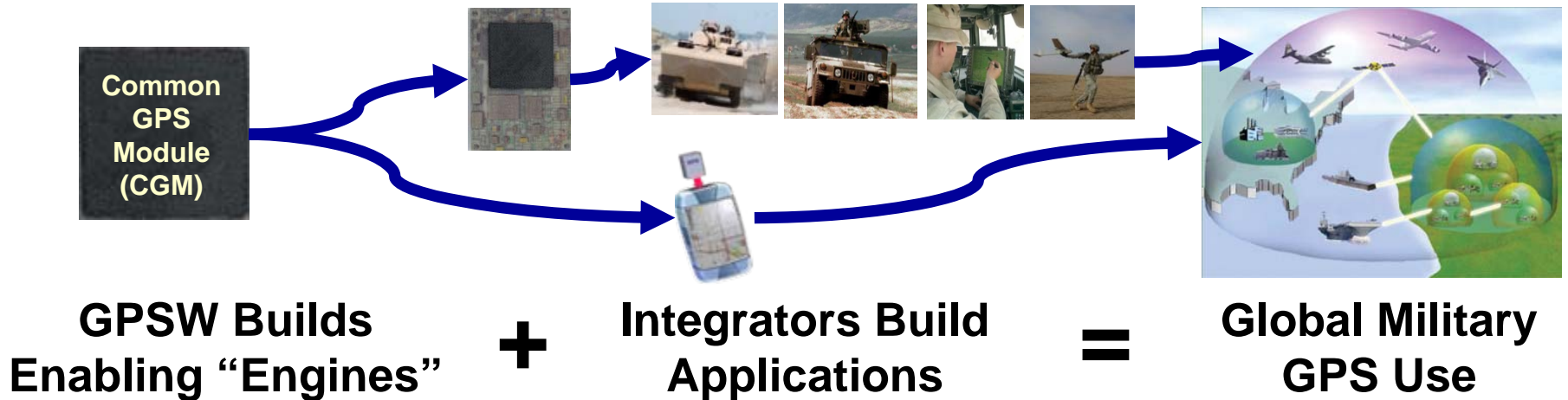
- Previous approach (2003): Study commercial devices and levy their benefits as requirements in a traditional military acquisition



**DAGR – Defense Advanced GPS Receiver:
All-in-view, Second Generation Security, under 1 lb**

- **Pro:** Strong military receiver performance
- **Con:** Interface and features are quickly outdated

Current approach (2012): Develop military components for insertion into COTS or non-COTS systems





Keys to the Global Success of GPS

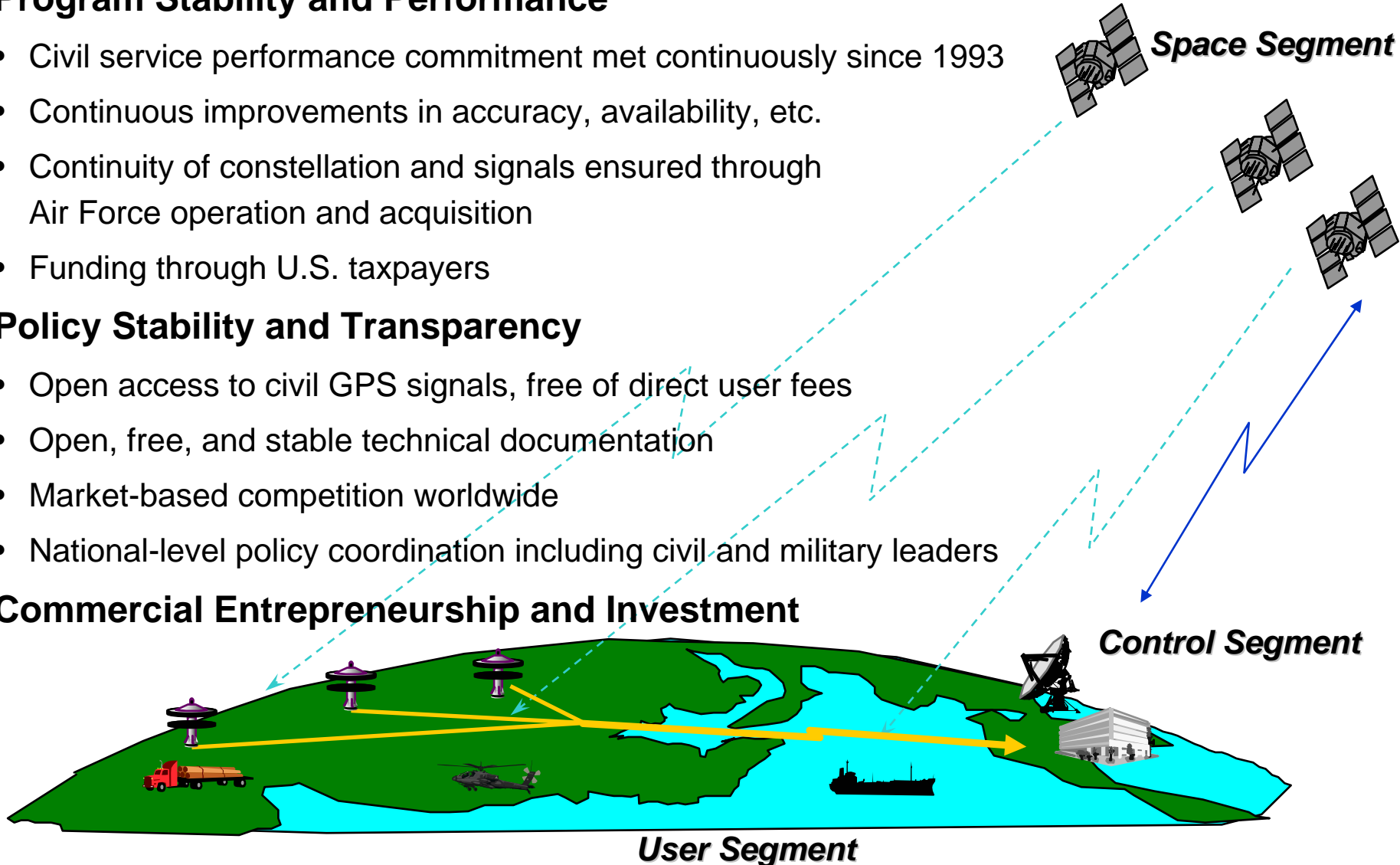
- **Program Stability and Performance**

- Civil service performance commitment met continuously since 1993
- Continuous improvements in accuracy, availability, etc.
- Continuity of constellation and signals ensured through Air Force operation and acquisition
- Funding through U.S. taxpayers

- **Policy Stability and Transparency**

- Open access to civil GPS signals, free of direct user fees
- Open, free, and stable technical documentation
- Market-based competition worldwide
- National-level policy coordination including civil and military leaders

- **Commercial Entrepreneurship and Investment**





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