
NAVSTAR
Global Positioning System
NAVSTAR GPS
Civil GPS Service
Interface Committee (CGSIC)
GPS Program Update
25 September 2006
Col Allan Ballenger
Commander, GPS Wing
Space and Missile Systems Center

Overview

- Mission success is top priority
- Sustaining worldwide military/civil utility
- Modernizing for civil and military users
- Acquisition challenges
  - Requirements – civil & military
  - Balancing sustainment & modernization
    - Cost & schedule of modernization efforts
  - Synchronizing space, control, and user equipment upgrades
- “Back to Basics” and incremental block approach

Continuously improving GPS services for military and civil users worldwide

Global Positioning Systems Wing

Mission:

Acquire and sustain survivable, effective, and affordable global positioning & timing services for our military and civil users

Col Allan Ballenger

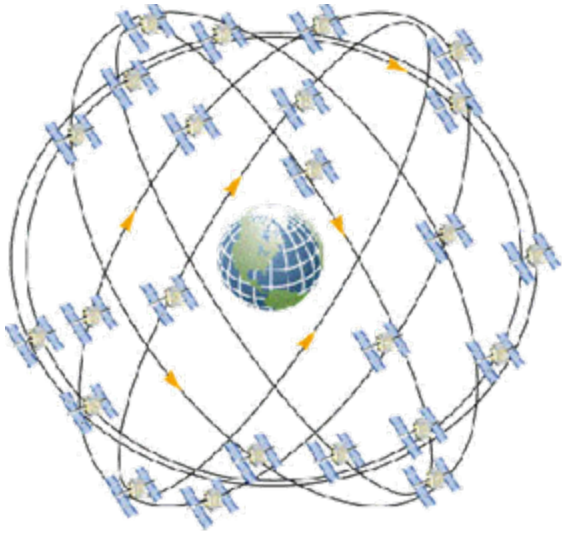
NAVSTAR GPS

We are the Center of Excellence for Space-Based Navigation

GPS Enterprise

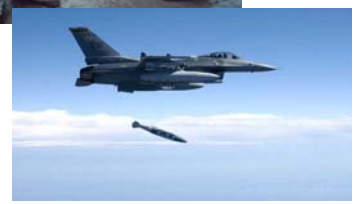
International Cooperation

- Japan – QZSS
- Russia - GLONASS
- Europe and other countries



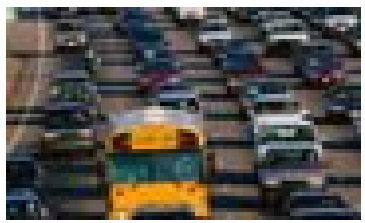
Department of Defense

- U.S. Army
- U.S. Navy
- U.S. Marine Corps



Civil applications

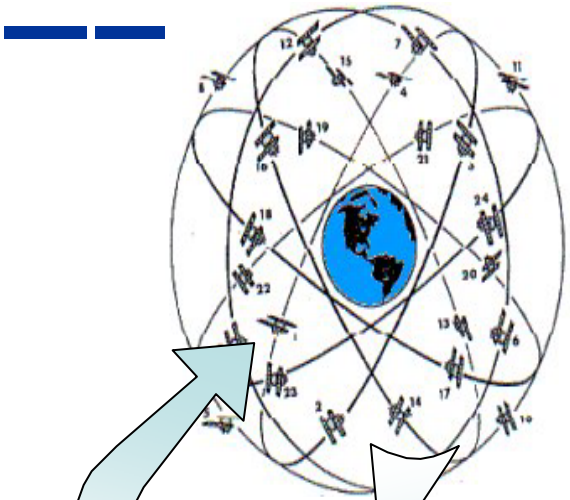
- Search and rescue
- Surveying and mapping
- Trucking and shipping
- Aviation
- Offshore drilling
- Fishing and boating

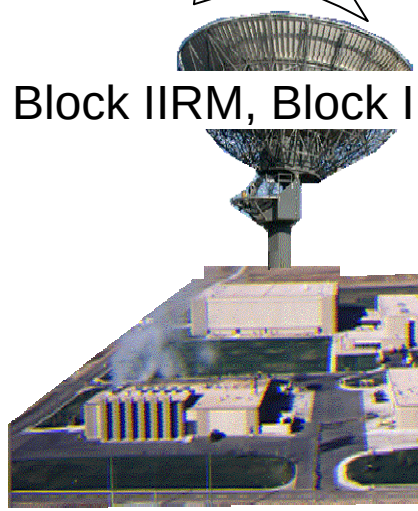


Department of Transportation
- and other Departments as well

GPS Program Overview

- **The Global Positioning System (GPS)**
  - Satellite-based radio navigation system
  - Provides continuous global coverage
  - Dual use military and civil
  - Space, Control, User segments
- **Space vehicle blocks**
  - Block IIA, IIR (on-orbit)
  - Block IIRM (25 Sep 05 first launch)
  - Block IIF (late 2008 first launch)
  - Block III (2013 first launch)
- **Control systems**
  - GOSC – Legacy system (Block IIA)
  - AEP – Architecture Evolution Plan (Block IIR, Block IIRM, Block IIF)
  - OCX – Next Generation control system
- **User equipment generations**
  - Miniaturized Airborne GPS Receiver (MAGR)
  - Defense Advanced GPS Receiver (DAGR)
  - Modernized User Equipment (MUE)
  - Modernized Space Receiver (MSR)





