Wide Area Augmentation System (WAAS) Overview

Presentation to EGNOS on WAAS successful implementation and return on experience in the US

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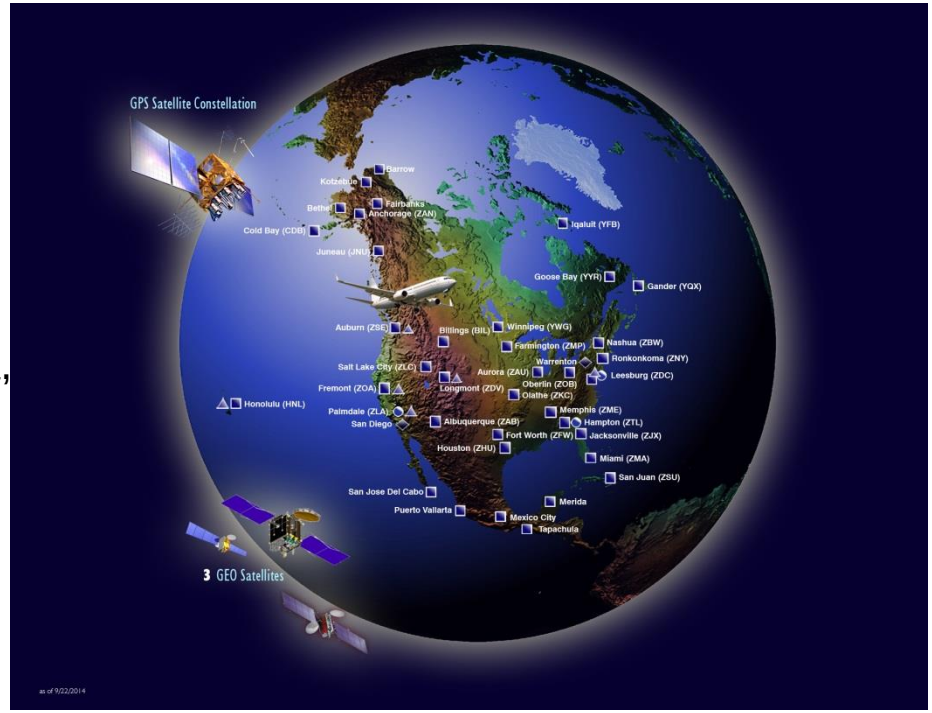
Agenda

- Overview
- Program Structure and Operation
- Program Organization and Interaction
- Second Level Engineering
- Service Availability
- LPV Production
- WAAS for usage outside aviation
- Global coverage
- Current and Future Applications

Wide Area Augmentation System

- WAAS includes ground based and space based elements that augment the GPS Standard Positioning Service (SPS)
- WAAS provides availability, accuracy and integrity allowing for uniform and high quality worldwide air traffic management
- WAAS provides coverage over North America, with a precision approach capability at over 4,000 runway ends in the United States and Canada



