



Federal Aviation  
Administration

# GNSS Program Status and Future Plans

Presented To: CGSIC

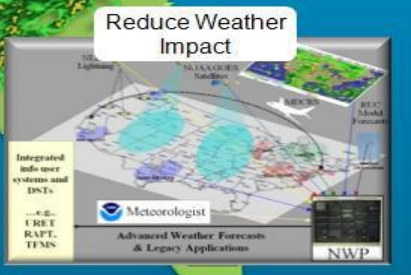
Date: September 18, 2012

By: Deborah Lawrence,  
Manager  
Satellite Navigation, FAA



# NextGen 2025 OV-1

## INTERNATIONAL HARMONIZATION

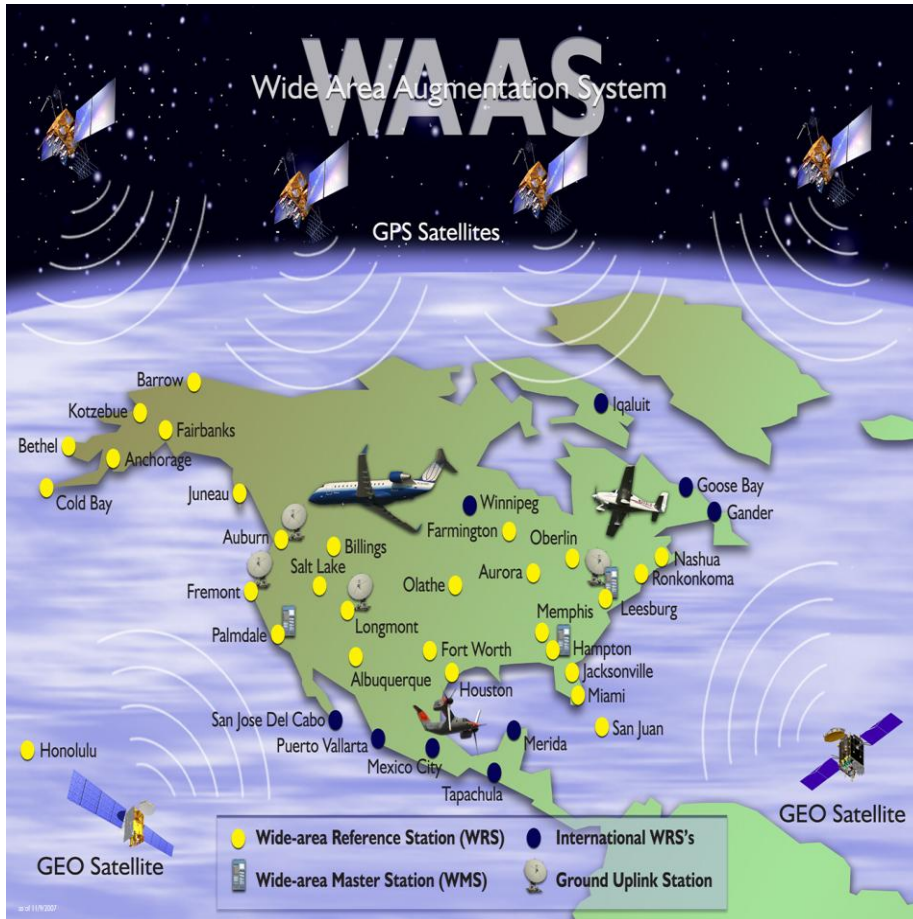


SOA CORE SERVICES										SUPPORT SERVICES				ENTERPRISE WIDE OPERATIONS (NATIONAL)				ENTERPRISE GOVERNANCE				ADMINISTRATIVE SERVICES			
Messaging Services	Interface Management	Security Service	Enterprise Services Mgt	Collaboration Services	Content Management	Data Acquisition	Flow Contingency Management	Capacity Management	Flight & State Data Management	SOA Governance	Run-time Management	Data/Network Support Services	Weather Information Management	Aeronautical Information Management	Surveillance Information Management	Services Provisioning Management	Training Support								
System & Services Analysis	System & Services Management	Safety Management Service	Trajectory Management																						





# Wide Area Augmentation System - 2003



38 Reference Stations



3 Master Stations



6 Ground Earth Stations



3 Geostationary Satellite Links



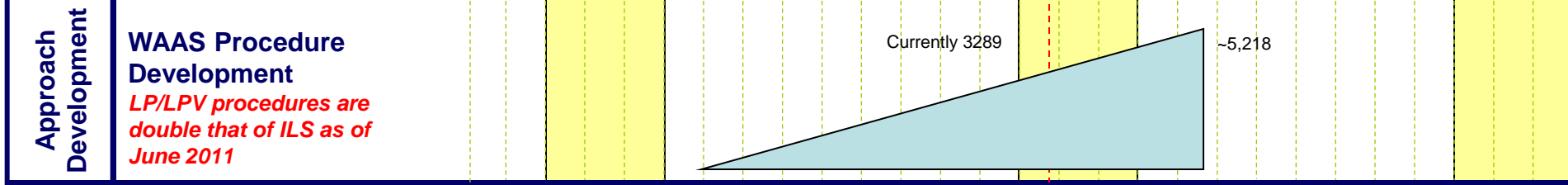
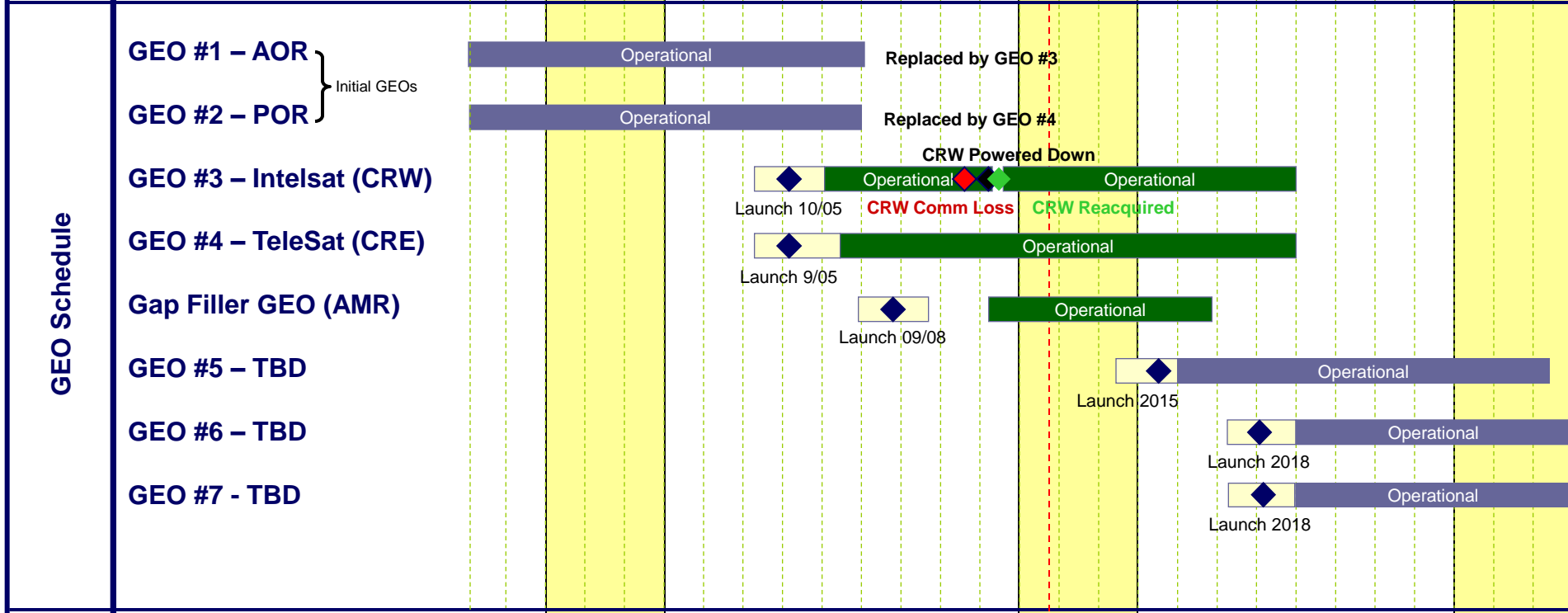
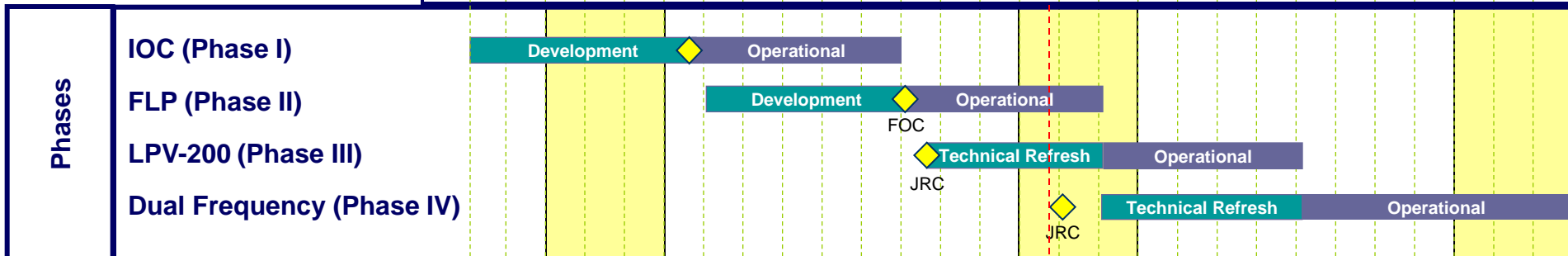
2 Operational Control Centers

# WAAS Phases

- **Phase I: IOC (July 2003) Completed**
  - Provided LNAV/VNAV/Limited LPV Capability
- **Phase II: Full LPV (FLP) (2003 – 2008) Completed**
  - Improved LPV availability in CONUS and Alaska
  - Expanded WAAS coverage to Mexico and Canada
- **Phase III: Full LPV-200 Performance (2009 – 2013)**
  - Development, modifications, and enhancements to include tech refresh
  - Steady state operations and maintenance
  - Transition to FAA performed 2nd level engineering support
  - Begin GPS L5 transition activities
- **Phase IV: Dual Frequency (L1,L5) Operations (2014 – 2028)**
  - Complete WAAS transition from L2 to L5
  - Commence dual-frequency, iono-free service
    - Improved availability and continuity, especially during severe solar activity
  - Maintain single frequency SBAS service
  - Other capabilities under consideration (see Technology Evolution slide)

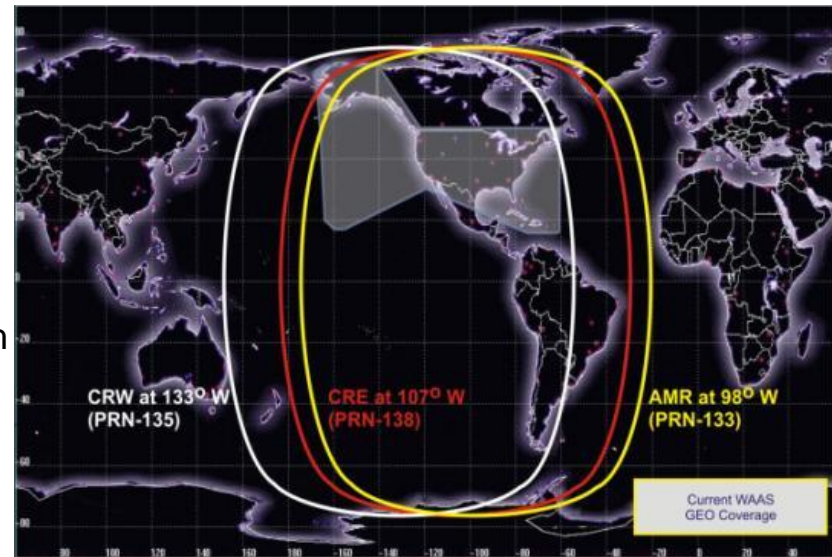
# WAAS Enterprise Schedule

FY 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



# Current Activities

- **Ground Segment**
  - Safety Computer
    - Processor throughput and obsolescence
    - Contract awarded June 2012
    - Expect to integrate into baseline ~2016-2018
  - Software Development
    - Release 3B Cutover September 10, 2012
    - Release 4 (Software Build Merge and Code Cleanup)
      - Projected complete September 2013
  - GIII Receiver Development
    - Adds L5, L1C and L2C tracking capabilities
    - Prototype Testing in Progress
  - Comm Upgrade
    - Planning efforts underway to support additional bandwidth and data associated with Dual-frequency WAAS
  - Dual-Frequency Capability
    - Continuing algorithm development
    - Capability follows L5 IOC (L5 IOC expected around 2019)
- **Current WAAS GEO satellites**
  - Intelsat Galaxy XV (CRW)
  - Anik F1R (CRE)
  - Inmarsat I4F3 (AMR) \*
- **GEO 5/6/7**
  - SIR package released December 2011
  - Anticipated contract award September 2012



# WAAS Reference Receiver (G-III)

- **WAAS program developing next generation reference receiver (G-III)**
- **G-III receiver will add significant new capability and support WAAS dual frequency upgrades in 2014 – 2019 timeframe**
  - Tracks up to 18 GPS satellites and 8 SBAS satellites
  - Capable of tracking GPS L1C/A, L1C, L2C, L2 P(Y), and L5 signal types
  - Expandable to support additional GNSS signals in the future
- **Current Status**
  - Test Readiness Review completed end of August
  - Software Development and Hardware Development Completed
  - Testing expected to begin in October
- **Development currently scheduled to be complete in FY2013**
  - ~14 Production Receivers
- **Follow-on contract for production receivers expected 3<sup>rd</sup> Qtr FY13**
  - ~165 Production Receivers







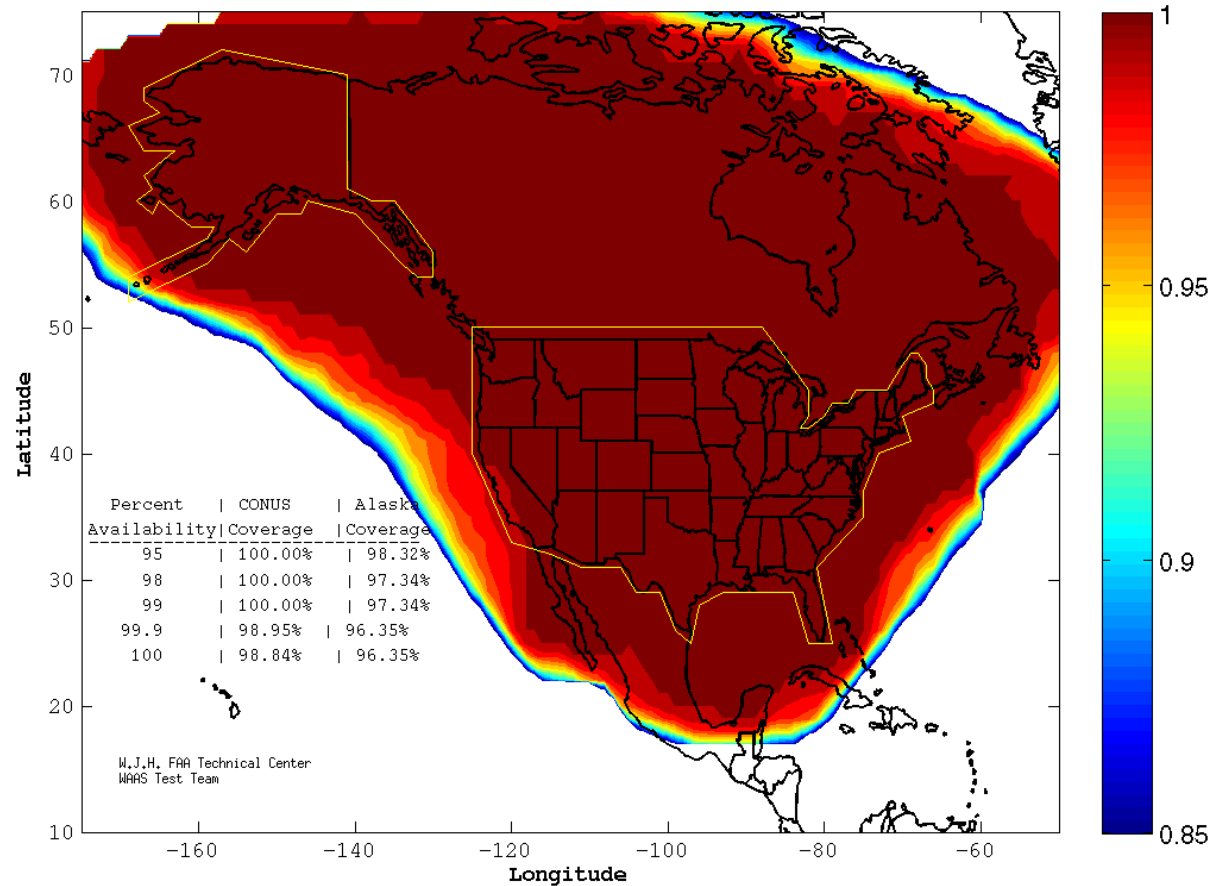


# WAAS LPV Coverage

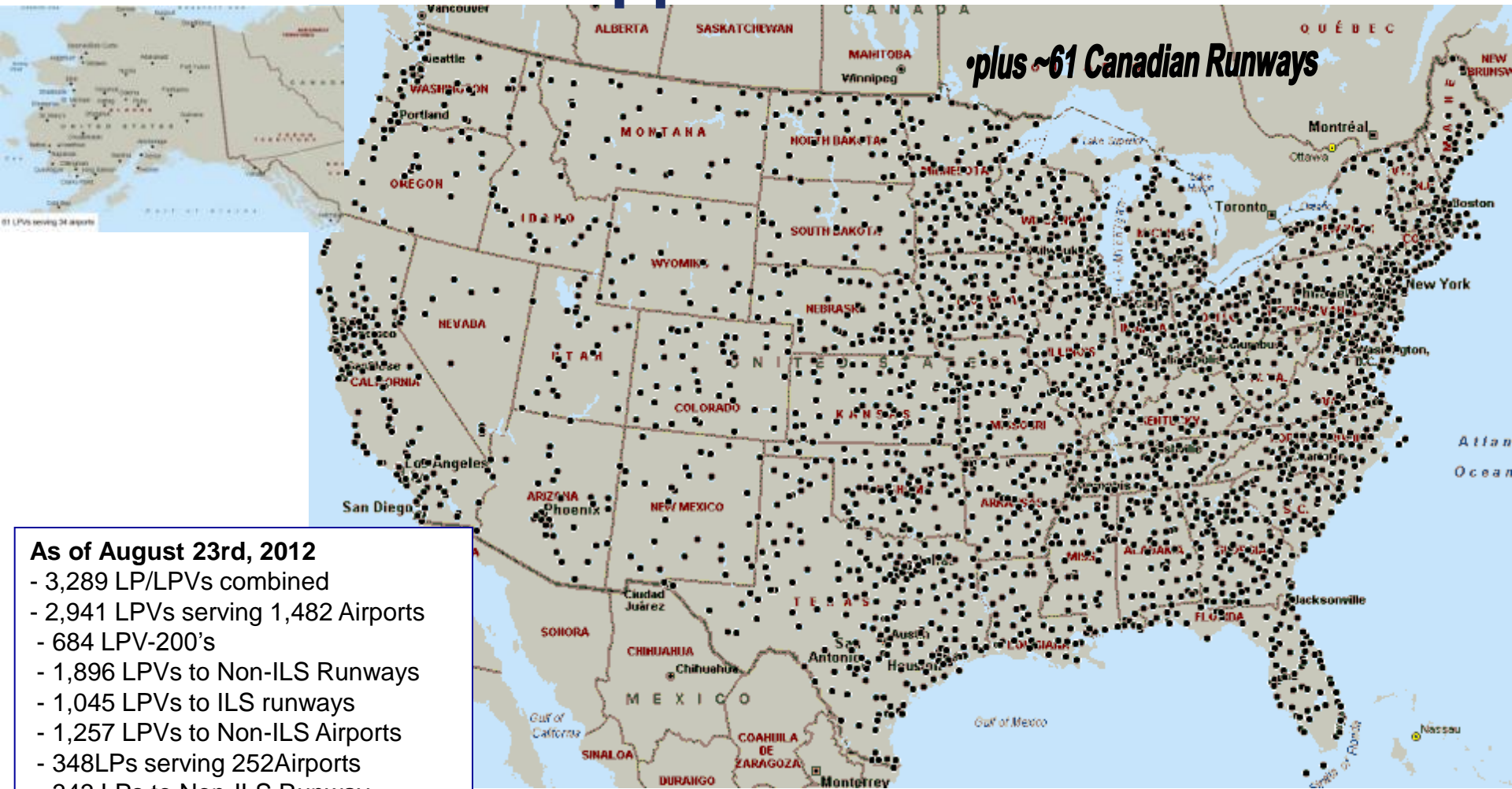
WAAS LPV Coverage Contours

09/12/12

Week 1705 Day 3



# Airports with WAAS LPV/LP Instrument Approaches



**As of August 23rd, 2012**

- 3,289 LP/LPVs combined
- 2,941 LPVs serving 1,482 Airports
- 684 LPV-200's
- 1,896 LPVs to Non-ILS Runways
- 1,045 LPVs to ILS runways
- 1,257 LPVs to Non-ILS Airports
- 348LPs serving 252Airports
- 343 LPs to Non-ILS Runway
- 5 LPs to ILS Runways



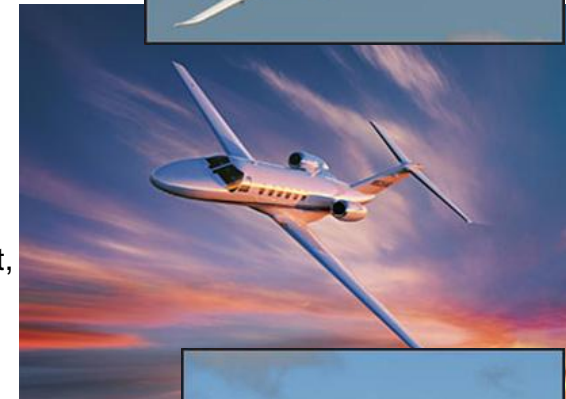
# WAAS Avionics Status

- **Garmin:**
  - 75,833+ WAAS LPV receivers sold
  - Currently largest GA panel mount WAAS Avionics supplier
  - New 650/750 WAAS capable units brought to market at the end of March 2011 to replace 430/530W units
- **AVIDYNE & Bendix-King:**
  - 140 Avidyne Release 9 units sold to date. Introduced IFD540 FMS/GPS/Nav/Com System with Touch screen
  - Bendix King KSN-770 certification pending
- **Universal Avionics:**
  - Full line of UNS-1Fw Flight Management Systems (FMS) achieved avionics approval Technical Standards Orders Authorization (TSOA) in 2007/2008
  - 2,400+ WAAS receivers sold as June 2, 2012,
- **Rockwell Collins:**
  - Approximately 2,700 WAAS/SBAS units sold to date
- **CMC Electronics:**
  - Achieved Technical Standards Orders Authorization (TSOA) certification on their 5024 and 3024 WAAS Sensors
  - Convair aircraft have WAAS LPV capable units installed (red label) and expect WAAS LPV certification by August 2012
  - Canadian North B-737-300 obtained STC for SBAS(WAAS) LPV using dual GLSSU-5024 receivers
- **Honeywell:**
  - Primus Epic and Primus 2000 w/NZ 2000 & CMC 3024 TSO Approval
  - Primus 2000 FMS w/CMC 5024 TSO pending



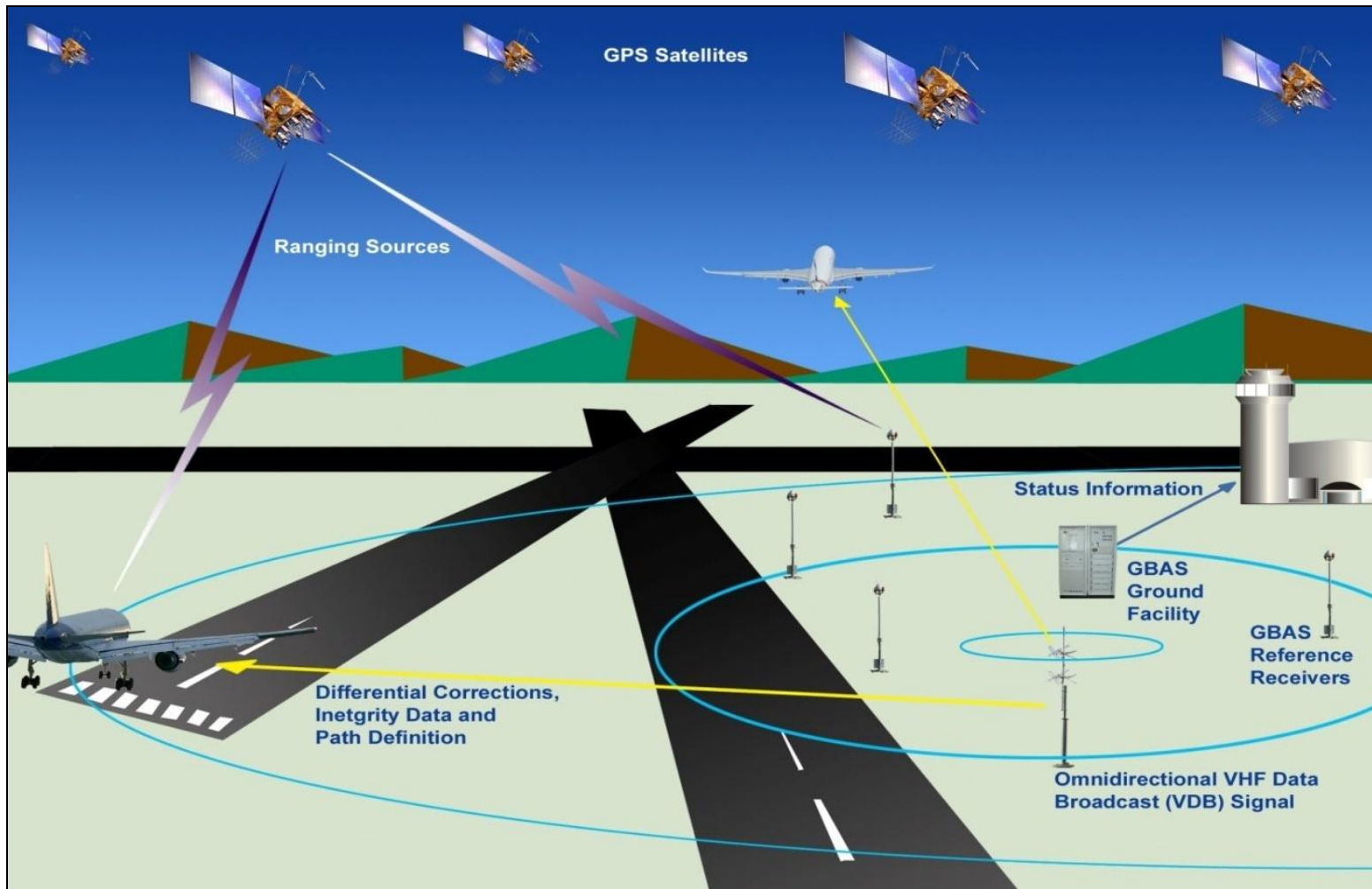
# WAAS STC Aircraft August 2012 (Estimate)

- **Garmin – 56,612 aircraft**
  - Covers most GA Part 23 aircraft.
  - See FAA Garmin Approved Model List (AML)
    - [http://rgl.faa.gov/Regulatory\\_and\\_Guidance\\_Library/rgstc.nsf/](http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgstc.nsf/)
- **Universal Avionics – 1,531 aircraft**
  - 120 fixed wing types and models
  - 12 helicopter types and models
  - Airframes to include (Boeing, de Havilland, Dassault, Bombardier, Gulfstream, Lear, Bell, Sikorsky, etc...)
- **Rockwell Collins – 950 aircraft**
  - 32 types and models
  - Airframes to include (Beechjet, Bombardier, Challenger, Citation, Dassault, Gulfstream, Hawker, KingAir, Lear)
- **Honeywell / CMC Electronics – 346 aircraft**
  - 16 types and models
  - Airframes to include (Gulfstream, Challenger, Dassault, Hawker, Pilatus, Viking)
- **Avidyne – 175 aircraft**
  - 3 types and models (Cirrus, Piper Matrix, and EA-500)
- **Cobham (Chelton) – 200 aircraft**
  - 4 types and models (Bell-407, Bell -412, Cessna 501, 550)
- **Thales – Airbus 350 certification pending**





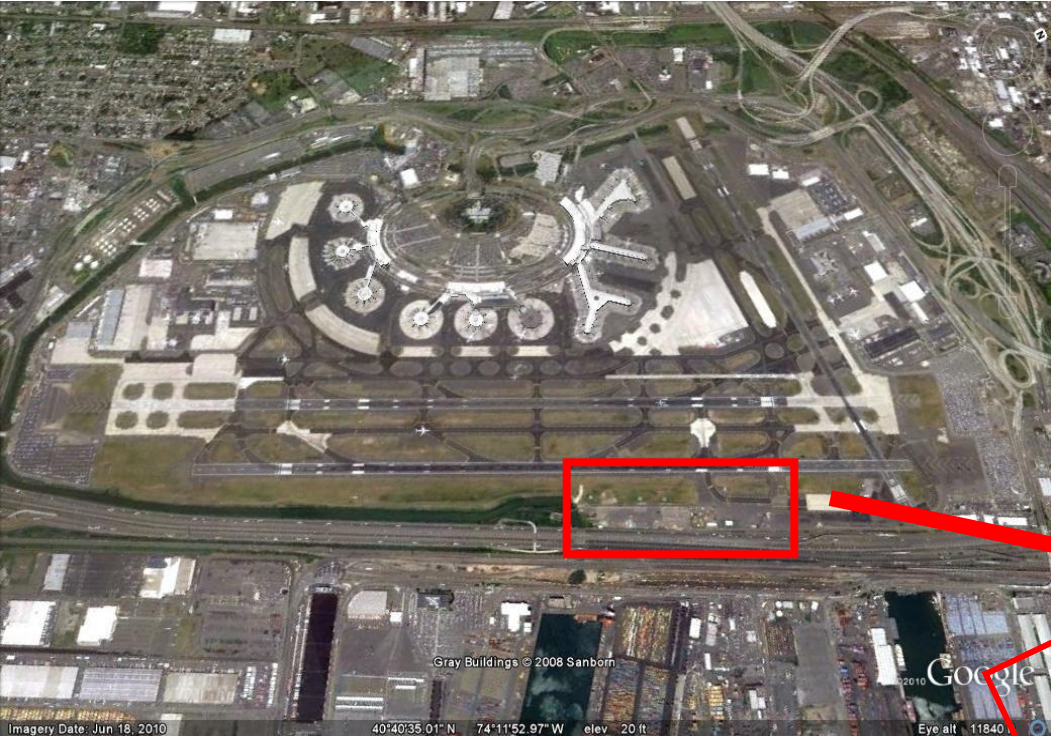
# GBAS (Ground Based Augmentation System)



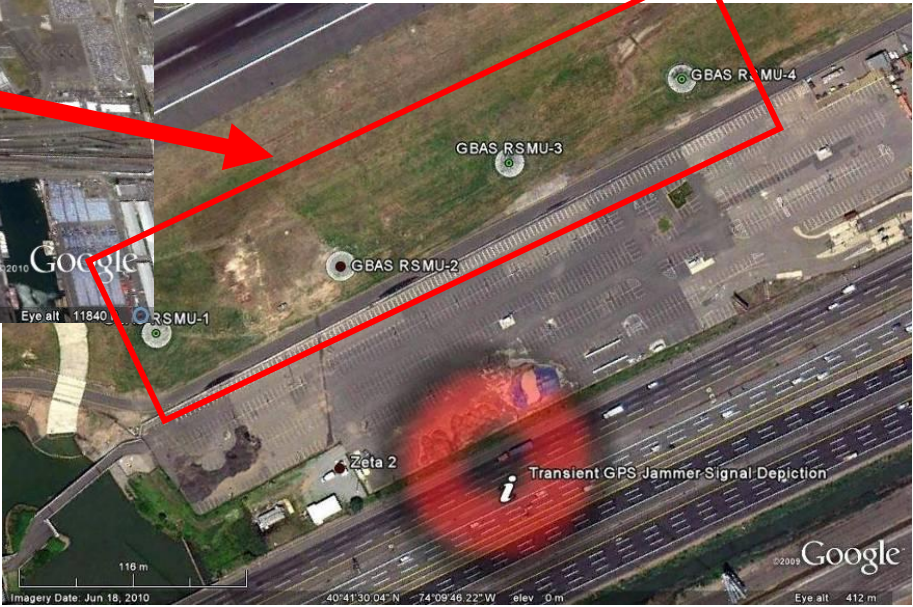
# FAA GBAS Program

- **The FAA has indefinitely delayed plans for GBAS acquisition**
- **The FAA GBAS program focuses on three task areas:**
  - GAST-D ICAO SARPs validation
    - FAA CAT III activities focus on single frequency GPS augmentation requirements
    - Produce an commercial prototype for validation testing
      - Vendor could seek NonFed approval
  - RFI analysis and mitigation
  - Limited CAT I implementation support
    - Newark NJ and Houston TX operational approval support
    - Gain operational experience with GBAS

# GBAS at Newark



- GBAS location and PPD Jammer example



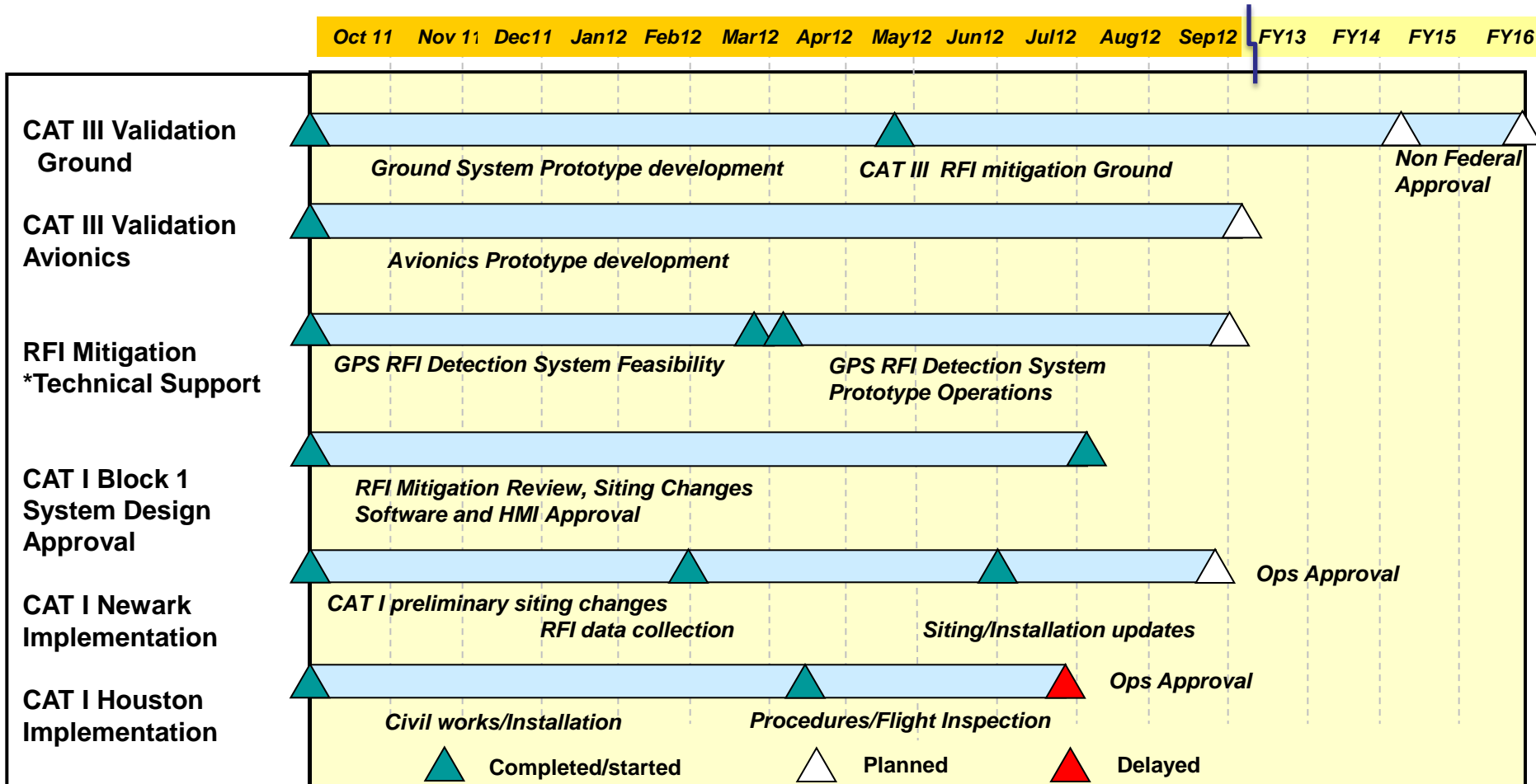
- GBAS location

# CAT III (GAST D) Technical Update

- **FAA executing two GBAS CAT III contracts (Ground and Avionics)**
  - Prototype ground system based on the SLS-4000
    - Includes a recent modification for robust RFI modifications
  - Prototype avionics system based on the Honeywell Integrated Navigation Receiver (INR)
- **Validation is the key product**
  - Finding and reporting requirements interpretation issues or potential interoperability problems
  - Analyzing fault-free performance to determine realistic thresholds
  - Includes comparisons to FAA baseline equipment



# FAA GBAS Project Schedule



# Federal Register Notice (76 FR 77939)

- **Published December 15, 2011**
- **FRN stated that the FAA:**
  - Transitioning to a Performance Based Navigation (PBN) system
  - Transitioning from airways defined by legacy NAVAID systems to NAS based Area Navigation (RNAV) and Required Navigation Performance (RNP)
    - Legacy NAVAIDs are identified as VHF Omni-direction Range (VOR), Tactical Air Navigation (TACAN) Azimuth, VOR/TACAN (VORTAC), VOR/DME and Non-Directional Beacon (NDB)
    - Distance Measuring Equipment (DME) stations and a minimum operational network (MON) of VOR stations will remain in place to ensure safety and continuous operations for high and low altitude en route airspace over the conterminous US (CONUS) and terminal operations at the Core 30 airports
    - The FAA is also conducting research on Alternate Positioning, Navigation and Timing (APNT) solutions that would enable further reduction of VORs below the MON.
  - Satisfy any new requirements for Category I instrument operations with WAAS localizer performance with vertical guidance (LPV) procedures.
    - A network of existing Instrument Landing Systems (ILS) would be sustained to provide approach and landing capabilities during GPS outages.



# VOR Minimum Operational Network (MON)

- FAA announced plans to reduce the Very High Frequency Omnidirectional Range (VOR) based navigation network to provide an alternate means of navigation in case of GPS outage called the Minimum Operational Network (MON) project
  - Projected full functionality by 2020
- Key elements of the project:
  - Minimum network of VORs that will support VOR to VOR navigation and proceeding to airports with Instrument Landing System (ILS) or VOR approach procedures.
  - The reduction in the number of VORs in the NAS.
  - Coverage above 5,000 ft Above Ground Level (AGL) in the continental US (CONUS) for navigation.
  - Support international arrivals and departures

# VOR MON (Cont.)

- The MON will permit non-GNSS guidance to an airport within 100 nautical miles (nm) that has an ILS or VOR approach procedure.
  - Aircraft will be able to navigate at or above 5,000 ft AGL and to an airport within 100 nm and land at that airport using non-GNSS-based landing aids such as an ILS or VOR.
  - Automatic Direction Finding (ADF), