



GNSS Operations

Global Navigation Satellite System (GNSS) Operations in the NAS

Industry Day Overview

Alan J. Hayes
Aeronautical Information Management (AIM)
GNSS Integrity and Prediction Modernization (GIP-M)

October 14, 2009 v1.0b



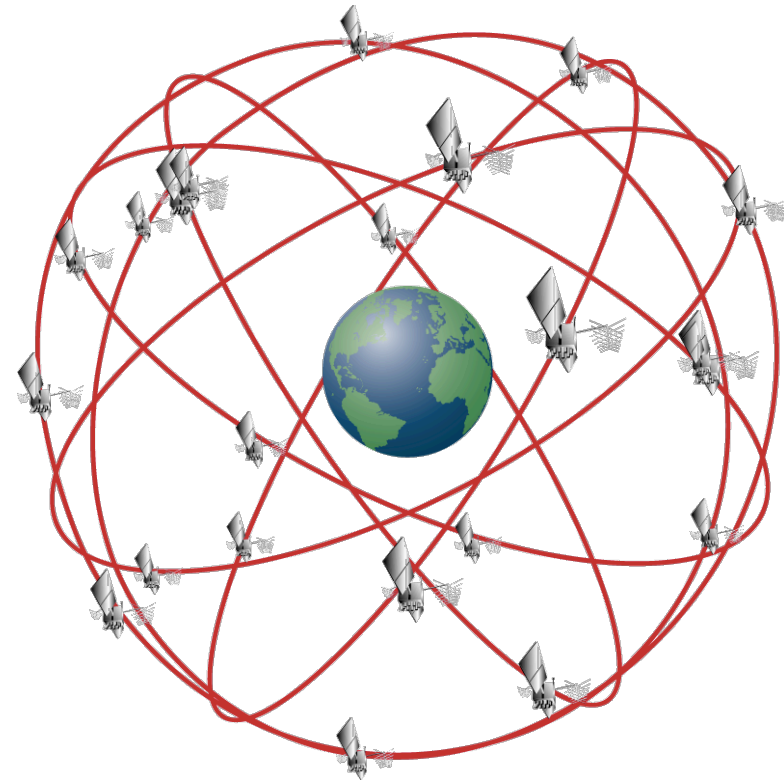
Federal Aviation
Administration



What is GNSS?

Global Navigation Satellite Systems (GNSS) is the generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage.