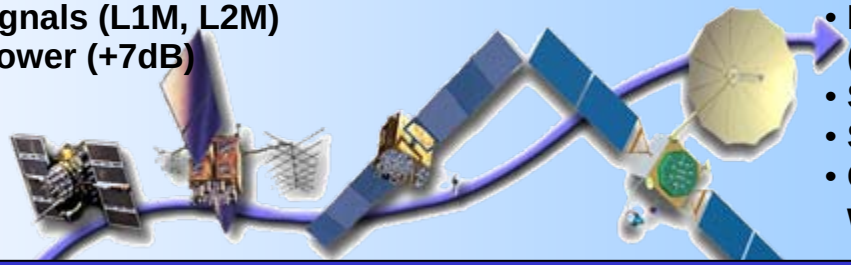
GPS Evolution

Space Segment

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

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

Modernized (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 signals with Galileo (L1C)

Control Segment

Legacy
- TT&C
- L1 & L2 monitoring

Upgraded (AEP)
- IIR-M IIF TT&C
- WAGE, AII, LADO
- SAASM
- New MCS/AMCS

Modernized (OCX V1)
- New Architecture
- Signal Monitoring

GPS III (OCX V2)
- GPS III TT&C
- NAVWAR, GNOC
- L1C, L2C, L5
- Flex Power
- Real-Time C2