3 Geostationary Satellite Links

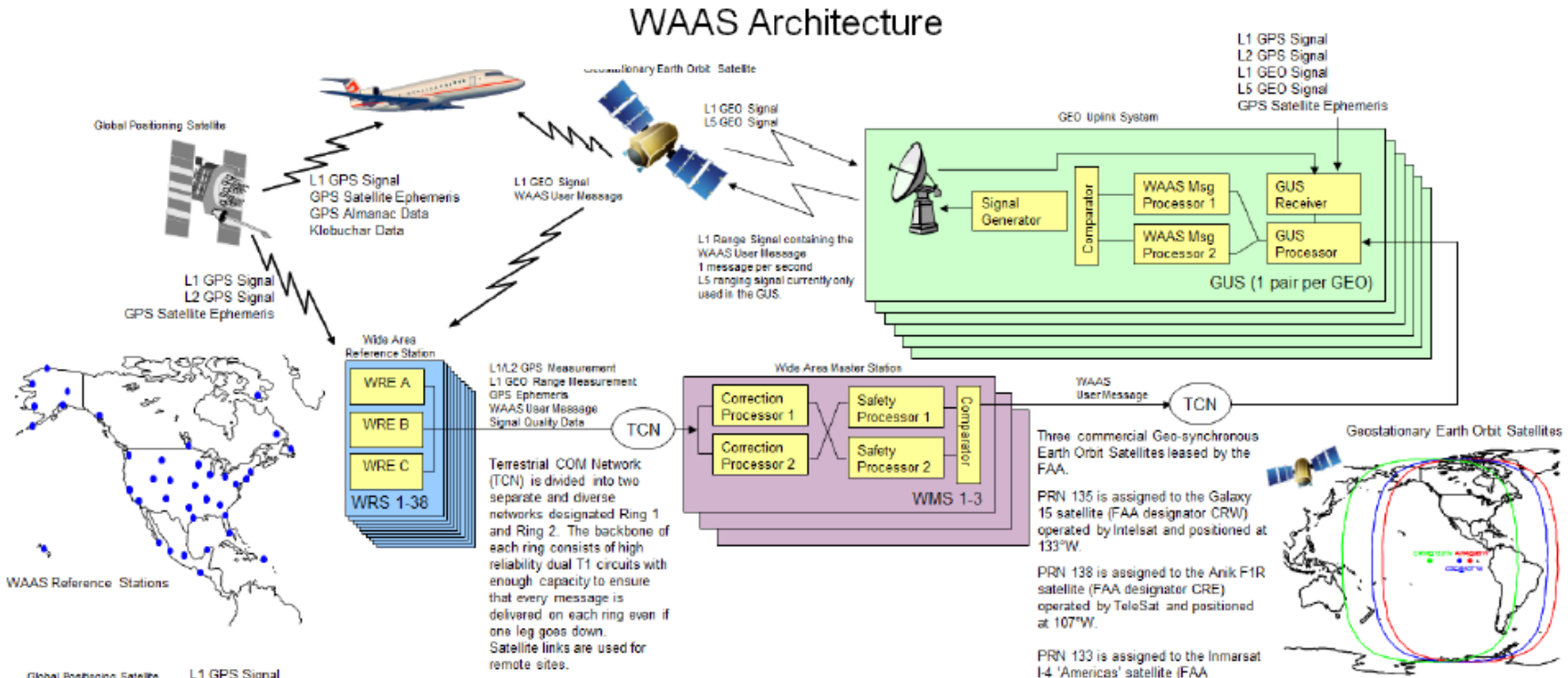
2 Operational Control Centers

38 Reference Stations

3 Master Stations

6 Ground Earth Stations

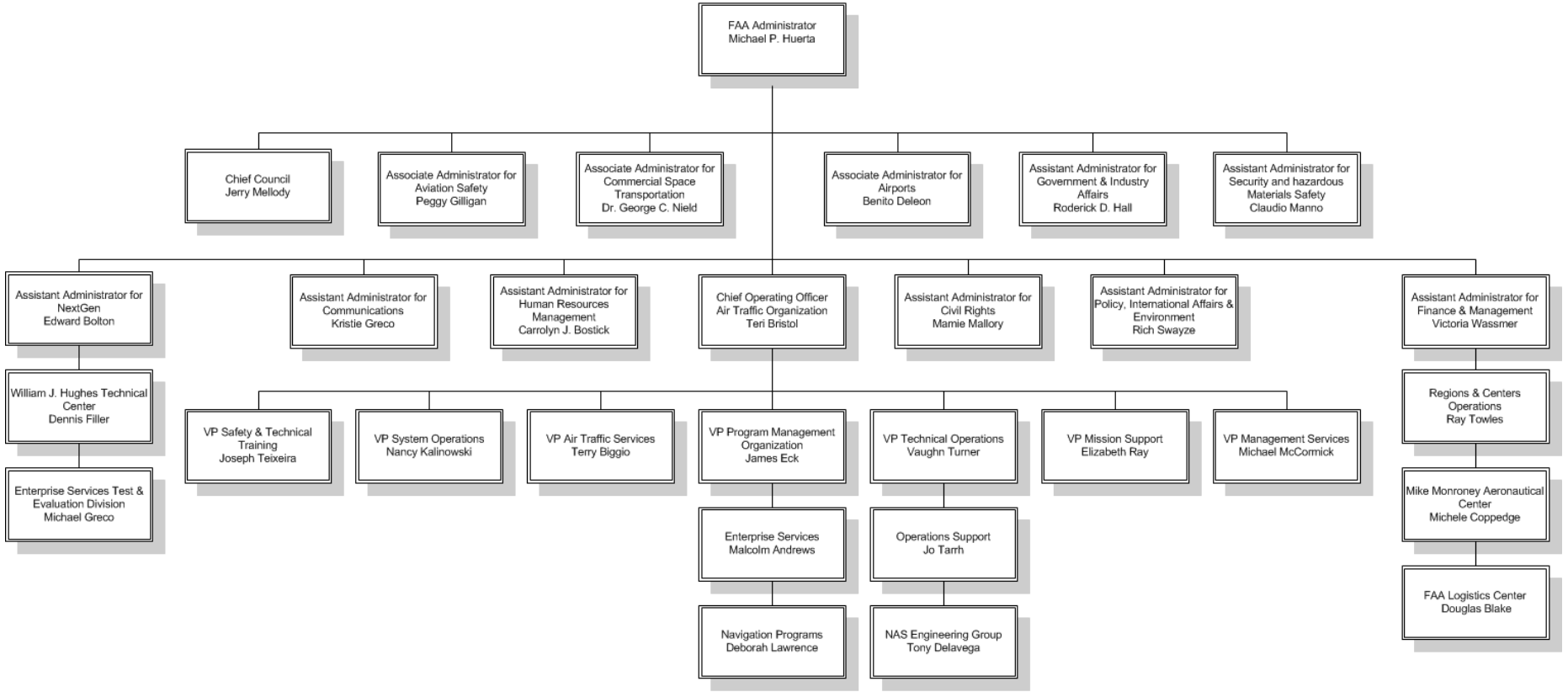
WAAS System Architecture



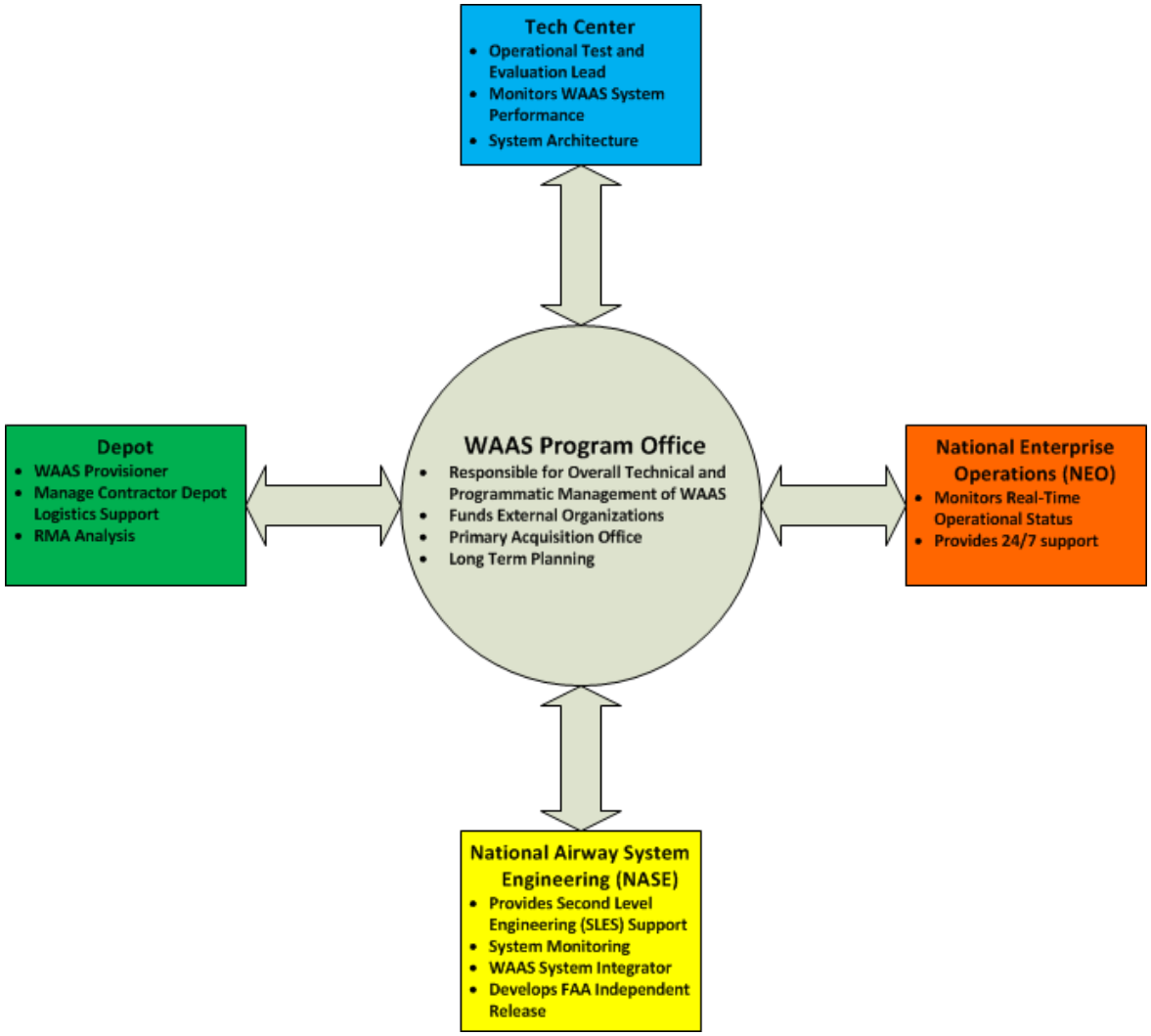
	WAAS Requirement	System Performance
Horizontal 95% Accuracy	1.5 m	0.5 m
Vertical 95% Accuracy	2.0 m	1.0 m
CONUS 99% LPV Availability	100% of CONUS	100% of CONUS
Alaska 95% LPV Availability	75% of Alaska	98% of Alaska
Alaska 99% LPV Availability	No Requirement	91% of Alaska

WAAS Full LPV final Test, May 2008

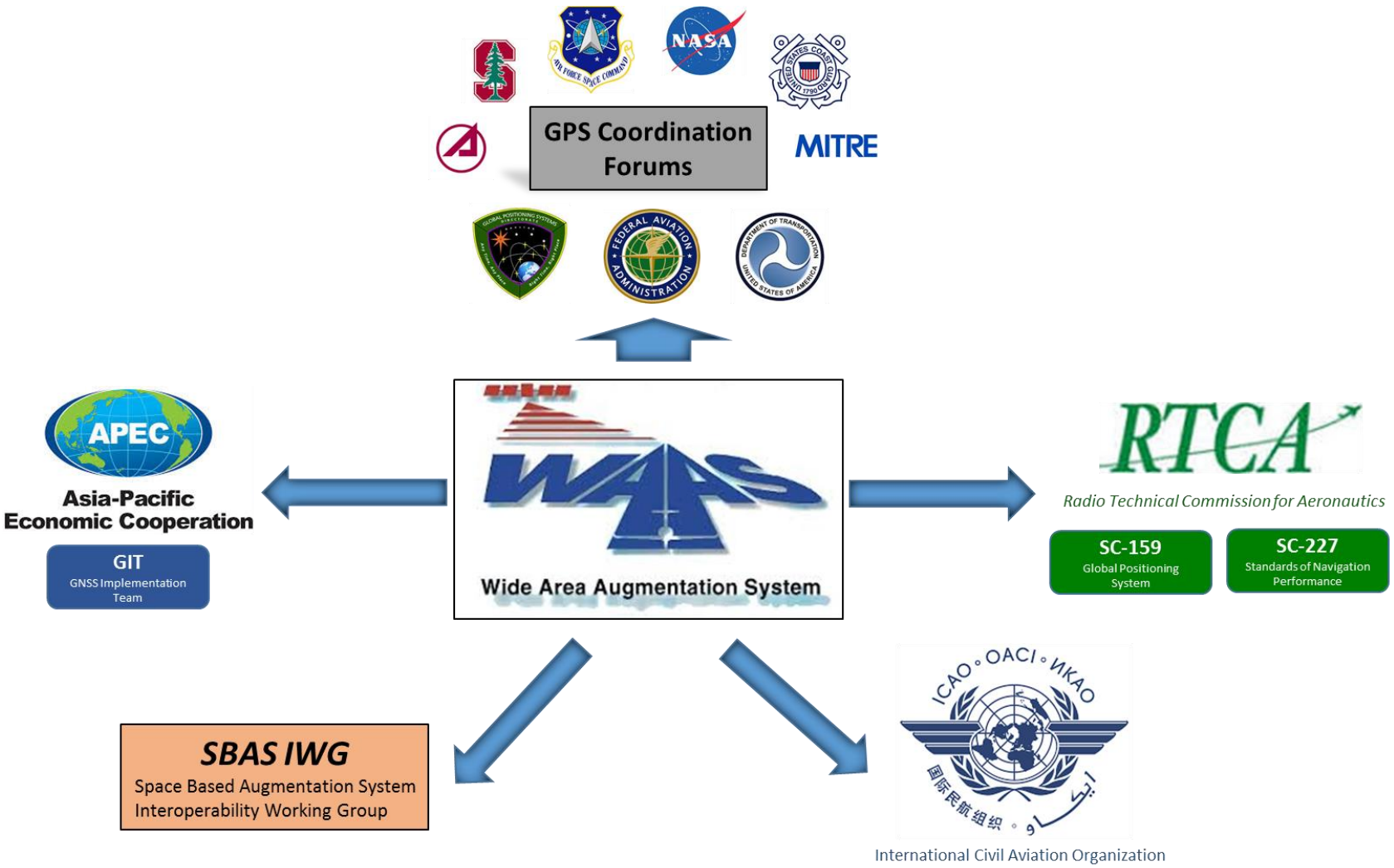
FAA Organization



WAAS Program Organization



WAAS External Coordination



WAAS Operations and Maintenance

Second Level Engineering Support (SLES)

