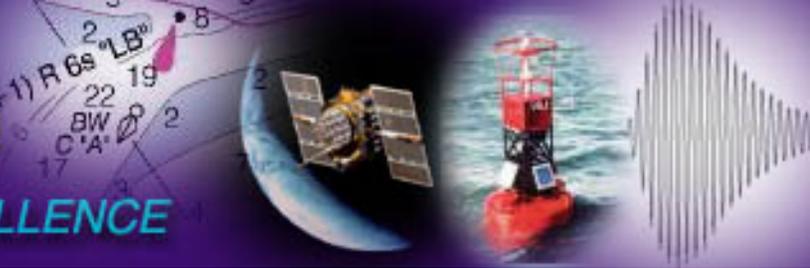




**U.S. COAST GUARD**

# NAVIGATION CENTER

THE NAVIGATION CENTER OF EXCELLENCE



# GLOBAL POSITIONING SYSTEM Status

## CGSIC

22 April 2008

**Doug Loudon**

Chief, Civil GPS Liaison, USCG

2SOPS/GPSOC

Civil Analyst

Schriever AFB

Colorado Springs, CO.

(719) 567-6615



# Introduction

---

- Like the Internet, GPS has become a critical component of the global information infrastructure
  - Scalable applications enabling broad new capabilities
  - Facilitating innovations in efficiency, safety, environmental, public security, and science
- Over the past decade, GPS has grown into a global utility providing space-based positioning, navigation and timing (PNT)
  - Consistent, predictable, dependable performance and policy
  - Augmentations improve performance even further



# ***GPS: Global Public Service***

---

- **Global GPS civil service performance commitment continuously met/exceeded since 1993**
- **Access to civilian GPS service is free of direct user charges**
  - **As well as USG augmentation services**
- **Public domain documentation**
  - **Free and equal availability to all users and industry**
  - **Equal opportunity to develop user equipment and compete on the world market**
- **Owned and operated by the U.S. Government**
  - **Managed at national level as multi-use asset**
  - **Acquired and operated by U.S. Air Force on behalf of USG**



# Overview

---

- **GPS Constellation Status**
- **Recent GPS Accomplishments**
- **Status of GPS programs**
  - **GPS Block IIR/IIR-M**
  - **GPS Block IIF**
  - **GPS Block III**
- **Summary**



# *The Global Positioning System*

- **Baseline 24 satellite constellation in medium earth orbit**
- **Global coverage, 24 hours a day, all weather conditions**
- **Satellites broadcast precise time and orbit information on L-band radio frequencies**
- **Two types of signals:**
  - **Standard (free of direct user fees)**
  - **Precise (U.S. and Allied military)**
- **Three segments:**
  - **Space**
  - **Ground control**
  - **User equipment**

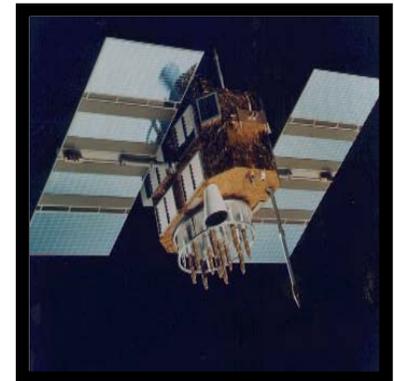




# Current Constellation

## 31 Operational Satellites (Baseline Constellation: 24)

- 13 Block IIA satellites operational
- 18 Block IIR satellites operational
  - 2 remaining Block IIR satellites are modernized
- 6 Block IIR-M satellites operational
  - Transmitting new civil signal (L2C codeless)
- U.S. Government continuously assessing constellation health to determine launch need
  - Newest IIR-M satellite launched
    - IIR-19 (M) 15 March 2008
    - Next launches: IIR-20 (M) ~30 Jun 08  
IIR-21 (M) ~11 Sep 08
- Global GPS civil service performance commitment met continuously since 1993





# Recent GPS Accomplishments

---

## ■ AEP Launched a new era of GPS services

- Upgrade the legacy control system to Architecture Evolution Plan (AEP).
- 14Sep 07- The US Air Force successfully transferred constellation operations from the legacy Master Control Station (MCS) to an upgraded Architecture Evolution Plan (AEP) New Master Control Station (NMCS)



# *What is included in the upgrade from legacy control system to AEP?*

---

- **This upgrade includes a new satellite control foundation:**
  - **Replace legacy system**
  - **Installing and activating a New Master Control Station (NMCS) at Schriever Air Force Base (AFB)**
    - New hardware and software to generate Navigation messages
    - New system for controlling satellites
    - New capability to command satellites through Air Force Satellite Control Network (AFSCN) increases available antennas
  - **Upgrading current GPS ground antenna software**
    - New software and digital communication



# AEP Transition

- **USAF is upgrading because:**
  - Legacy is system difficult to sustain, and cumbersome operations
  - Entire GPS system is evolving with new capabilities
  - Need for efficient operations, better operations tools
- **Upgrade includes:**
  - NMCS / AMCS
  - Upgrade to ground antennas
  - Control foundation allows expansion for new satellites and security features
- **Upgrade used a phased transition**
- **Upgrade was transparent to users**
- **AEP problems**
  - After AEP transition the upgrade had code differences between delivered SEM and YUMA almanacs from Legacy to AEP
  - A IIR satellite upload problem in Oct was also identified and corrected with rewritten procedures
  - 2SOPS and the GPS Wing were able to fix all problems while NAVCEN/GPSOC were in communication with the affected users.

**Transparent to GPS users**



- **PRN 32**
- **History**
  - **PRN 32 was used in 1992 with one known user concern (receiver registering “00”, still provided navigation solution) due to UE vendors not adhering to most current ICD specification**
  - **ICD released to users in early 80s identifying need for user equipment to read up to 32 PRNs**
  - **UE misreading PRN32 has never been resolved; as interim measure, AFSPC deferred use of PRN 32**
  - **AF notified users with GPS Wing letter DTD 29 Sep 06**
  - **L-band tuned on SVN 23/PRN 32 Dec 06. PRN 32 was not in almanac or set unusable**
  - **Dec 06 L-band turned off; 02 Apr 07 L-band transmitting again**
  - **27 Jun 07 put into almanac set unusable**
  - **26 Feb 08 1801Z PRN 32 set usable**



## ■ Issue

- **GPS UE was designed to the GPS system specification in 1980. The spec required availability of all 32 PRN codes in the UE despite the fact that the GPS system was only defined for 18 SV constellation. This is the source of the minimum 5 bit data field for PRN output purposes.**
- **Also notable is the fact that data bits in 1980 were a hot commodity and very expensive**
- **Some older user equipment non compliant with IS-GPS-200D (7 Dec 2004) were affected by setting PRN 32 healthy in Feb 08**



- ***Prior to setting PRN 32 Usable***
- **GPSOC received civilian feedback when L-band was turned on 1-6 Dec 06**
  - **NASA Global Differential GPS System (JPL)**
  - **Fugro Chance, Inc. (marine remote positioning services)**
  - **Kongsberg Maritime DGPS Systems (merchant vessel positioning, surveying, & navigation)**
  - **Civilian UE fixes in place and user impacts mitigated**
- ***After PRN 32 set Usable***
  - **USCG NAVCEN received reports from users of SAAB AIS R3 (Leica MX 420), Novatel All-star receiver, Northrop Grumman-Sperry Marine heading Compass, Trimble 990 & 5800 receivers and the Northstar 941X**
  - **All manufacturers have a work around in place listed on their website and when possible distributed to their customers**
  - **The USCG NAVCEN and the USAF GPSOC worked closely with all affected users and manufactures.**
  - **The Swedish Navy issued a Baltic Sea Navigation warning and the US Coast Guard worked with NGA (National Geospatial-Intelligence Agency) who sent a US Navigation Warning about older equipment recognizing PRN 32**



# Modernized GPS – Civil Signals

- **New acquisition strategies for next generation GPS**
  - GPS IIF Satellites
  - GPS Block III satellites
- **Second civil signal (“L2C”)**
  - **Designed to meet commercial needs**
    - Higher accuracy through ionospheric correction
    - Higher effective power and improved data structure reduce interference, speed up signal acquisition, enable miniaturization of receivers, may enable indoor use
  - **Began with GPS Block IIR-M in Sep 2005; 24 satellites: ~2015**
  - **Third civil signal (“L5”)**
    - **Designed to meet demanding requirements for transportation Safety of Life**
      - Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
      - IIR-20(M) scheduled to have L5 demo on board
    - **Begins with GPS Block IIF**
    - **First launch: ~Feb 2009; 24 satellites: ~2018**
- **Fourth civil signal (“L1C”)**
  - **Designed with international partners to enable GNSS interoperability**
  - **Begins with GPS Block III**
  - **First launch: TBD; 24 satellites: TBD**