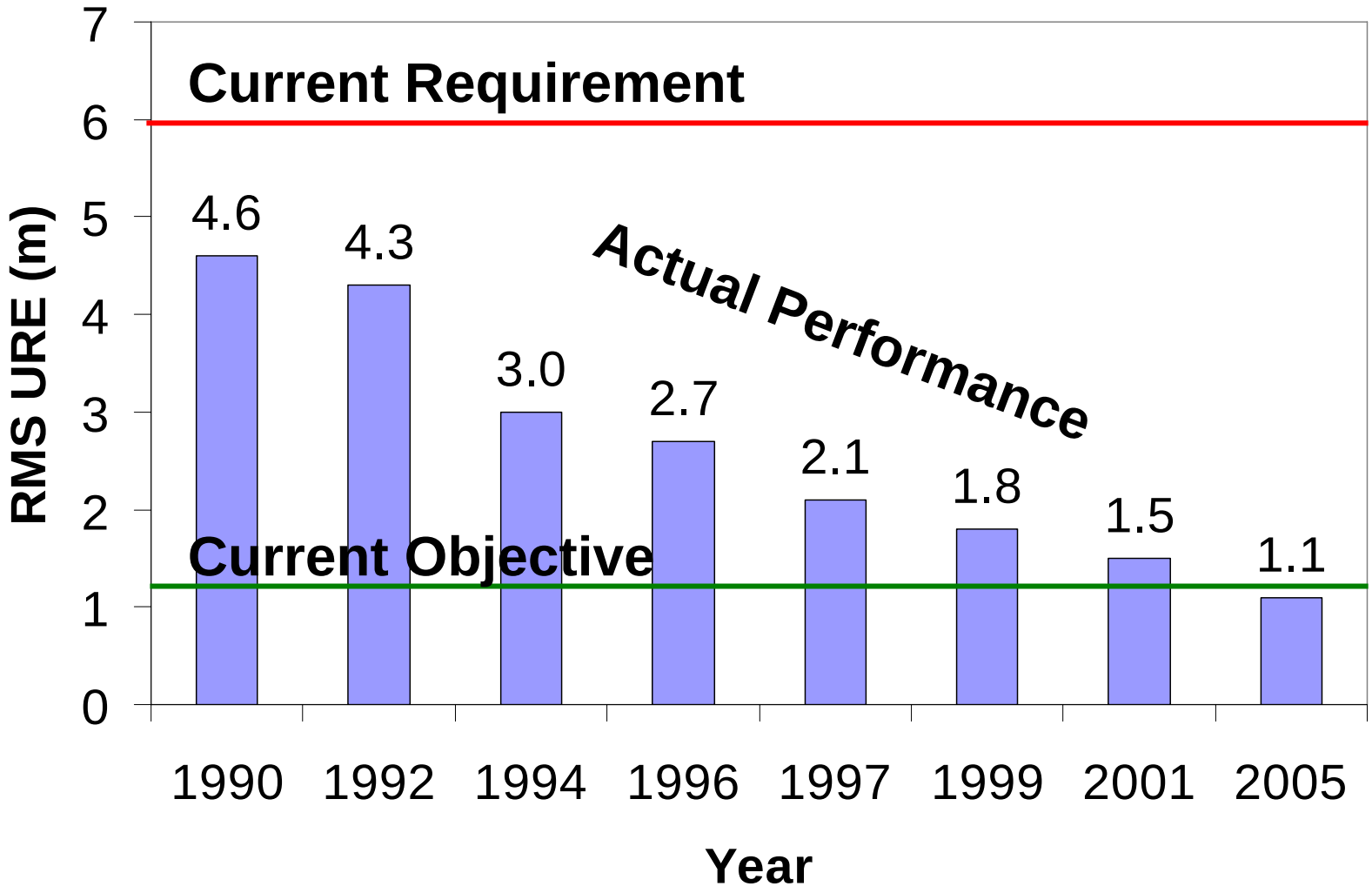
User Segment

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

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

Modernized
- MUE
- MSR

GPS User Range Error (URE) History



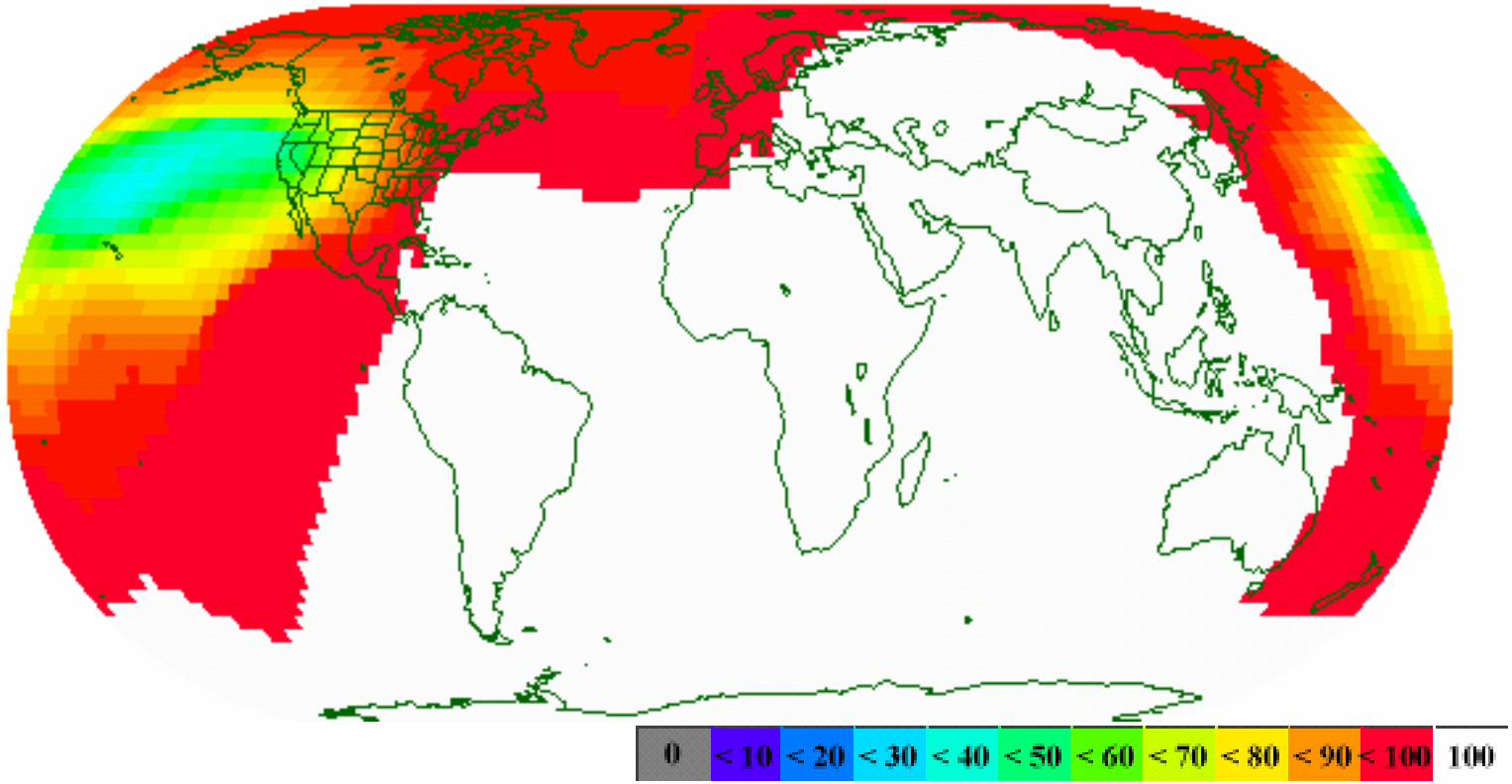
Accomplishments Since Last Year

- Launched a new era of GPS services for military & civil users
  - **GPS IIR-14(M) launched 25 Sep 05, operational on 16 Dec 05**
  - **New military signal (M-Code) and new civil signal (L2C)**
- Fielded operational improvements (AFSPC 50 SW)
  - **Legacy Accuracy Improvement Initiative operational**
    - Increases accuracy 10%-50%
  - **TALON NAMATH provides "zero age of data" to warfighters**
- Refined acquisition strategies
  - **GPS III – next incremental block of satellites**
  - **OCX – next-generation ground control network**
  - **MUE – Modernized User Equipment contracts awarded May 06**
  - **MSR – Modernized Space Receiver in source selection**

What Legacy Accuracy Improvement Initiative (L-AII) Provides

- Specialized defense systems will see 35% improvement
- All users see a small accuracy improvement
- More importantly, all users enjoy improved SV monitoring
- Additional tracking data eliminates monitoring gaps
  - Every satellite now “watched” by at least two tracking stations at all times—two stations needed
  - Without L-AII some satellites were out of view of any tracking station for over two hours at a time
- Air Force controllers now can see satellite problems sooner
- User exposure to erroneous satellite signals is reduced