- **WAAS Program Office has a Procurement Directive (PD) signed with National Airways System Engineering (NASE) to fund SLES on an annual basis**
- **Work and budget collaboratively developed by NASE and WAAS Program Office during its annual Program Execution Plan (PEP)**
- **Services NASE provide are**
  - Field Support
  - Anomaly Investigation
  - System Monitoring
  - OLM Quarterly Reports
  - HMI Analysis
  - Shadow Testing
  - Software and Hardware Releases
  - Coordination with Prime Vendor

WAAS Operations

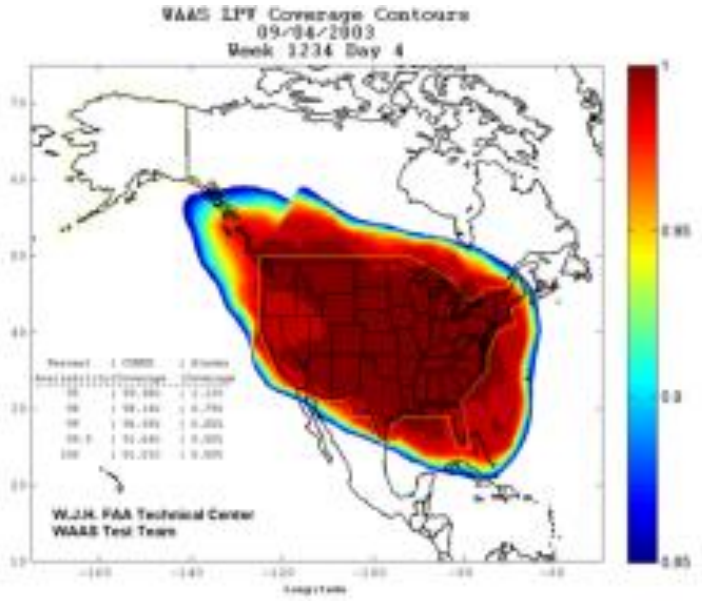
- **Satellite Operations Group (SOG)**
  - Part of the National Enterprise Operations (NEO) organization
  - Funded and provided oversight through the FAA office of Technical Operations
  - Split into two areas
    - WAAS Operations East (Operate out of the NOCC)
    - WAAS Operations West (Operate out of the POCC)
- **Services provided at the NOCC and POCC**
  - Performs real-time monitoring and control of the WAAS
  - Performs event-based certifications for Signal Generation Subsystem (SGS) and WRSs
  - Originates NOTAMs for WAAS related unavailability and Solar Storm events
  - Performs oversight of FAA owned WAAS equipment
  - Provide first-level maintenance and interface with site maintainers and service providers
  - Performs real-time national oversight of Surveillance and Broadcast Services (SBS) including delivery of ADS-B, ADS-R, TIS-B and FIS-B services
  - Coordinates WAAS/GPS Aircraft Accident investigation
  - Initiates CRUCIBLE exercises and GPS anomaly investigations
  - Investigates anomalies, coordinates response to reports of RFI and GPS anomalies
  - Collaborates with maintenance personnel, engineering support, logistics and program office elements as well as organizations external to the FAA to manage WAAS and SBS operations on a national level

WAAS Test and Evaluation

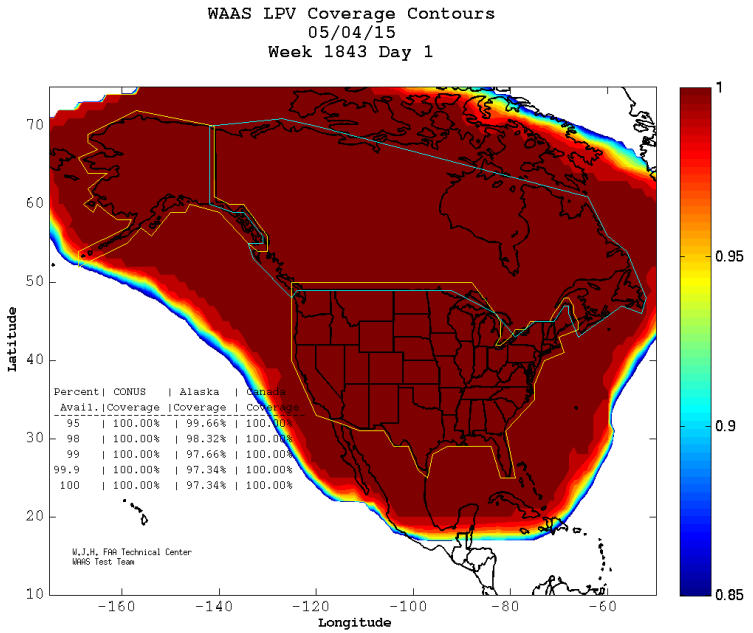
- **Navigation System Verification and Monitoring Branch**
  - Engineering Services Test and Evaluation Division
  - Report to Technical Center Director
  - Part of NextGen organization
- **Perform test, evaluation, and monitoring of new and existing navigation systems**
  - Performance monitoring, develop and publish WAAS/GPS performance reports
    - Recently completed Civil Navigation (CNAV) Message testing using G3 test network to collect CNAV messages
    - Compared new (2014) Air Force CNAV messaging performance to 'legacy' navigation message performance
  - Support test conduct on all site installations
  - Developed and continually update Global SBAS Coverage Tool
    - Completed with WAAS, EGNOS, and MSAS data
    - Real time: http://www.nstb.tc.faa.gov/sbas
    - Recently added GAGAN monitoring

