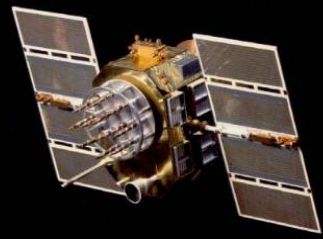


# Global Positioning System
# *Status*

**Joint Meeting of Action Team on GNS**

**and**

**GNSS Experts of UN/USA Regional Workshops**

**and**

**International Meeting 2001 - 2002**

**December 8, 2003**


**Hank Skalski**

**U.S. Department of Transportation**

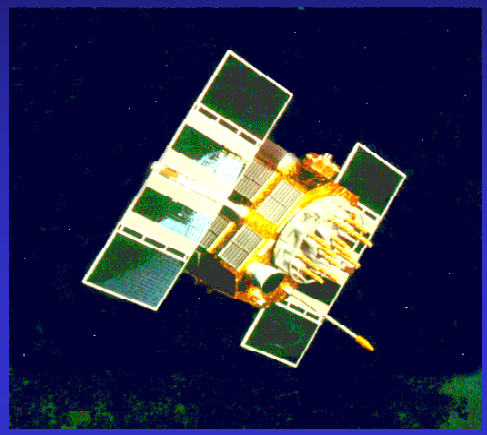
# Overview

- **Background**
- **Performance Standards**
- **GPS Modernization**
- **Spectrum**

# GPS Background

- Active program for over 25 years
  - Created from separate programs in 1973
  - Developmental satellites began launch in 1978; operational satellites in 1989
  - Initial Operational Capability in 1993; Full Operational Capability in 1995
- Designed as a dual-use system
  - Military applications for US and Allied use
  - Civilian applications for worldwide use
- Consistent U.S. National Policy from both Executive and Legislative branches
  - Presidential Decision Directive - March 1996
  - U.S. Public Law - December 1997

# GPS Satellites



## Block II/IIA

- All have been launched
- Rockwell (now Boeing)
- First launch Feb 1989
- 20 operational
- Mean Mission Duration (MMD) 9.88/10.64 yrs

## Block IIR/IIR-M

- In production
- Lockheed/Martin
- 21 procured
- 8 operational
- 1 Destroyed on launch
- MMD 10.62/8.57 yrs

## Block IIF

- In development
- Boeing
- 6 already procured
- Options for 10 more
- MMD 11.0 yrs

# Improve Civil GPS Services

- **Given current GPS system, civil performance improvements are needed**
  - **Early 1990's began developing GPS augmentation systems**
  - **2000 – Selective Availability set zero**
  - **Mid-2000s will begin launch of GPS IIR/IIF satellites with new civil signals**
  - **2010 and beyond: System architecture for GPS III and Galileo being considered**

# GPS Open Market

- Civil service is free of user charges
  - Now and in the future
- Publicly published GPS specifications allow anyone to build receivers (no licensing fees)
- Equipment is becoming a common commodity
- Great potential in value-added services
  - Software development
  - Embedded applications
  - Localized geographic info systems (GIS) databases
  - Internet integration
  - Wireless markets

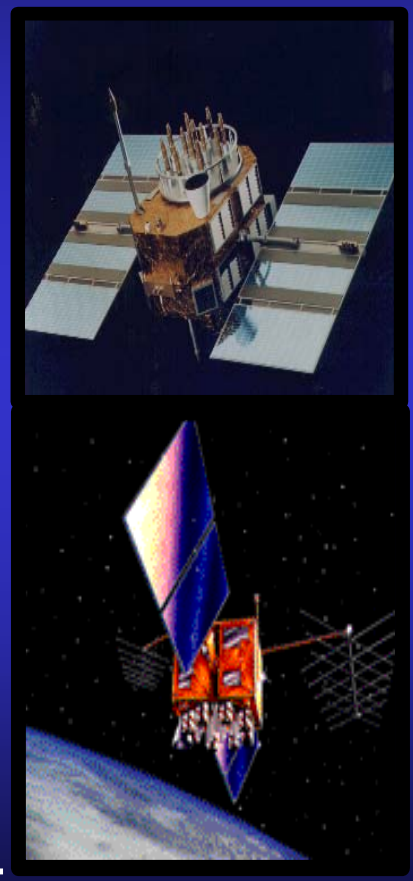
# Overview

- Background
- Performance Standards
- GPS Modernization
- Spectrum

# GPS Constellation Status

**28 Operating Satellites**
**(to ensure 24)**

- **20 Block II/IIA satellites operational**
- **8 Block IIR satellites operational**
  - **12 of 21 Block IIR satellites available**
  - **Modernizing up to 8 Block IIR satellites**
  - **Last launch: 31 Mar 03**
- **Next Launch: 20 Dec 03 (GPS IIR-10)**
- **Continuously assessing constellation health to determine launch need**
- **Global civil service performance commitment has been met continuously since Dec 93**