# GPS Block IIR/IIR-M Status

---

- **21 satellite procurement; 13 IIRs, 8 IIR-Ms**
  - 12 IIRs operational; 1st IIR launch, 22 Jul 97
  - 6 IIR-Ms operational; 1st IIR-M launch, 25 Sep 05
    - Includes M-Code capability
    - Broadcasting new civil signal (L2C) – w/o Nav Message
    - Provides improved accuracy for civil users with L2C receivers
  
- **Two Block IIR-M launches remain**
  - Next launches planned for Jun and Sep 08



# ***GPS Block IIF Status***

---

- **12 satellite procurement**
  - **Adds third civil signal – L5**
  
- **USG Commitment: IIF-1 available for launch**
  - **Objective Feb 09**
  
- **Current estimate for IIF-1 launch is 24 Feb 09**



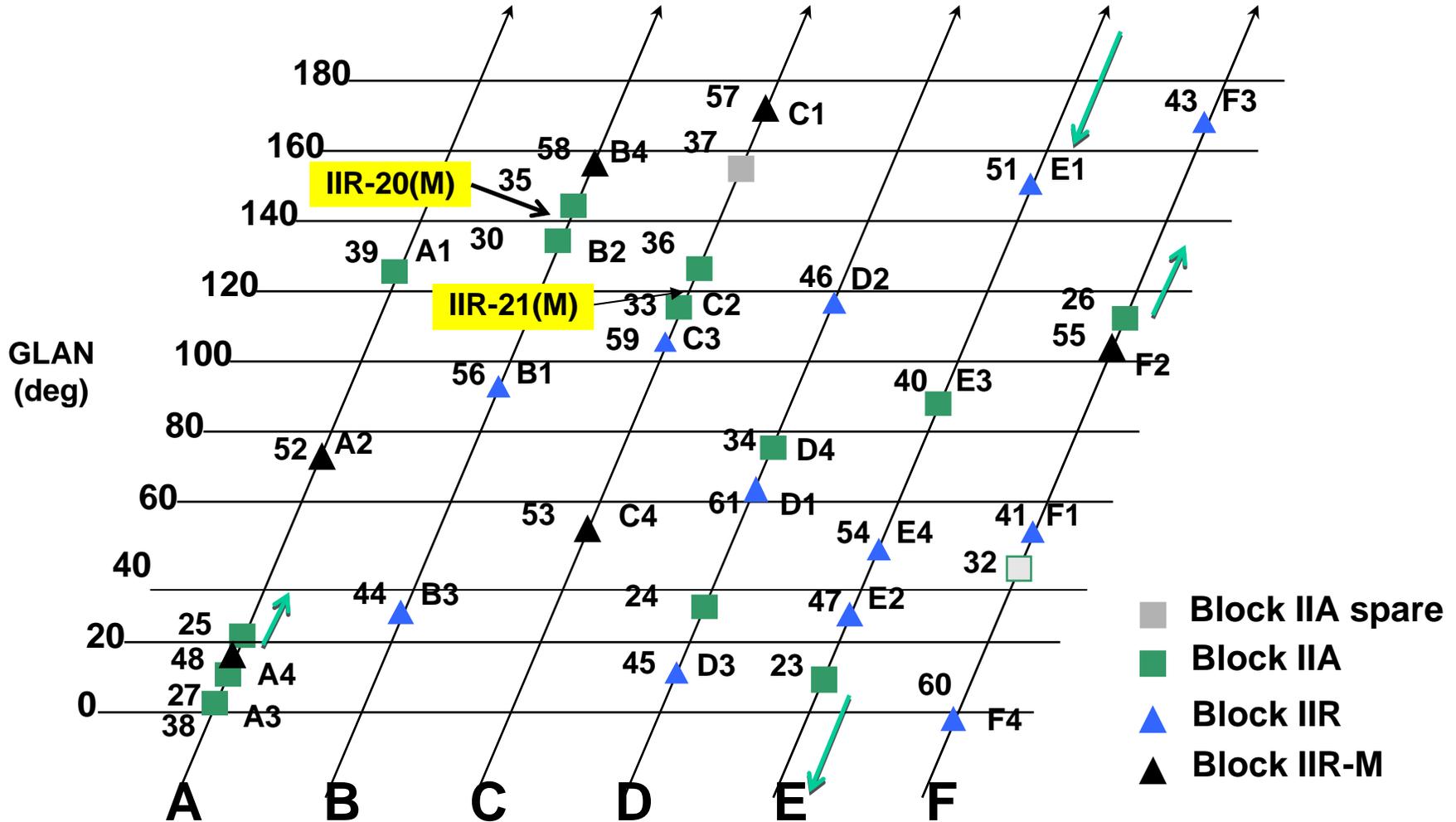
# GPS Block III Capabilities

---

- **GPS III includes IIR-M/IIF capabilities, plus**
  - L1C (fourth civil signal) compatible with Galileo
  - +10dB earth coverage military signal power increase
- **Civil benefits:**
  - Provides operational capability for L2C and L5
    - In combination with GPS IIR-M and IIF satellites
  - **Delivers L1C for interoperability with Galileo and Quasi-Zenith Satellite System (QZSS)**
  - Significant increase in system accuracy
  - Improved availability of accuracy with integrity