Increased Service Availability

- **WAAS Availability increase**
  - 3rd GEO added in 2010 increasing the WAAS coverage area over all of CONUS
  - WAAS Reference Stations (WRS) were added in Mexico and Canada in 2007/2008 to expand LPV coverage outside of the US
  - Software and Hardware updates to legacy ground based WAAS infrastructure



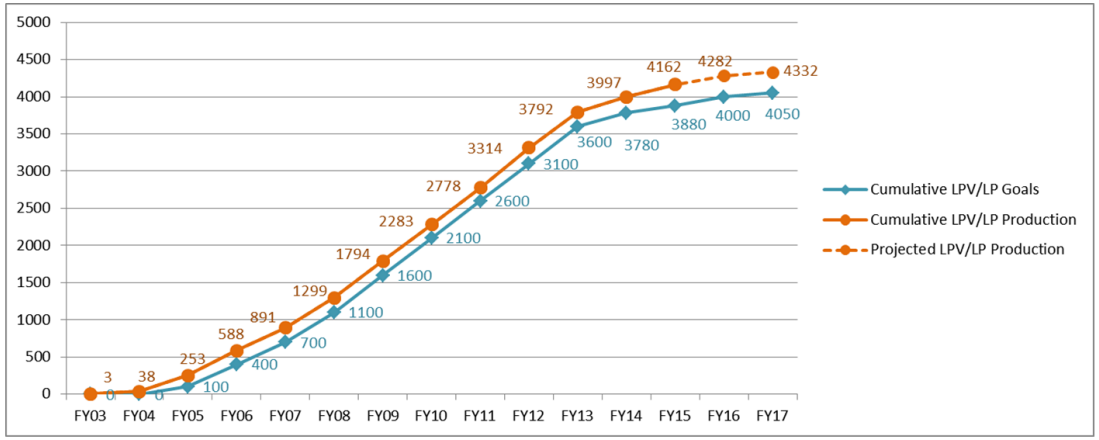
2003 IOC – LPV Coverage in lower 48 states only



2015 Coverage - Full LPV 200 Coverage in CONUS (3 Satellites)

Increased LPV Publication

- **Since 2003 the WAAS program has been adding new approaches to meet the FAAs goal to have an LP/LPV approach available at all qualified runway ends in the US**
  - In September of 2008 the number of WAAS procedures surpassed the number of legacy ILS approaches in the National Airspace System (NAS)
  - Currently there are more than 4100 WAAS procedures published serving nearly 2000 airports
  - Most airports capable of supporting an instrument approach within the US have one or more WAAS approaches available



	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
Non-ILS Runway Ends	0	7	80	187	195	263	259	375	411	460	443	181	156	0	0
ILS Runway Ends	3	28	135	148	108	145	236	114	84	76	35	24	9	0	0
LPVs/LPs	3	35	215	335	303	408	495	489	495	536	478	205	165	0	0
Annual LPV/LP Goals	0	0	100	300	300	400	500	500	500	500	500	180	100	120	50
Cumulative LPV/LP Goals	0	0	100	400	700	1100	1600	2100	2600	3100	3600	3780	3880	4000	4050
Cumulative LPV/LP Production	3	38	253	588	891	1299	1794	2283	2778	3314	3792	3997	4148	4148	4148

