



# **GPS/WAAS Program Update**

**UN/Argentina Workshop on the Applications of  
GNSS**

**19-23 March 2018  
Cordoba, Argentina**



# GNSS: A Global Navigation Satellite System of Systems

- Global Constellations

- **GPS (24+3)**
- GLONASS (24+)
- GALILEO (24+3)
- BDS/BEIDOU (27+3 IGSO + 5 GEO)

- Regional Constellations

- QZSS (4+3)
- IRNSS/NAVIC (7)

- Satellite-Based Augmentations

- **WAAS (3)**
- MSAS (2)
- EGNOS (3)
- GAGAN (3)
- SDCM (3)
- BDSBAS (3)
- KASS (2)





# U.S. National Space Policy

## ***Space-Based PNT Guideline: Maintain leadership in the service, provision, and use of GNSS***

- Provide civil GPS services, free of direct user charges
  - Available on a continuous, worldwide basis
  - Maintain constellation consistent with published performance standards and interface specifications
  - Foreign PNT services may be used to complement services from GPS
- Encourage global compatibility and interoperability with GPS
- Promote transparency in civil service provision
- Enable market access to industry
- Support international activities to detect and mitigate harmful interference

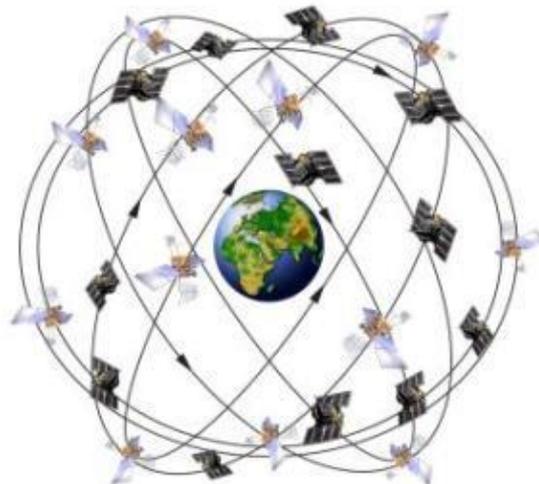


# GPS Status

**35 Satellites / 30 Set Healthy**  
**Baseline Constellation: 24 Satellites**

Satellite Block	Quantity	Average Age	Oldest
GPS IIR	11	16.1	20.6
GPS IIR-M	7	10.6	12.4
GPS IIF	12	4.1	7.8
Constellation	30	10.0	20.6

AS OF 1 MAR 18





# Current GPS Constellation

## Three Generations of Operational Satellites

- **Block IIR - 11 Operational**
  - 7.5 year design life (oldest operational satellite is 19 years old)
  - Launched 1997 to 2004
- **Block IIR-M - 7 Operational**
  - 7.5 year design life
  - Launched 2005 to 2009
  - Added 2nd civil navigation signal (L2C)
- **Block IIF - 12 Operational**
  - 12 year design life
  - Launched 2010 to 2016
  - Added 3rd civil navigation signal (L5)



Block IIR/IIR-M Satellite – Designed & Built by Lockheed Martin



Block IIF Satellite – Designed & Built by Boeing



# GPS III: Newest Block of GPS Satellites

- 4 civil signals: L1 C/A, L1C, L2C, L5
  - First satellites to broadcast common L1C signal
- 3 improved Rubidium atomic clocks
- Better User Range Error than IIF Satellites
- Increased availability
- Increased integrity
- 15 year design life





# GPS Ground Segment

- Current Operational Control Segment (OCS)
  - Flying GPS constellation using Architecture Evolution Plan (AEP) and Launch and Early Orbit, Anomaly, and Disposal Operations (LADO) software capabilities
  - Increasing Cyber security enhancements
- Next Generation Operational Control System (OCX)
  - Modernized command and control system - replaces legacy system and adds modern features
  - Worldwide, 24 hr/day, all weather, position, velocity and time source for military & civilian users
  - Modern civil signal monitoring and improved PNT performance
  - Robust cyber security infrastructure
  - New capabilities including civil signal performance monitoring capability