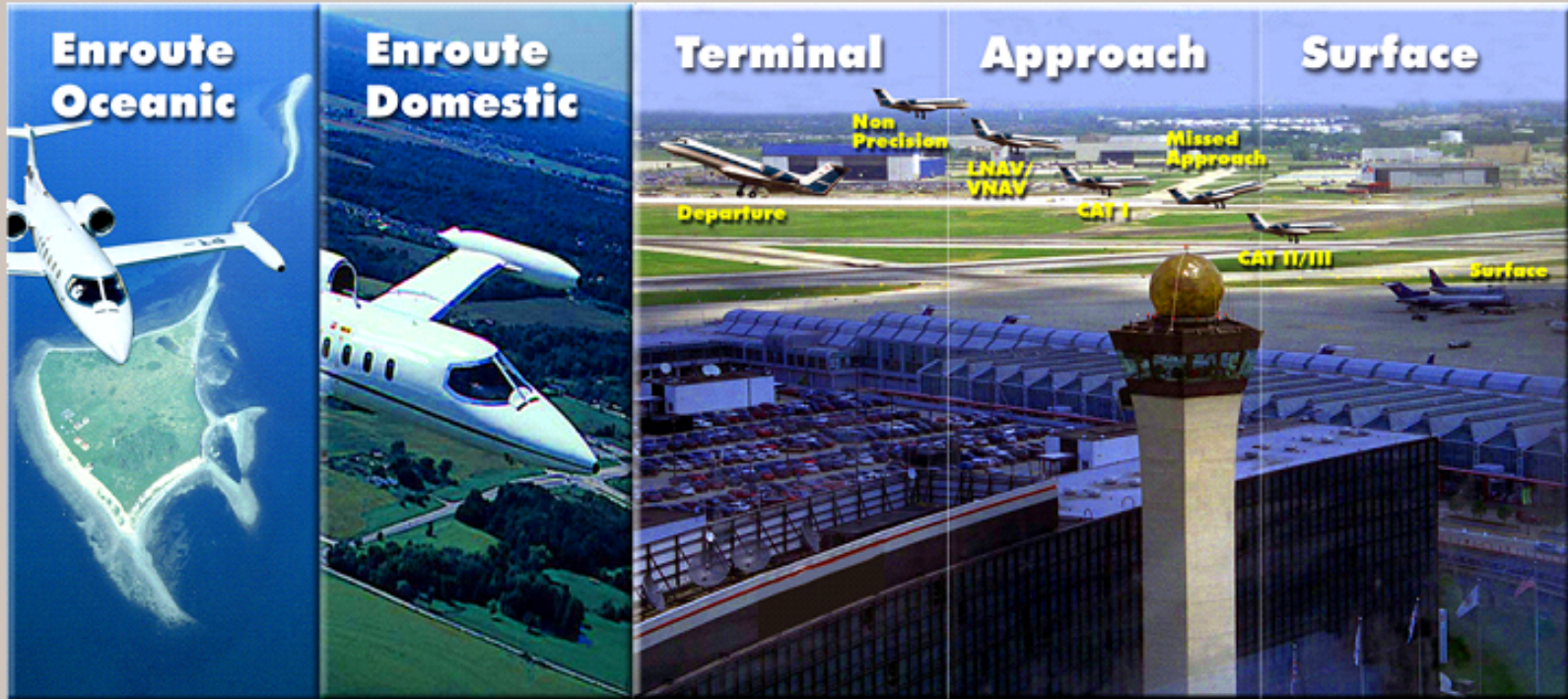
GNSS allows receivers to determine their location (longitude, latitude, and altitude) to within a few meters using time signals transmitted along a line-of-sight by radio from satellites.



FAA Satellite Navigation

WAAS

ADS-B



GPS

LAAS

GNSS Outage Reporting

- **GNSS is Different From Ground-Based Nav aids**
 - Impact of Satellites Out of Service Not Intuitively Known
 - Areas of Degraded Coverage Not Stationary
- **Pilots/ATC Need to Know Where and When GNSS Service is Not Available**
 - Only NOTAMs currently available to ATC
 - Some data is provided to Flight Service
- **A New Predictive Coverage Model is Required**
 - Limitations in the current model (GPS and WAAS only)
 - Needs to Incorporate Status of the constellation & ground elements
 - Provide Timely Warnings When a System Should Not Be Used for Navigation
- **GPS Does Not Have a Built-In Real-Time Integrity Monitoring System Which Will Satisfy Aviation Requirements**
 - Satellites are not monitored real-time, except by user of service
- **GPS Receivers Certified For Aviation Must Provide their own Integrity**



Global Positioning System (GPS)

GPS Basics:

GPS Constellation

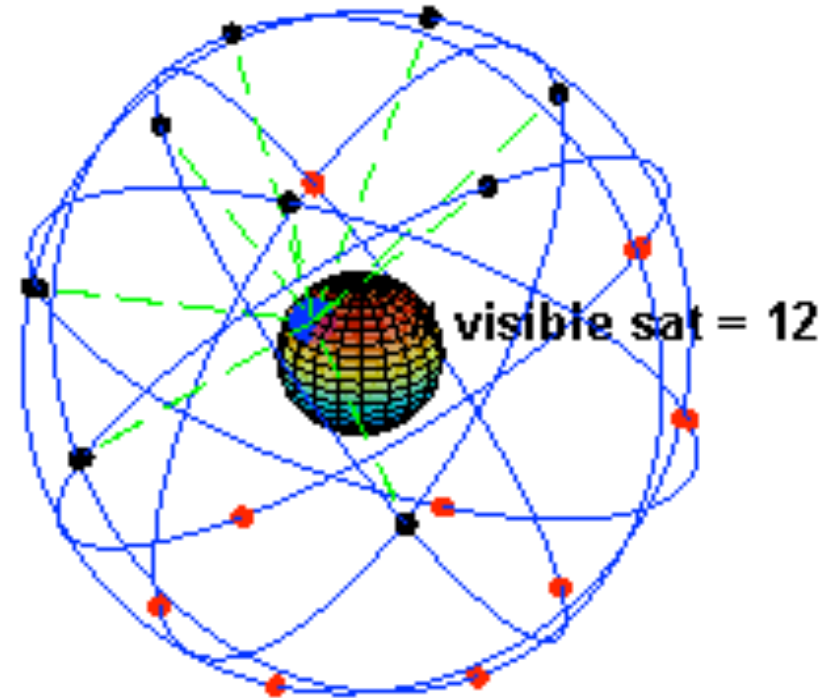
- 24 operational satellites in six circular orbits 10,900 NM above the earth at an inclination angle of 55 degrees with a 12 hour period.
- A minimum of 6 satellites will be in view to users anywhere in the world. The satellites continuously broadcast position and time data.

Control Segment

- Master Control Station (DoD)
- 5 GPS Monitor Sites

User Segment

- Military & Civil Receivers
- Precise Positioning Service (PPS)
- Standard Positioning Service (SPS)



A simulation of GPS showing the evolution of the number of visible satellites from a fixed point (45°N) on earth (considering "visibility" as having direct line of sight to a satellite).

The National Space-Based Positioning, Navigation, and Timing (PNT) Executive Committee manages GPS, while the U.S. Coast Guard acts as the civil interface to the public for GPS matters.

What is RAIM Availability?

- Receiver Autonomous Integrity Monitoring (RAIM):
 - Means of providing GPS signal integrity monitoring
- Impact:
 - Delays of several hours can occur before an erroneous satellite transmission can be detected and corrected by DoD satellite control
 - Up to 2 satellites occasionally forecast “down” for maintenance; often one is in a primary orbital position without backup
 - RAIM availability is impacted when one or more primary slot satellites are under maintenance due to the geometry of the constellation
- Guidance:
 - AC 90-100A, paragraph 10.a.(5): “...*RAIM availability must be confirmed using current GPS satellite information...*”
- Spoiled by success (~33 satellites):
 - Spare satellites improve availability of a particular “slot position”, not necessarily the geometry