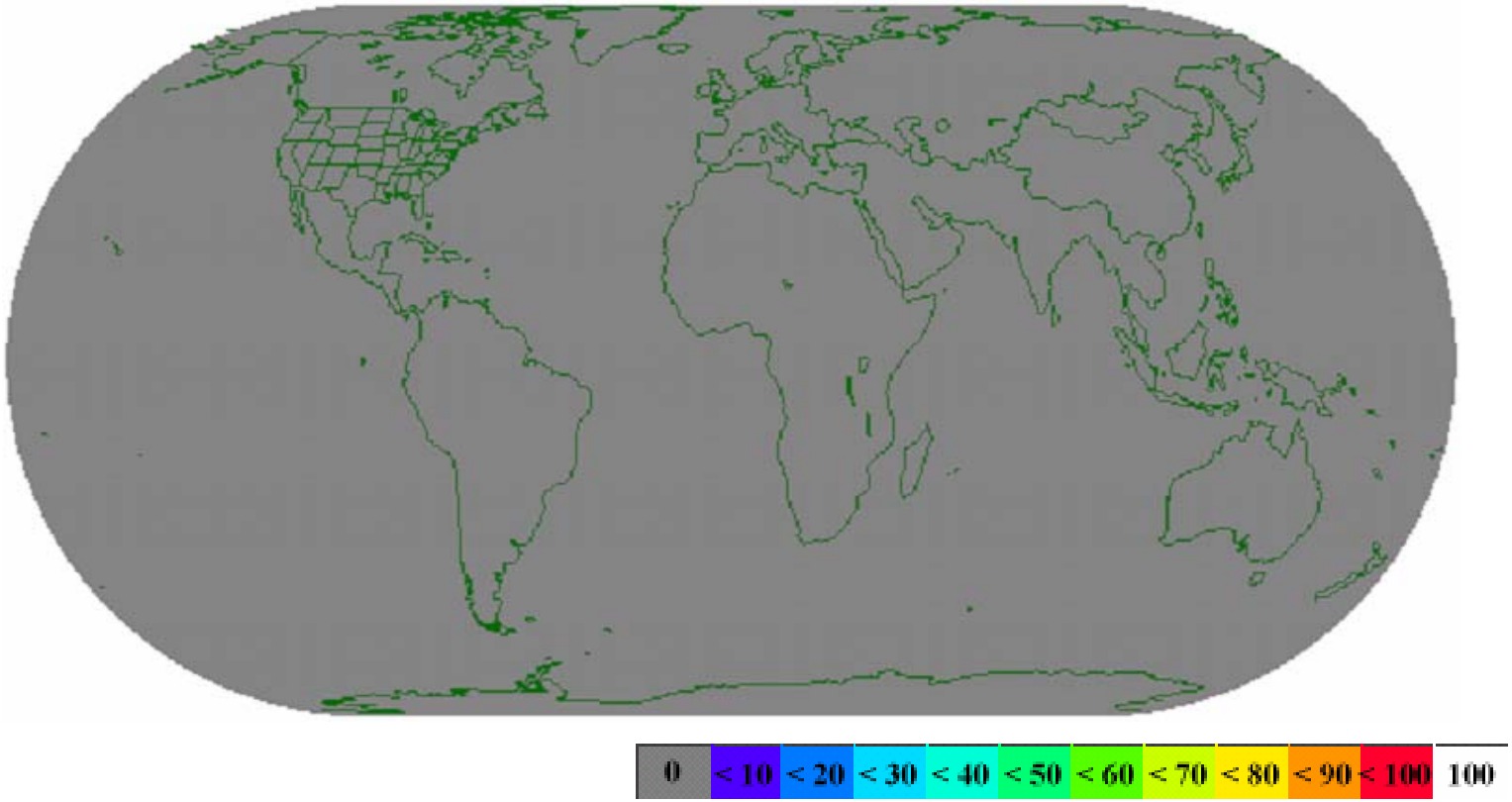
SV Monitoring Before L-All



GPS users on approximately half of the Earth's surface (shown in white) see at least one unmonitored GPS satellites 100 % of the time

A GPS satellite is considered to be "monitored" if it is seen by at least two GPS tracking stations; the minimum of two stations ensures that an alarm is caused by a problem on the satellite and not at a tracking station. Monitoring enables GPS operators to identify errors in satellite transmissions; further upgrades to GPS are needed to ensure that corrective action can executed with sufficient timeliness.

SV Monitoring After L-All



No GPS users anywhere on the Earth's surface ever see an unmonitored GPS satellite

A GPS satellite is considered to be "monitored" if it is seen by at least two GPS tracking stations; the minimum of two stations ensures that an alarm is caused by a problem on the satellite and not at a tracking station. Monitoring enables GPS operators to identify errors in satellite transmissions; further upgrades to GPS are needed to ensure that corrective action can executed with sufficient timeliness.

U.S Space-Based Positioning, Navigation & Timing (PNT) Policy – 8 Dec 04

- Objectives
  - Provide uninterrupted availability of PNT services
  - Meet growing national, homeland, economic security, civil requirements, and scientific and commercial demands
  - Remain the pre-eminent military space-based PNT service
  - Continue to provide civil services that exceed or are competitive with foreign civil space-based PNT
  - Remain essential components of internationally accepted PNT
  - Promote U.S. technological leadership in applications involving space-based PNT
- New National PNT EXCOM & National PNT Coord Office

Ubiquitous, ultra-precise PNT is a central enabling utility of the Information Age

Top Priorities

- ***Sustaining*** capabilities for military and civil users worldwide
  - Launching satellites to sustain constellation – partnership with 50th Space Wing
  - Fielding GPS enhancements such as Legacy Accuracy Improvement Initiative
- ***Modernizing*** by adding new signals and capabilities
  - Second IIR-M launch Sep 06, first IIF launch 2008, first III launch 2013
  - New civil and military GPS signals
  - Transitioning control segment from legacy to AEP in Apr 07
  - Continuing work with Galileo and international community
- ***Planning*** to execute next generation of GPS
  - Acquisition strategies for space, ground, and user segments
  - Synchronizing space, control, and user equipment upgrades
- ***Managing*** GPS systems & being responsive to diverse customer base
  - National PNT Executive Committee (NPEC) next meeting Oct 06
  - GPS Independent Review Team, Defense Science Board recommendations

Department of Defense and Air Force are committed to responsible stewardship of GPS as a global utility