Monitor Station



Ground Antenna



# Modernized GPS Civil Signals

- Second civil signal “L2C”
  - Designed to meet commercial needs
  - Broadcast since 2005
  - Currently 19 satellites broadcasting L2C



- Third civil signal “L5”
  - Meets transportation safety of life requirements
  - Uses Aeronautical Radio Navigation Service band
  - Enables triple-frequency positioning techniques
  - Currently 12 satellites broadcasting L5

- Fourth civil signal “L1C”
  - Designed for GNSS interoperability
  - Specification developed in cooperation with industry
  - Improved performance in challenged environments
  - Launches with GPS III in 2018



***Continuous Broadcast of the new civil navigation “CNAV” message on L2C and L5 began April 28, 2014***



# GPS Performance Report Cards

- 2013-2016 performance reports now available on [gps.gov](http://gps.gov)
- 2017 performance report in coordination
- These reports measure GPS performance against GPS SPS PS commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

Performance Standard Metric		2013	2014	2015	2016
SIS Accuracy	URE Accuracy	✓	✓	✓	✓
	UTC OE Accuracy	N/A	N/A	✓	✓
SIS Integrity	Instantaneous URE Integrity	✓	✓	✓	✓
	Instantaneous UTC OE Integrity	N/A	N/A	✓	✓
SIS Continuity	Unscheduled Failure Interruptions	✓	✓	✓	✓
	Status and Problem Reporting	N/A	✗	✓	✗
SIS Availability	Per-Slot Availability	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓



# GPS SIS Performance Scoreboard

## GPS SIGNAL IN SPACE (SIS) PERFORMANCE (CM)

**BEST WEEK\***

**BEST DAY\***

**WORST DAY\***

**ENDING**

**SIS**

**ENDING**

**SIS**

**ENDING**

**SIS**

**ROLLING YEAR**

**20 SEP 17**

**48.9**

**26 JAN 17**

**35.0**

**1 DEC 17**

**77.7**



**BEST WEEK EVER**

**29 NOV 16**

**44.1**

*\*ROLLING YEAR*





# Wide Area Augmentation System (WAAS)

- Satellite Based Augmentation System (SBAS)
- Designed for aviation use, but available and used by many GPS users today
- Localizer Performance with Vertical Guidance (LPV)-200 approach is comparable to ILS Category I
- Provides the capability for increased availability and accuracy in position reporting, allowing more time for uniform and high quality air traffic management.
- Provides service for all classes of aircraft in all phases of flight



# Wide Area Augmentation System (WAAS) Architecture





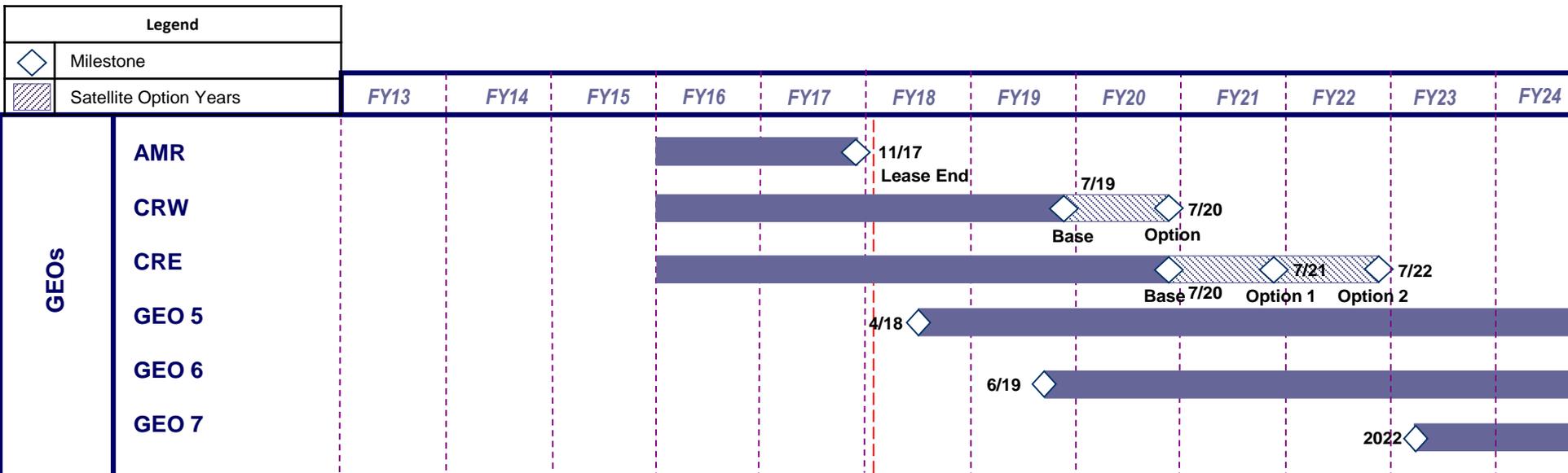
# GEO Constellation

## • GEO 5/6 Satellite Acquisition

- GEO 5
  - EUTELSAT 117 West B (ex SatMex 9) satellite
    - Provides full coverage of CONUS and Alaska
  - Integration activities started, expected operational 2018
- GEO 6
  - Host satellite is SES-15, planned for 129 West
  - In-Orbit Testing completed December 2017
  - Expected Operational in mid-2019

## • GEO 7 Satellite acquisition

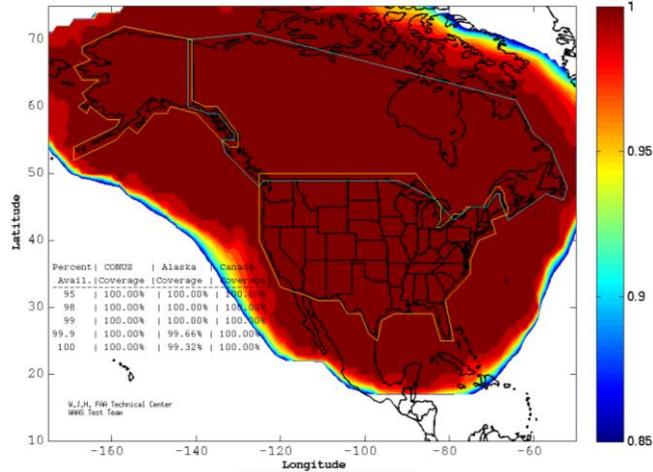
- Multiple IDIQ contracts awarded September 2017
- Targeting early 2018 to award task order for delivery of GEO 7 to one vendor