# GPS Locations(26 Mar 08)



PRN 32/SVN-23 Rephase Complete Jul '08 PRN 26/SVN-26 Rephase Complete 05 Mar '09  
 PRN 25/SVN-25 Rephase Complete Apr '08 PRN 6/SVN-36 Rephase Complete 06 Jun '08



# *Interference Reporting*

---

- **The Navigation Center appreciates your reports regarding service degradations, outages, or other incidents or anomalies.**
- **Please report problems via our GPS Problem Report Page.**
- **After a GPS user completes these forms, they are sent to a database for tracking, analysis, and resolution.**
- **Reports may be received via phone/fax**



# ***Interference Reporting Process***

---

- **User contacted for additional information, if necessary.**
- **If the report is aviation related it will be directed to the FAA for tracking, analysis, and resolution.**
- **Maritime and terrestrial related reports will be processed simultaneously by the USCG GPS Liaison to the GPS Operations Center at Schriever AFB and MIOC personnel for resolution.**
  - **Check for constellation events during reported outage period by using NANU.**
  - **Perform analysis of constellation activity during reported outage times.**



# *Delivering the Best Space based PNT 24/7*

- ***Sustaining*** capabilities for military and civil users worldwide
  - Maintain ground systems/on-orbit satellites, launch new satellites
  - Fielding GPS enhancements
- ***Modernizing*** constellation with new signals and capabilities
  - First IIR-M launch Sep 05, first IIF launch 2009, first GPS III launch TBD
  - New civil and military GPS signals
  - Continuing work with Galileo and international community
- ***Managing*** GPS systems & supporting stakeholders

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



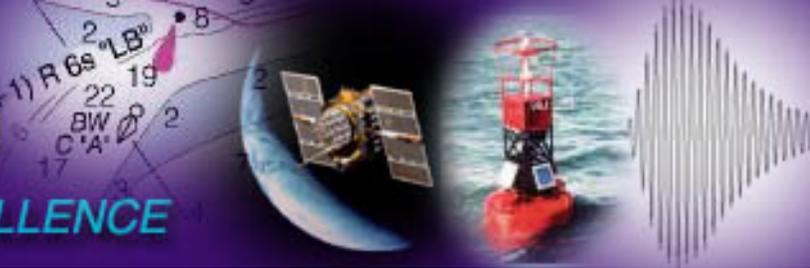
# Constellation Summary

---

- **33 satellites on-orbit**
  - **31 satellites set healthy to users in the operational almanac**
  - **3 satellites launched since May 2007**
    - **SVN 55/PRN 15 launched 17 Oct 07 to F2**
    - **SVN 57/PRN 29 launched 20 Dec 07 to C-1**
    - **SVN 48/PRN 07 launched 15 Mar 08 to A-4**
- **Constellation changes since May 2007**
- **3 satellites decommissioned (SVN 29/PRN 29, SVN 37/PRN 07, SVN 32/PRN 01)**
  - **SVN 29 disposed**
- **SVN 23/PRN 32 E-plane re-phase Complete 01 Jul 08**

Improves PDOP over polar regions

  - **PRN 06 (C-Plane) re-phase ongoing: Complete 06 Jun 08**
    - **Provides backup for SVN 33/PRN 03 (in plane)**
  - **PRN 26 (F-Plane) re-phase: Complete 05 Mar 09**
    - **Provides backup for SVN 55/PRN 15 (in plane)**



## **Maritime Information Operation Center MIOC**

- <http://www.navcen.uscg.gov>
- <http://www.navcenter.org> (mirror site)
- GPS.GOV or PNT.GOV (US PNT sites)
- E-mail: [TIS-PF-NISWS@uscg.mil](mailto:TIS-PF-NISWS@uscg.mil)
- Phone: +1 703 313 5900
- Fax: +1 703 313 5920

**Doug Loudon, USCG  
GPSOC, Civil Ops Analyst  
(719) 567-6615  
Cell: (303) 241-2416**