GPS Constellation Status

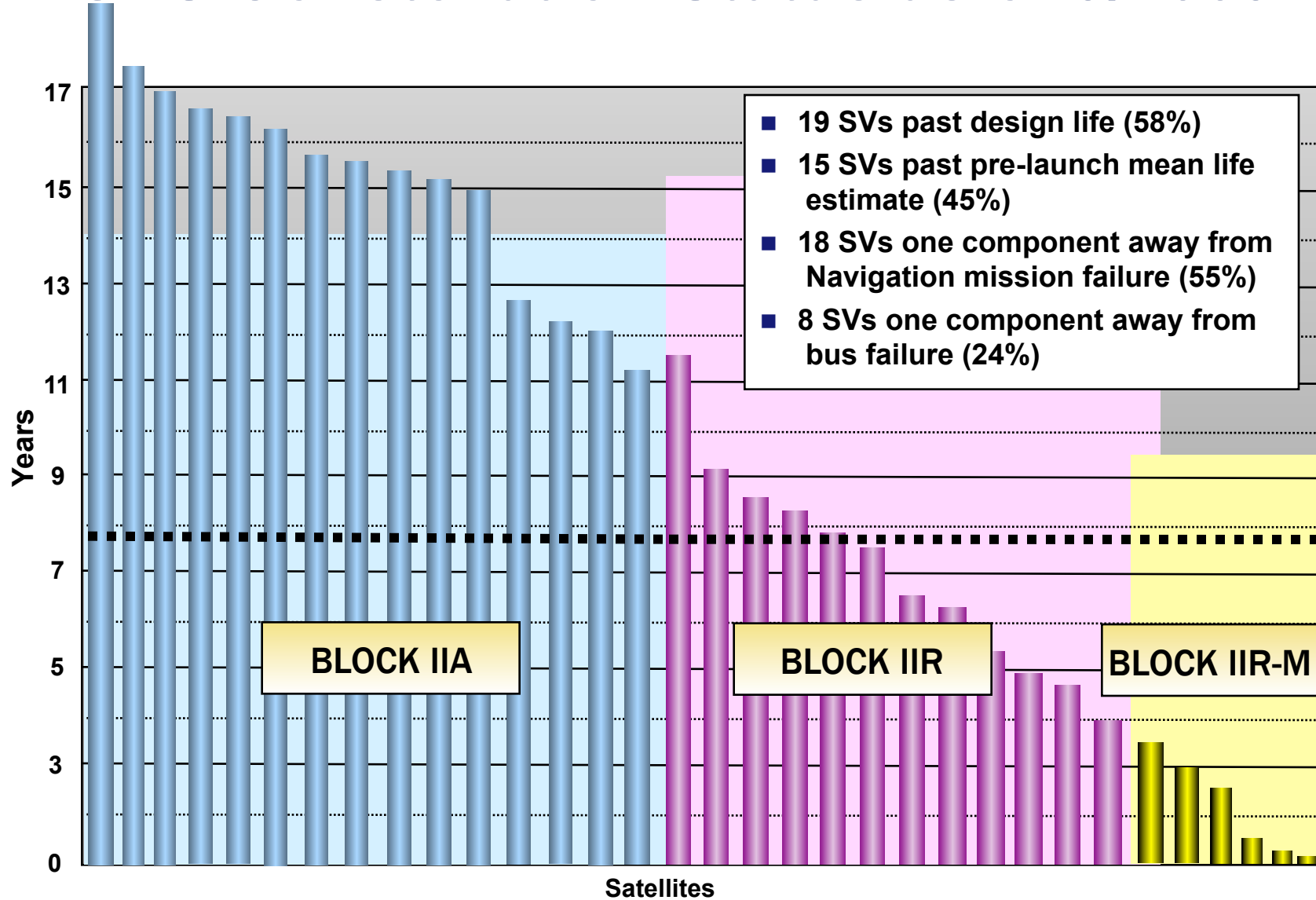
As of 15 September 2009: 33 Operational Satellites
(Based on a Constellation With 24 Nominal Plane/Slot Positions)

- **Satellites:**
 - 5 are transmitting new second civil signal (L5 – not in use)
- **DoD is continuously assessing constellation health to determine future launch need**
- **24 Operational Satellites 95% availability (averaged over any day)**
 - Not All 24 May Be Operating
 - Not All SV's May Be Located in Primary Orbit Slots
- **21 of 24 Plane/Slot Positions Must Be Set Healthy and Transmitting a Navigation Signal With 98% Probability (averaged yearly)**
- **4 Meter User Range Error (URE)**