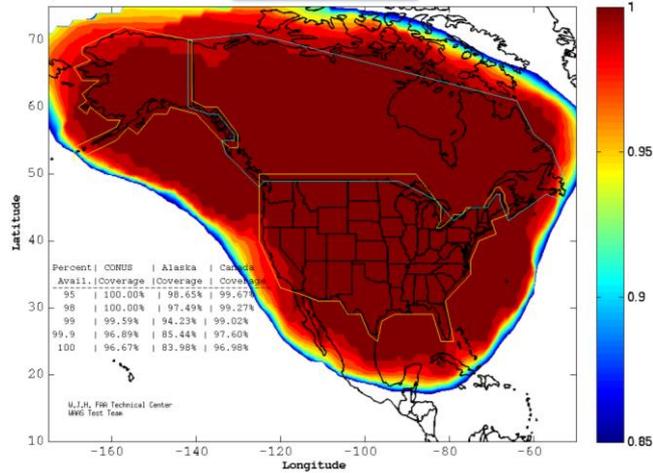


# Current WAAS Performance

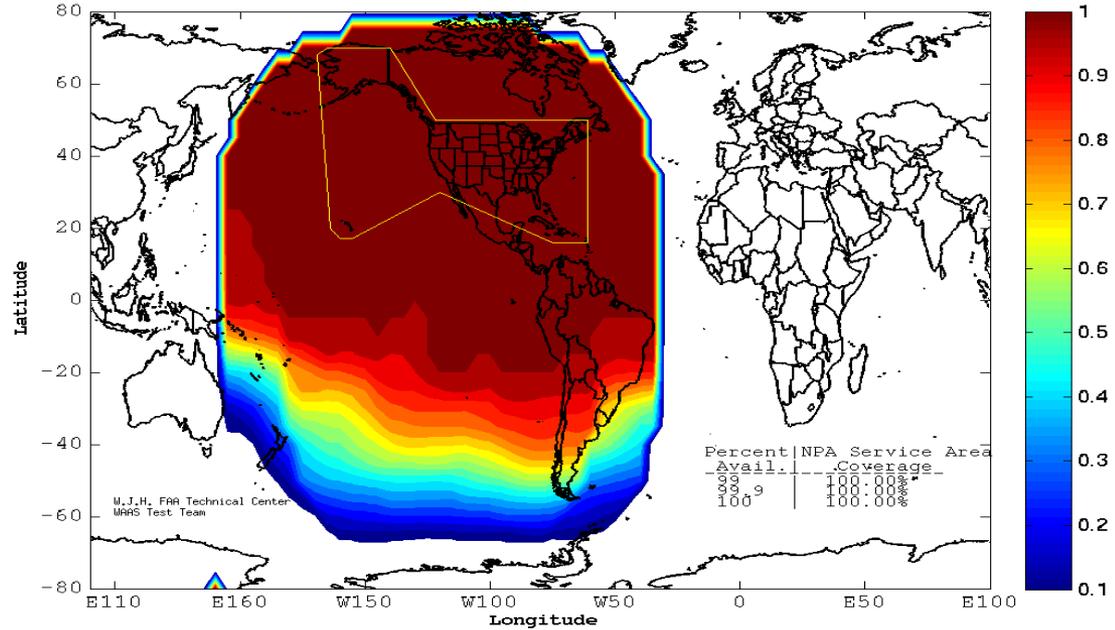
**LPV**



**LPV - 200**



**RNP 0.3**





# WAAS Dual Frequency Service

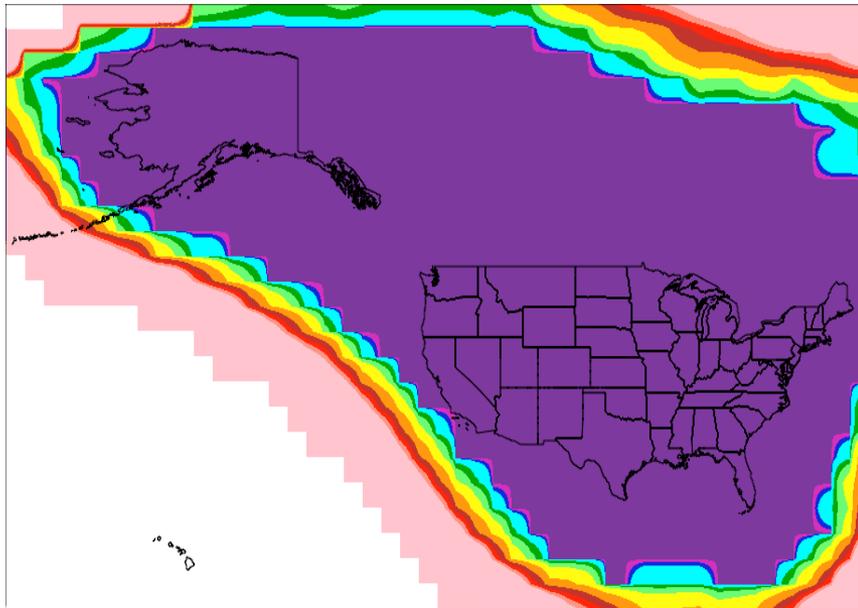
- WAAS has implemented system changes to enable a L1/L5 user
  - Upgraded reference station receivers to receive L5
  - Upgraded communication network to handle additional data (Dec 2017)
  - New safety computer with improved processor performance (Sep 2019)
- Minimum Operational Performance Standards (MOPS) and Standards And Recommended Practices (SARPS) requirements development is underway
- Significant additional work needed to implement a dual frequency WAAS Service
  - Preparing for FAA investment decision in 2019
- Have also installed non-operational test receivers at 6 WAAS reference sites to record Galileo data
  - Currently being collected for research purposes only