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BACKUP

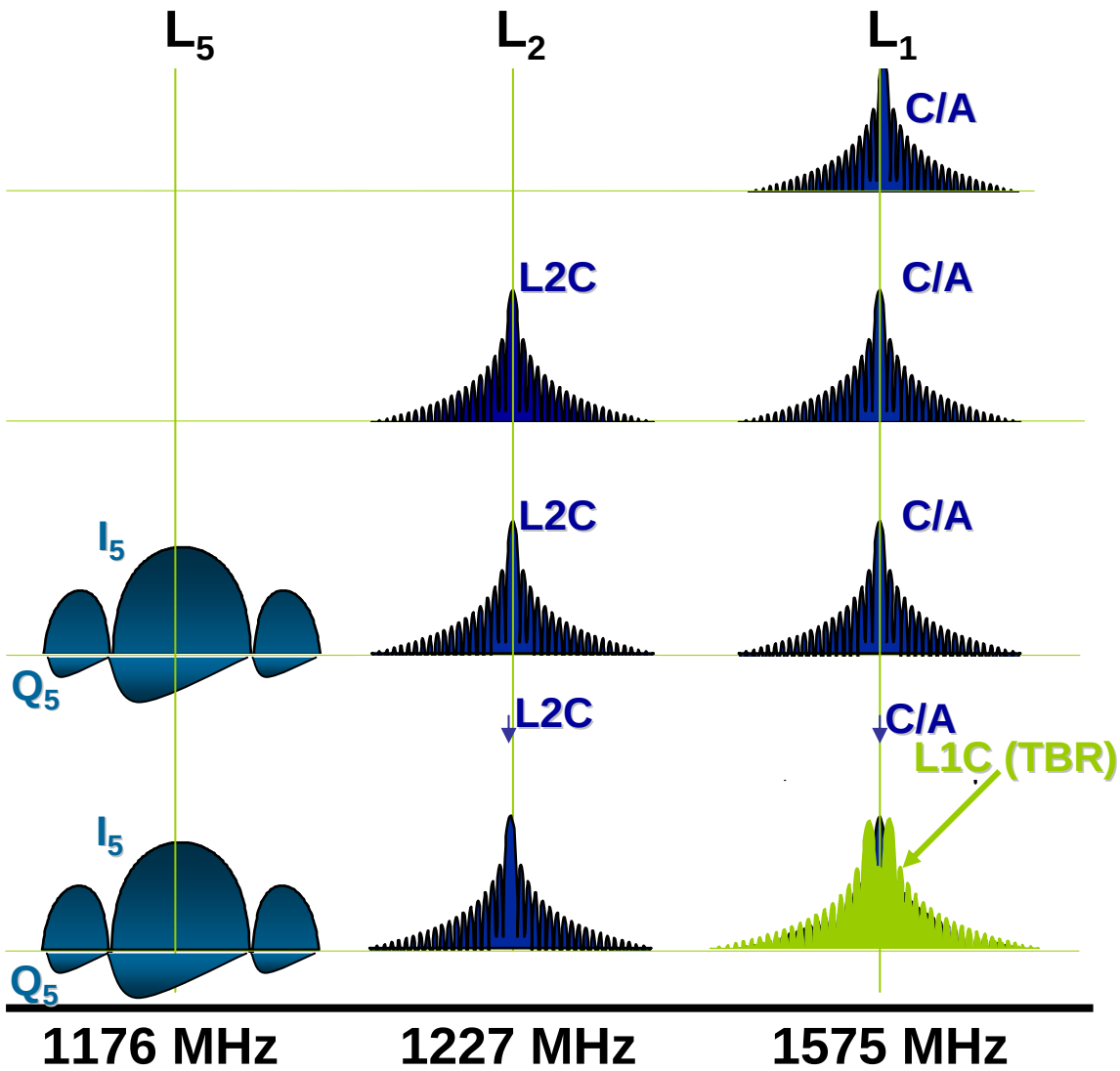
GPS Civil Signals

1st Civil
Block II/IIA/IIR

2nd Civil
Block IIR-M

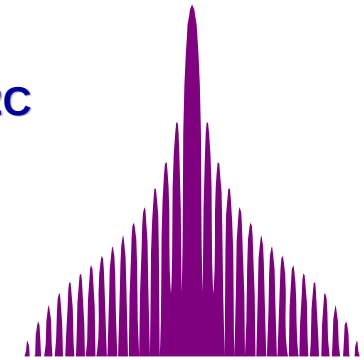
3rd Civil
Block IIF

4th Civil
Block III



L2C Second Civil Signal

- Benefits of L2C
  - **Improves PNT for current scientific/commercial dual frequency users via ionospheric effect cancellation**
  - **Extends safety-of-life, single-frequency E-911 applications**
  - **Provides better protection than C/A against code cross correlation and continuous wave (CW) interference**
  - **Improved data structure for enhanced data demodulation**
  - **Provides backup link in case of local interference**
- Defined in IS-GPS-200D
- First available with IIR-M launch 21 Sep 05
  - **Configuration of signal determined via ongoing interagency process**
  - **Use L2C at user's risk--configuration can change (NANU process)**



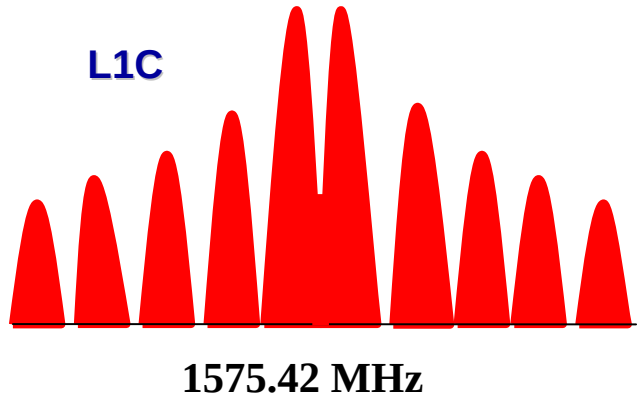
L5 Third Civil Signal

- **Improves signal structure for enhanced performance**
  - **Higher power**
  - **Wider bandwidth = 10x processing gain**
  - **Longer spreading codes (10x C/A)**