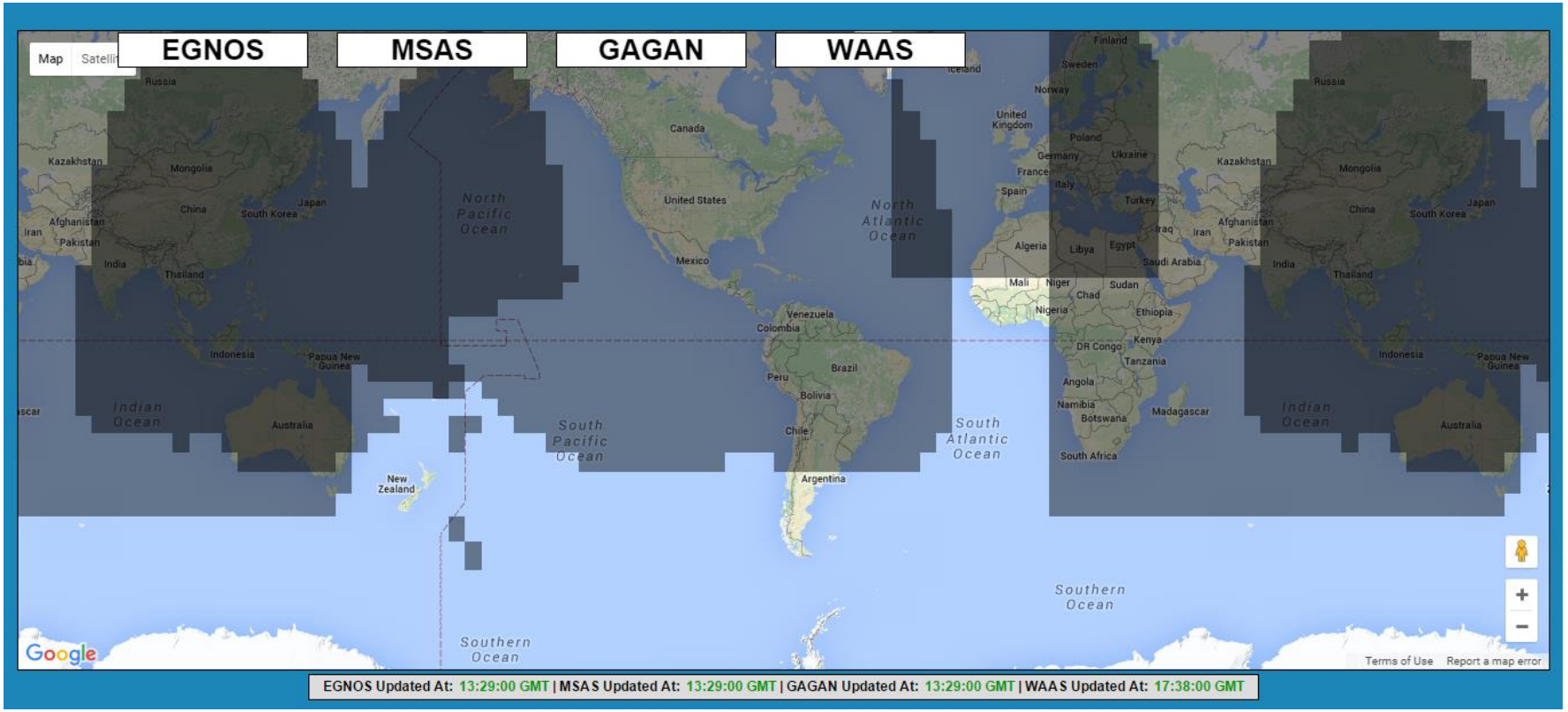
Addition of LPV-200

- **WAAS Commissioned For IFR Use On July 10, 2003**
  - Originally supported capability down to a decision height of 250’
- **Minimum decision height of new LPV approaches lowered from 250’ to 200’ in March of 2006**
  - Historical performance of the WAAS shows that the system normal performance to 200’ HAT DA’s is well within its expected bounds when compared with existing international and domestic ILS metrics
  - Worst observed vertical bias error during the entire WAAS service history was 8.9 m based on 1.8 billion observations
- **Safety Case Approved in May 2007**
- **1st LPV-200 Published in January 2008**
- **In 2011 the FAA issued a policy stating it was no longer publishing any new CAT I ILSs and that it plans to satisfy any new requirements for CAT I instrument operations with WAAS LPV**
- **FAA committed in 2016 to make a decision on CAT I ILS rationalization**

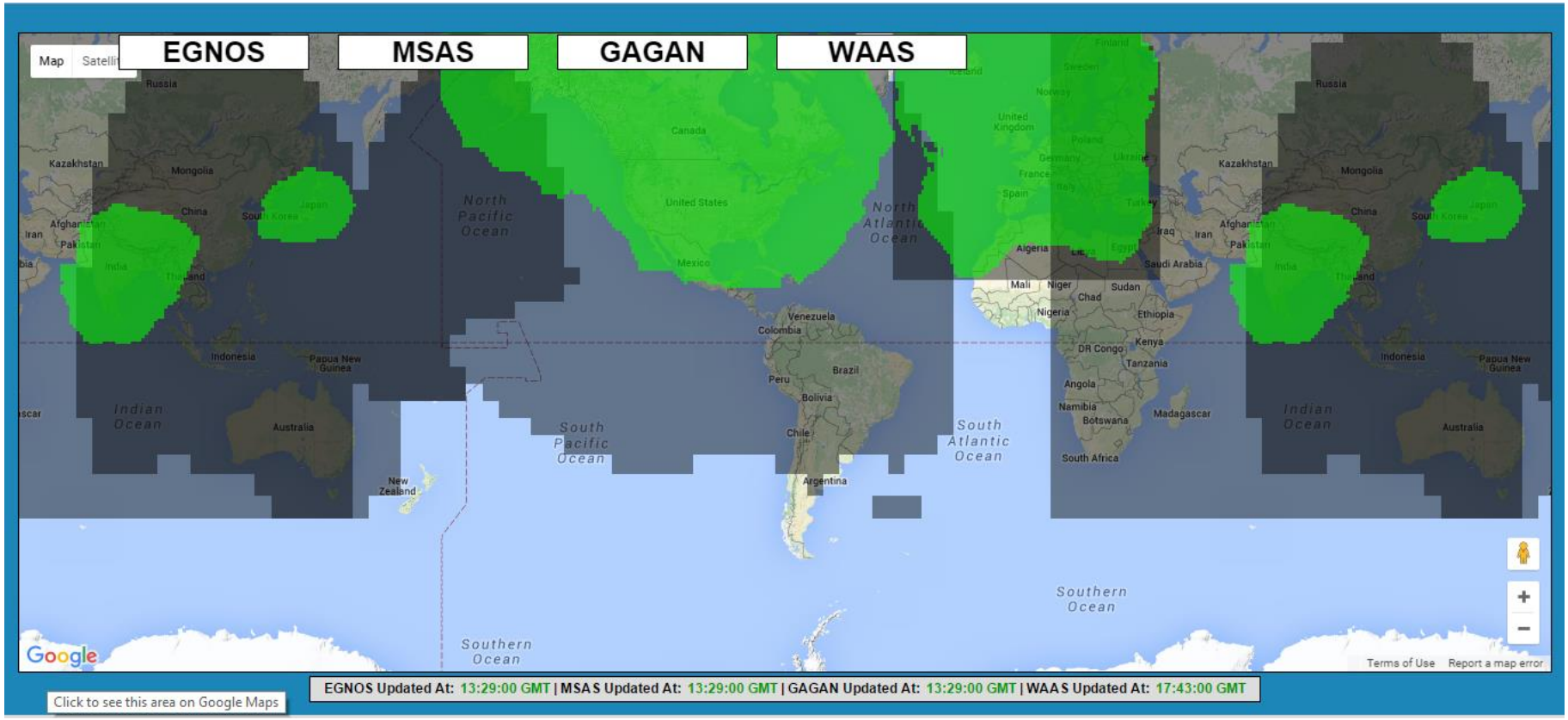
WAAS – A Multi User System

- **WAAS has become a relied upon utility for a number of non-aviation uses:**
  - Maritime
    - Navigation of Harbors
    - Navigation of Channels
  - Mapping & Survey
    - Precise location identification
  - Farming
    - Sub-meter accuracy for spreading, seeding and harvesting
  - Recreational
    - Personal GPS units

SBAS RNP 0.3 Coverage – Sept 24, 2015



SBAS LPV Coverage – Sept, 24 2015



Current and Future Applications

- **Automatic Dependent Surveillance Broadcast (ADS-B)**
  - WAAS is currently the only technology that meets all of the most stringent requirements for a positioning source for ADS-B
- **Dual-Frequency Multi-constellation Capability**
  - International Focus is on taking advantage of other GPS like constellations
    - International Civil Aviation Organization (ICAO) Navigation Systems Panel (NSP) has developed work plan that supports development of future standards for use of other Global Navigation Satellite Systems (GNSS)
    - ICAO working on CONOPS addressing all DFMC applications (e.g. SBAS, GBAS)
  - User Equipment Standards for Dual-Frequency Operations
    - FAA working with Interoperability Working Group (IWG) on definition document that provides the basis for interface design and MOPS development for L1/L5 and multi-constellation
- **Advanced RAIM (ARAIM)**
  - Avionics-centric approach to dual-frequency multi-constellation
  - ARAIM subgroup developing more detailed concept definition
    - Will be used to coordinate standards development with ICAO, RTCA and EUROCAE
    - Updated Milestone 2b report analysis and conclusions based on public feedback and incorporate in Milestone 3 report at meeting held the week of March 23rd 2015
    - The Milestone 2b report to be published at following meeting when formal review cycle completes

Questions?