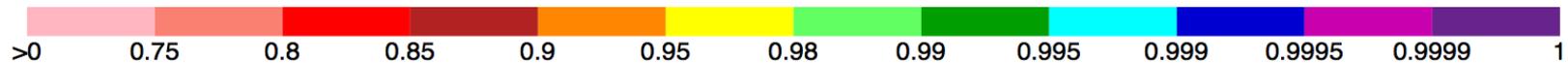
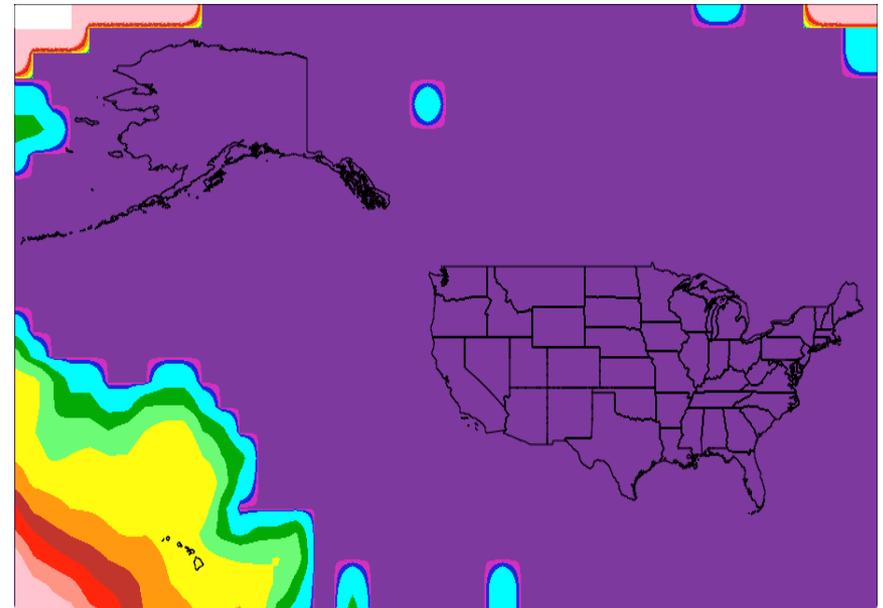
# Benefits of Dual Frequency Operations