# GPS SPS Performance Standard

- Defines the **levels of performance** the U.S. Government commits to provide to domestic and international civil GPS users
- **Not a requirements** document
- Current edition published **October 2001**
  - Updated performance as a result of discontinuing Selective Availability (SA)

**Commitment of Service**

# SPS Performance Standard (cont'd)

- **Main body** -- The performance standards
  - Constellation management
  - Service availability
  - Service reliability
  - Accuracy
  - Status and problem reporting

- **Appendix A** -- Documented historical performance and supporting analysis
  - For information only

# SPS Performance Standard (cont'd)

| GPS Performance Standard Metric | 2nd Edition SPS Signal Specification June 1995 | SPS Performance Standard October 2001 | Representative Performance |
|---|---|---|---|
| **Global Accuracy** | | | |
| All-in-View Horizontal 95% | 100 meters | 13 meters | 4 meters |
| All-in-View Vertical 95% | 156 meters | 22 meters | 6 meters |
| **Worst Site Accuracy** | | | |
| All-in-View Horizontal 95% | 100 meters | 36 meters | 6 meters |
| All-in-View Vertical 95% | 156 meters | 77 meters | 10 meters |
| **Time Transfer Accuracy** All-in-View Time Transfer User Solution 95% | 340 nanoseconds | 40 nanoseconds | 7-10 nanoseconds |
| **Constellation RMS User Range Error** | NONE | 6 meters | 1.6 meters |
| **Geometry (PDOP ≤ 6)** | 95.87% global<br>83.92% site | 98% global<br>88% site | 99.9% global<br>98% site |
| **Constellation Availability** | NONE | 95% Probability of 24 Operational Satellites | 25-28 Healthy Satellites |
| **Service Reliability** | 99.97% global<br>99.79% worst site | 99.94% global<br>99.79% worst site | 100% global<br>100% worst site |
| Service Failure Threshold | 500 m Horizontal Error | 30 m SIS URE | (28 July 2001 PRN22 Failure almost 2 hours of URE > 30 m |
| Service Failure Rate | 3/Year | 3/Year | |
| Service Failure Duration | Up to 6 Hours/Failure | Up to 6 Hours/Failure | |

# SPS Performance Standard (cont'd)

- The U.S. Government, DoD, and U.S. Air Force are committed to being good stewards of GPS
- GPS SPS Performance Standard available on US Coast Guard Navigation Center website

http://www.navcen.uscg.gov/

# Overview

- Background
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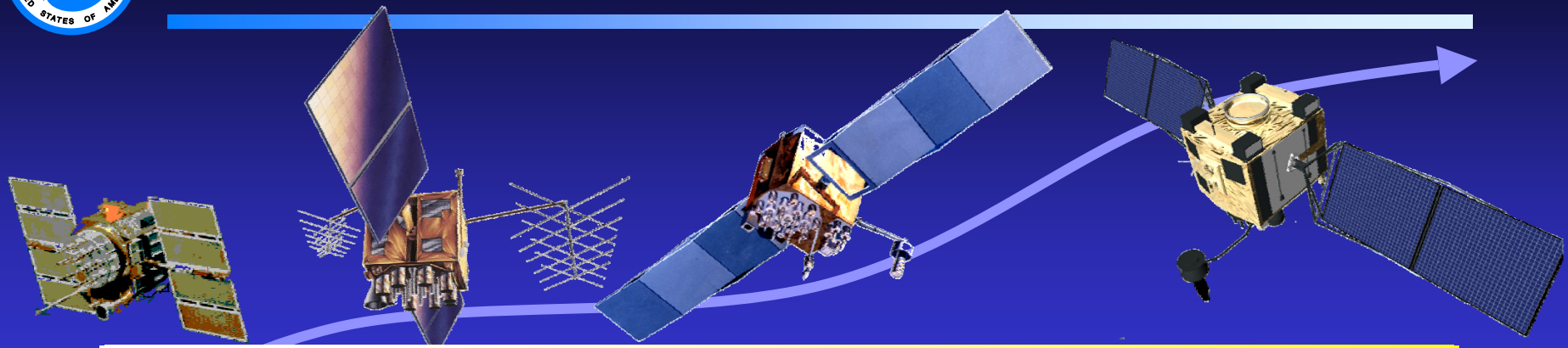
- Spectrum

# GPS Modernization Plan



*Increasing System Capabilities ◆ Increasing Defense/Civil Benefit*

## Block IIA/IIR

- Basic GPS
- Std Service (16-24m SEP)
  - Single frequency (L1)
  - C/A code navigation
- Precise Service (16m SEP)
  - Two frequencies (L1&L2)
  - P-code navigation