- **Aeronautical Radionavigation Services band**
  - **WRC-2000 added space signal component to this aeronautical band**
  - **So aviation community can manage interference to L5 more effectively than L2**
- **Defined in IS-GPS-705**
- **First available with first GPS IIF launch (2008)**

New L1C Signal Improvements

- Implementation will provide C/A code to ensure backward compatibility
- Assured of 1.5 dB increase in minimum C/A code power to mitigate any noise floor increase



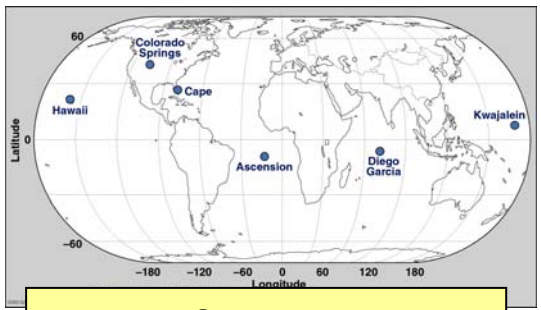
- Data-less signal component pilot carrier improves tracking
- Enables greater civil interoperability with Galileo L1
- First available with first GPS III launch in 2013

Civil Applications

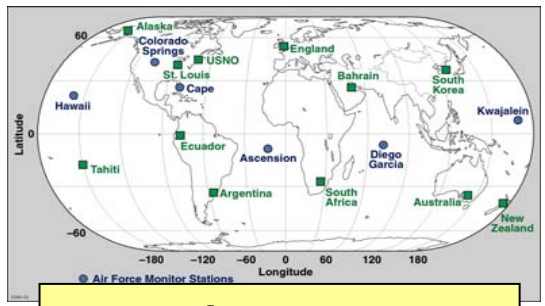
- **Enabling technology**
  - **Unlimited growth potential**
  - **$68 billion industry worldwide by year 2010**
- **Wide use in transportation safety**
  - **Aviation, maritime, railroad, highway, etc.**
  - **Potential to reduce land-based navigation systems**
  - **Centerpiece of future transportation infrastructure**
- **Ever increasing range of civil uses**
  - **Telecommunications, surveying, law enforcement, emergency response, agriculture, mining, etc.**
  - **Used in conjunction with remote sensing**
  - **Supporting civil applications never envisioned**

How L-AII Works

- Key to L-AII is incorporation of 6 additional ground stations that track GPS satellites
  - Additional tracking stations improve the GPS satellite position accuracy
  - Additional stations monitor satellite errors, making the GPS signals more trustworthy
  - An additional five stations will be added



Before L-AII:
6 Monitor Stations



After L-AII:
12 Monitor Stations

Mission

User Segment

NDS

Vision:
We are the Center of Excellence for Space-Based Navigation

Mission:
Acquire and Sustain Survivbable, Effective, and Affordable Global Positioning Services for our Customers

Motto:
"Any Time, Any Place
Right Time, Right Place"

Space Segment

Control Segment

Value Proposition of Space: GPS as a Transformation Enabler

WWII Schweinfurt Raids vs Today:
Dropped 24 million pounds of bombs to destroy 5 ball bearing plants

Same mission today…GPS + B-52 + 5 JDAMs

Operational Support

Patrol using GPS outside Tuzla Air Base, Bosnia

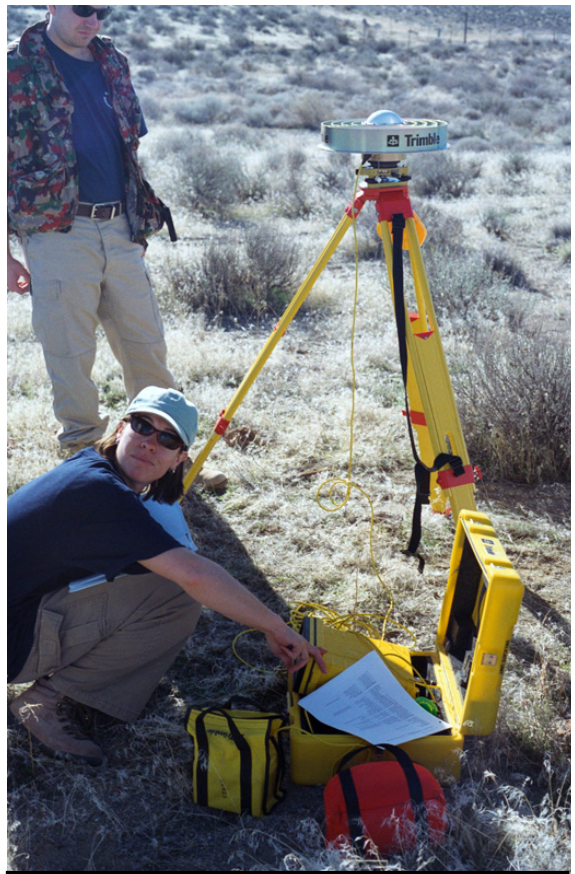
F-16 dropping GPS-guided Joint Direct Attack Munition