- Dual frequency L1/L5 service improves availability and continuity

L1



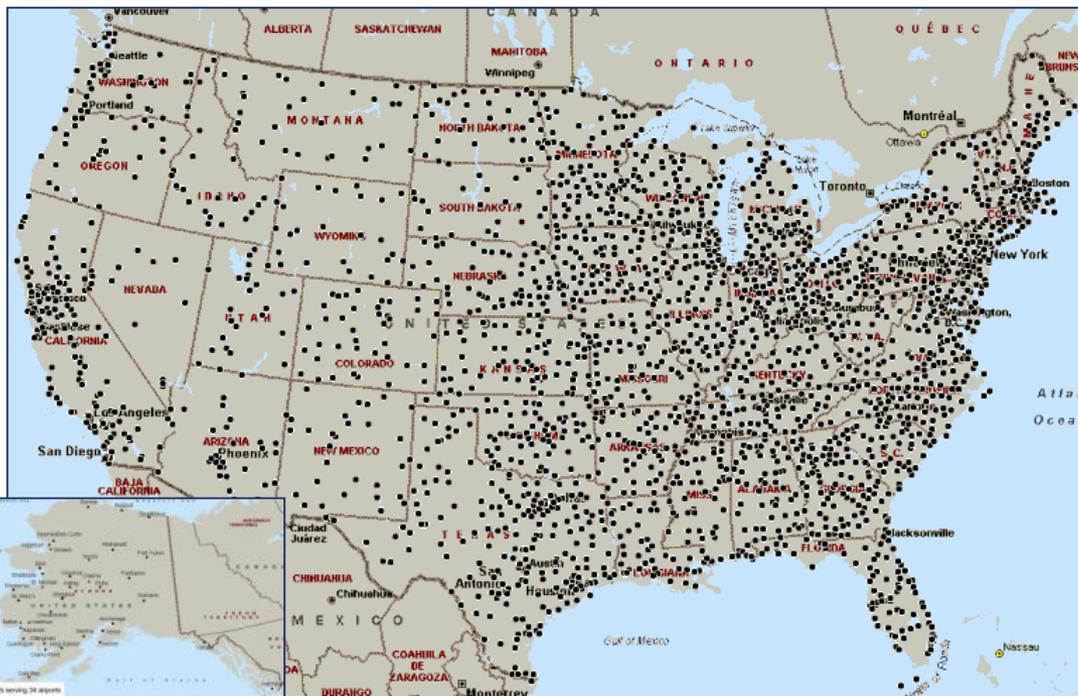
L1, L5



Simulation



# Procedures and Users Depending on WAAS



## Approach Procedures

- 4527 WAAS Procedures published (as of Jan 2018)
  - 3872 Localizer Performance with Vertical guidance (LPV) procedures
  - 655 Localizer Performance (LP) procedures



## Users

- Over 91,000 WAAS/SBAS equipped aircraft
- All aircraft classes served in all phases of flight
- WAAS/SBAS is enabling technology for FAA NextGen
  - Automatic Dependent Surveillance Broadcast (ADS-B)
  - Performance Based Navigation (PBN)





# U.S. Objectives in Working with Other GNSS Service Providers

- Ensure **compatibility** — ability of U.S. and non-U.S. space-based PNT services to be used separately or together without interfering with each individual service or signal
  - Radio frequency compatibility
  - Spectral separation between M-code and other signals
- Achieve **interoperability** – ability of civil U.S. and non-U.S. space-based PNT services to be used together to provide the user better capabilities than would be achieved by relying solely on one service or signal
- Promote fair competition in the global marketplace

***Pursue through Bilateral and Multilateral Cooperation***



# For Additional Information...

# GPS.gov

 Official U.S. government information about the Global Positioning System (GPS) and related topics

[Home](#)[What's New](#)[Systems](#)[Applications](#)[Governance](#)[Multimedia](#)[Support](#)

Home » [Support](#) » [GPS Service Outages & Status Reports](#)

## SUPPORT:

[Frequently Asked Questions](#)[Address, Route, & Map Problems](#)[Service Outages & Status Reports](#)[Civil GPS Service Interface Committee \(CGSIC\)](#)[Technical Documentation](#)[External Links](#)[About This Website](#)[Contact Us](#)

## TAKE ACTION:

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## GPS Service Outages & Status Reports

Users experiencing GPS service problems can get support from one of three federal agencies, depending on their application: civil non-aviation, civil aviation, or military. The responsibilities of the support agencies are documented in an interagency agreement. [VIEW AGREEMENT](#) →

### Civilian User Support – Non-Aviation

The U.S. Coast Guard Navigation Center (NAVCEN) is the primary point of contact in the government for providing operational GPS user support to the civilian community. The following links lead to pages on the NAVCEN website.



- [Check the operational status of the GPS satellites](#) →
- [Look up planned GPS service disruptions due to interference testing](#) →
- [Report a GPS service outage or anomaly \(non-aviation\)](#) →
- [Receive GPS status messages & user advisories via email](#) →

If you suspect a GPS disruption due to illegal signal jamming ([LEARN MORE](#) →), please call the FCC Jammer Tip Line immediately at 1-855-55-NOJAM, then submit an outage report to NAVCEN.

[www.gps.gov](http://www.gps.gov)