## Block IIR-M, IIF

**IIR-M**: IIA/IIR capabilities plus
- 2nd Civil Signal on L2 (L2C)
- Earth coverage M-Code on L1 & L2

**IIF**: IIR-M capability plus
- 3rd Civil Signal on L5

Flex Power upgrade adds ability to increase power on both P and M-Code signals to defeat low level enemy jamming

## Block III

**GPS III**
- Navigation Surety
- Increased Accuracy
- Assured Availability
- Controlled Integrity
- System Survivability
- Continuation of Legacy Signals

# GPS Modernization

- **Additional civil GPS signals**
  - L2C civil signal: First launch 2004
  - L5 civil signal: First launch 2006
  - Further capability with GPS III
- More **robust** satnav service
  - Reduces vulnerability to interference
- **Dual frequency** for worldwide safety-of-life transportation applications
- **Centimeter-level** accuracy for scientific and survey applications

# Second Civil Signal (L2C)

- **More robust civil signal service**
  - Civil users currently only have codeless/semi-codeless access to P(Y) on L2
- **Increased accuracy**
  - Coded dual-frequency ionospheric corrections at the receiver
- **Advanced signal structure**
  - Working Group defined signal characteristics
  - Better cross-correlation properties than C/A
  - Data-free component for robust tracking
  - Designated primary L2 civil code versus C/A

# Third Civil Signal (L5)

- Improved signal structure for enhanced performance
  - 6 dB Higher power relative to L1 (-154 dBW)
  - 20 MHz (minimum) broadcast bandwidth
  - Improved data message
- ARNS allocation to support civil aviation
- DME compatibility achieved by frequency reallocation, if required
- L5 signal definition
  - RTCA SC 159, WG #1, developed L5 Specification
  - GPS JPO originated/coordinated ICD-GPS-705

# GPS L5 for Safety-of-Life

- **Domestic** operations
  - Improves reliability and availability
  - Significantly reduces possibility of unintentional interference
  - Some improvement in anti-jam capability
- **International** operations
  - Improves safety
  - Provides precision guidance throughout the world without costly infrastructure

# Civil Benefits of GPS Modernization

- More robust GPS service worldwide
  - Reduces vulnerability to unintentional interference
- Centimeter-level accuracy for scientific and survey applications
- Reduced data rate for Differential GPS (DGPS) corrections
- Worldwide dual frequency for safety-of-life applications
  - Satellite-based augmentation systems (e.g., WAAS, EGNOS, Gagan, MSAS) will require less ground infrastructure to provide capability

# GPS III Civil Goals

- Significant increase in system accuracy
- Improve robustness to interference
- Improve level of integrity for all users
- Improve availability of accuracy with integrity
- Backward compatibility with existing receivers
- Initial Operating Capability for L5
  - In combination with GPS IIF satellites
- Flexibility to respond to evolving requirements with limited programmatic impacts

# Overview

- Background
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- Spectrum

# Spectrum: The Great Enabler

- Critical for modernizing transportation systems
  - Increasingly dependent on spectrum
- All radio bands under scrutiny for commercial use
- Support technological innovation/creativity while jointly shaping a safe operating environment
- Presidential Spectrum Policy Initiative
  - U.S. National Spectrum Management Reform
  - Equitable spectrum management and coordination

# Spectrum Challenge

- **Protect spectrum** for GNSS/GPS and other current/future critical systems from interference (e.g., Ultra Wideband (UWB), Mobile Satellite Service (MSS))
  - GPS degradation harms strategic military and civil plans
  - Goal is to enable new GPS applications (e.g. ITS, E911)
- **Compatibility/interoperability** with other global satellite navigation systems (Galileo, QZSS, etc.)
- **Spectral separation** of civil/military GNSS/GPS signals
  - Facilitates preservation of peaceful civil use outside an area of conflict

# The Road Ahead

- Launch of satellites with **new civil/military GPS signals** starts next year with enhancements through GPS III
  - Augmentations are **an integral component** of current civil GPS service provision
- Hopeful that Galileo will be **compatible as well as interoperable** with GPS
  - Greater satnav capabilities for civil users worldwide
  - **Spectral separation** of civil and military GNSS signals facilitates preservation of peaceful civil use
- **Spectrum protection** requires vigilance and early action on emerging issues

# Summary

- **Stable, consistent** GPS policy and service
- **Expanding use** in transportation safety and other civil uses
- GPS Modernization is a **multiple step** process
  - Selective Availability set to zero
  - Second civil signal (L2C): First launch in 2004
  - Third civil signal (L5): First launch in 2006
  - GPS III addressing future dual-use requirements
- Continuing **international outreach** to be responsive to global user needs

**Future GPS performance will dramatically improve as a result of modernization**