Military applications

- Force location
- Navigation
- Force employment
- Weapon guidance
- Satellite positioning
- Comm network timing

Civil applications

- Search and rescue
- Surveying and mapping
- Trucking and shipping
- Aviation
- Offshore drilling
- Fishing and boating



Investigating sediment depths in Nevada

A global utility for military and civilian applications

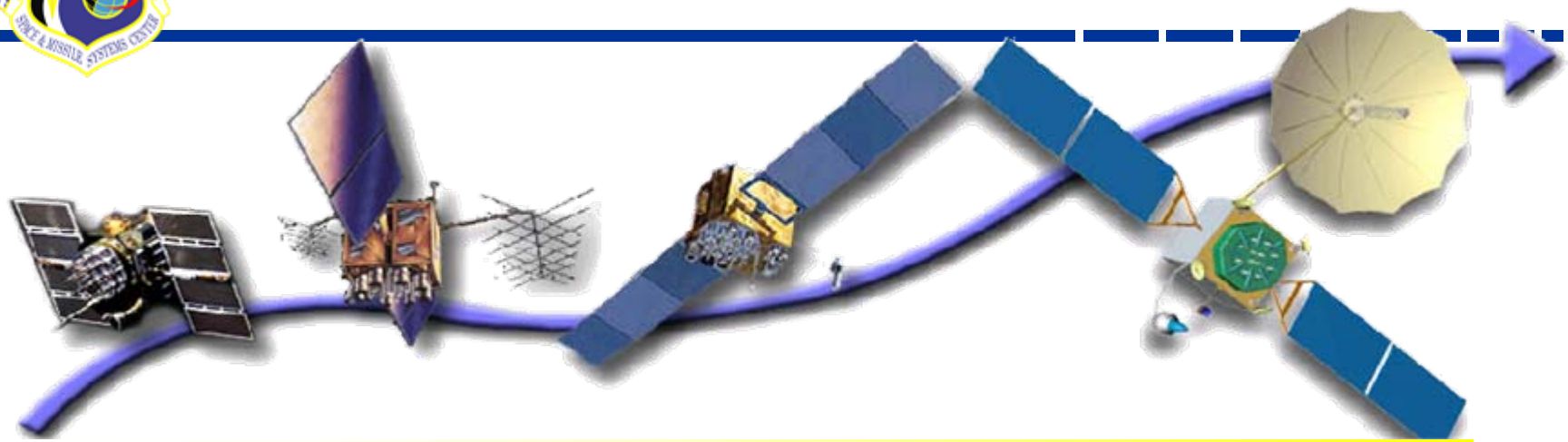
Top 3 Challenges

- Finalize Acquisition Program Baseline (APB) and associated funding
  - **Proposed APB update returns all segments to green with margin**
  - **Finish Block IIF satellite development and enter production**
  - **Transition Control Segment to AEP and LADO**
  - **Initiate development of Block III, OCX, MUE, & MSR this year**
  - **Congressional marks and reprogramming actions**
- Sustain constellation with Block IIR-M satellites
- Workforce reductions to FFRDC, SETA, military, and civilian staff

PLGR vs DAGR

PLGR (Legacy)		DAGR
Single (L1 only)	Frequency	Dual (L1/L2)
PPS-SM	Security	SAASM
Text only	Display	GUI w/maps
5 Maximum	Satellites	All-In-View
24 dB	Anti-Jam	41 dB (+)
6 minutes	TTFF	1 minute
60 sec	TTSF	20 sec
2.75 lbs	Weight	.94 lb
NTE 120 cu. In.	Volume	Fit in secured 2-clip Ammo Pouch
13 hrs (8 batteries)	Battery Life	14 hrs (4 batteries,-20C)
2000 hr	Reliability	5000 hr

GPS Modernization Path



Increasing System Capabilities ◆ Increasing Defense / Civil Benefit

Block IIA/IIR

Basic GPS

- Std Service (16-24m SEP)
  - Single frequency (L1)
  - Coarse acquisition (C/A) code navigation
- Precise Servicze (16m SEP)
  - 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)
  - Eliminates SA for denial
- Anti-jam flex power

IIF: IIR-M capability plus

- 3rd civil signal (L5)
- Anti-jam flex power

Block III

Block IIIA:

- Increased anti-jam power
- Increased security
- Increased accuracy
- Navigation surety
- Backward compatibility
- Assured availability
- Controlled integrity
- System survivability
- 4th civil signal (L1C)