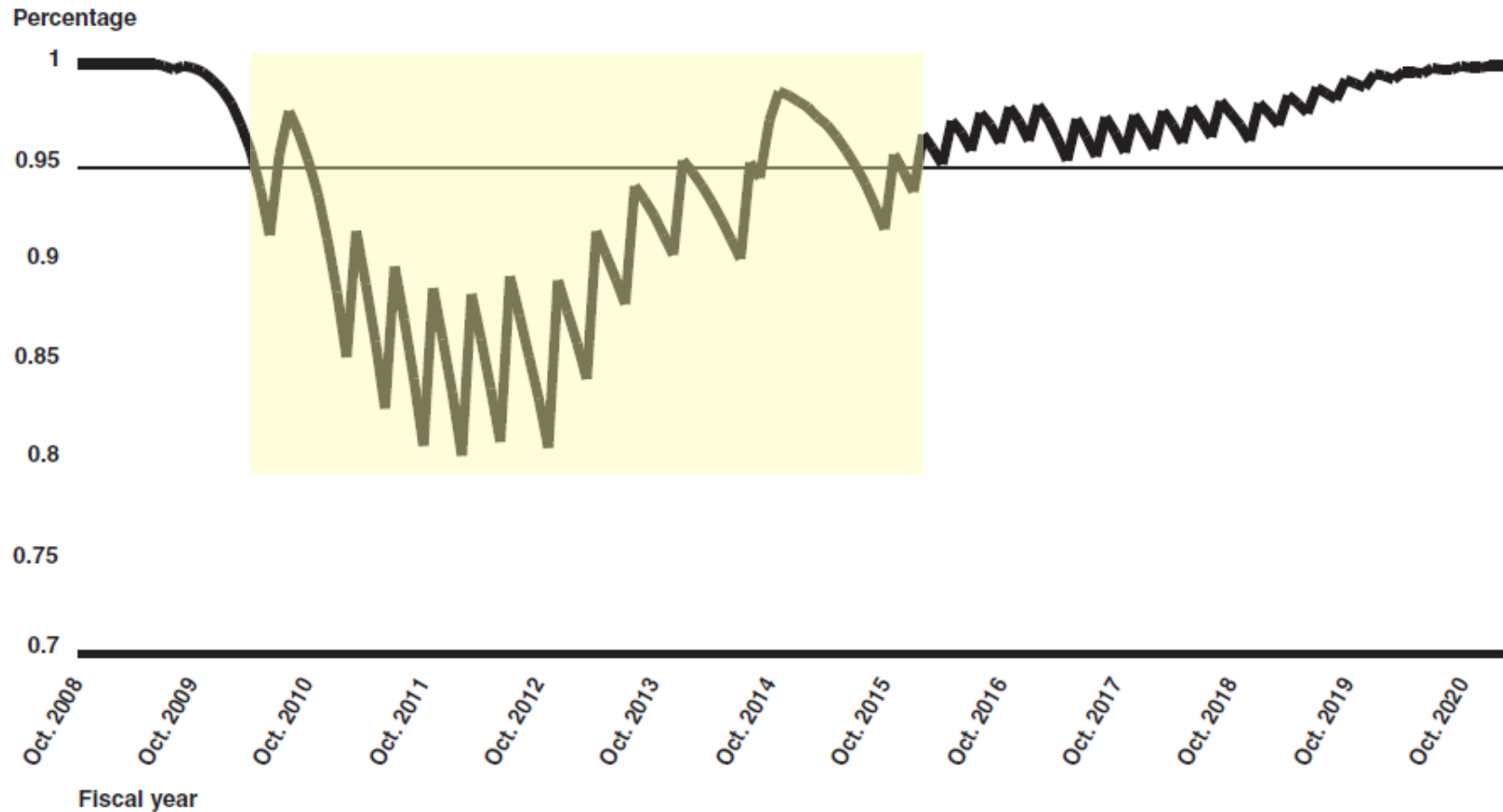
GPS is in 4th Decade of Service
>> First Launch 22 Feb 1978 <<



GPS Constellation Status as of 9/2009



Probability of Maintaining a 24 SV Constellation



— Committed probability of maintaining 24-satellite constellation

— Actual probability of maintaining 24-satellite constellation

Source: GAO analysis of DOD data.

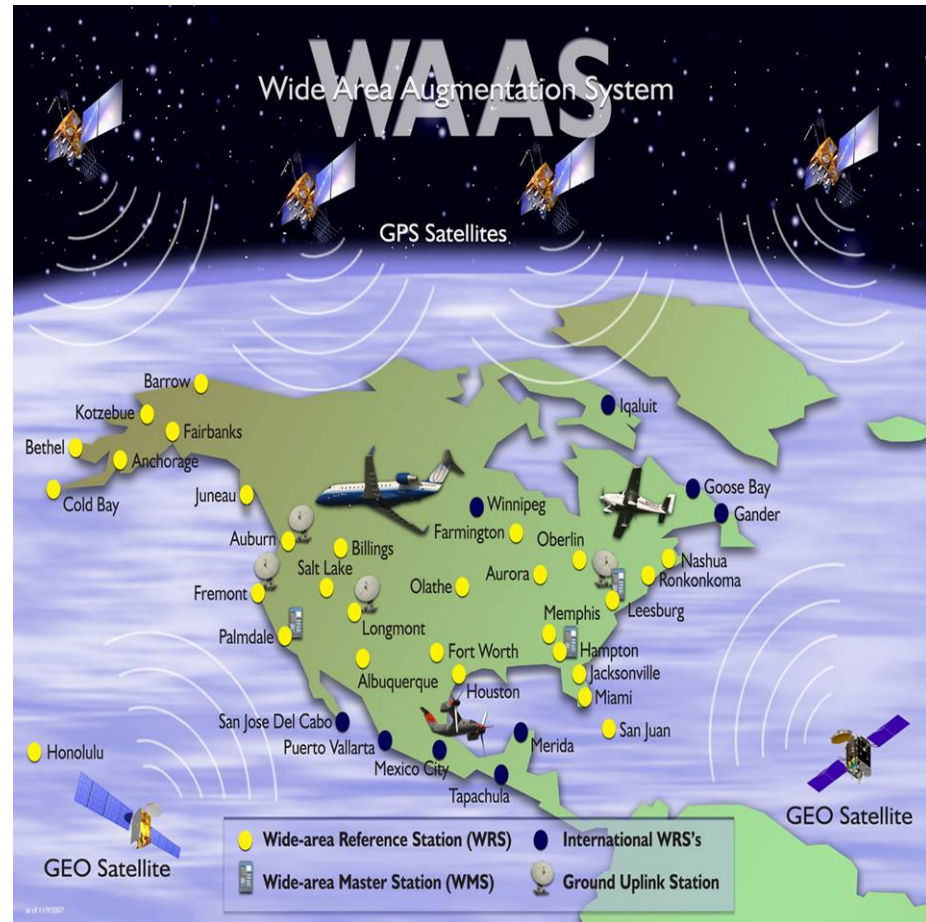
Wide Area Augmentation System (WAAS)

WAAS provides service for all classes of aircraft in all phases of flight, including:

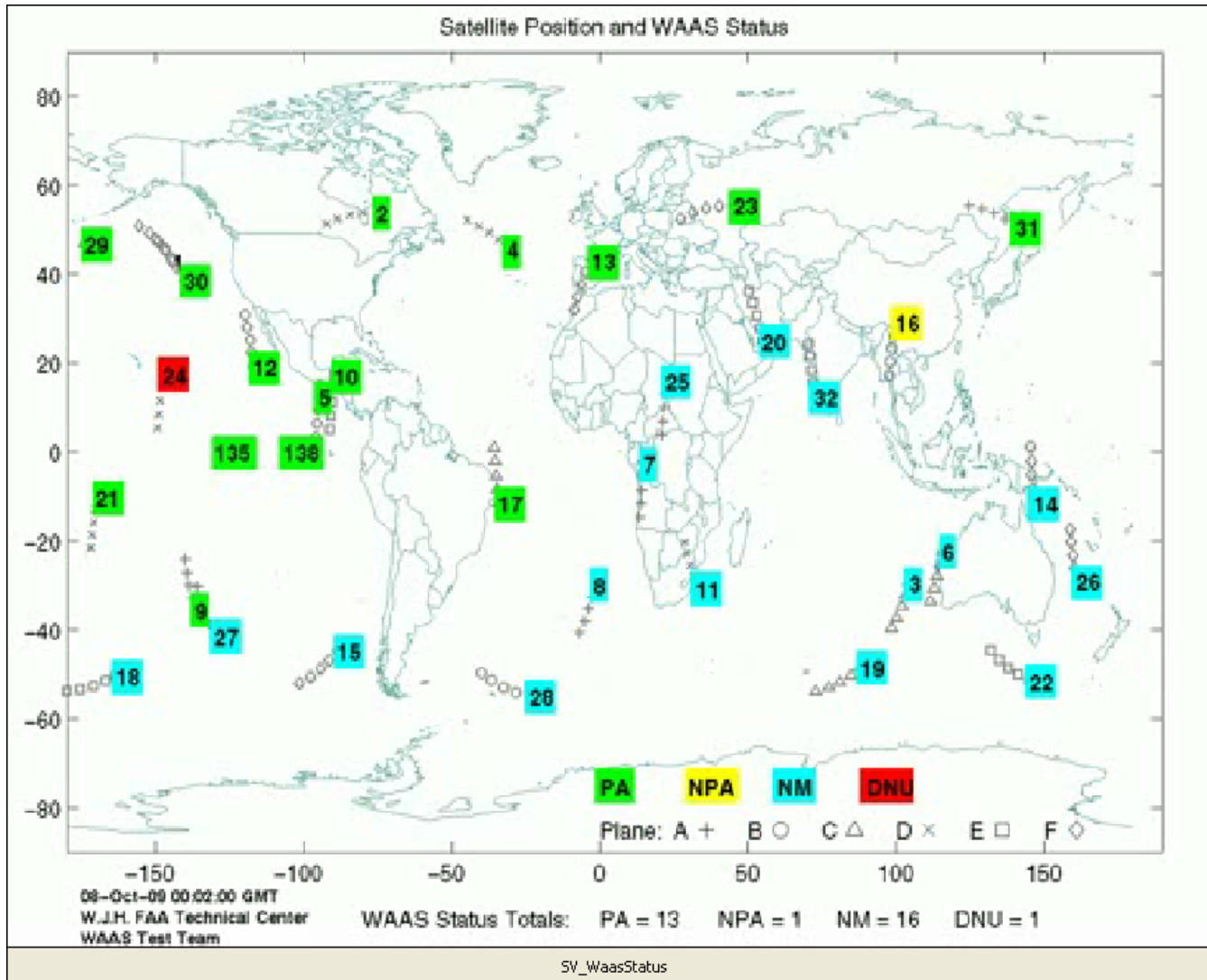
- en route navigation
- airport departures, and
- airport arrivals

WAAS provides NAS users with error correction and enhanced accuracy.

There are currently 2 geosynchronous satellites providing WAAS service. A 3rd satellite is planned.



GPS/WAAS Coverage



AIM Role Segments I & II

- **Monitor the status of each satellite in its plane/slot position**
 - Receive the latest GPS constellation status (e.g., NOTAMs or Notice Advisory to Navstar Users - NANUs),
 - Utilize the latest Almanac data from the satellite constellation
 - Compute Receiver Autonomous Integrity Monitoring (RAIM) availability using model-specific RAIM prediction software
 - Generate GPS and WAAS Outage NOTAMs



AIM Role Segments I & II (cont.)

- **Predicted, continuous loss of RAIM > 5 minutes**
 - Generate NOTAM
- **Maintain the FAA RAIM prediction website**
 - Today: www.raimprediction.net
 - Tomorrow: Integrated into Pilotweb
- **Integration with LAAS and ADS-B (FY11-14)**
 - Send & Receive outage information



Questions?

For more Information, contact

Alan Hayes at

alan.hayes@faa.gov

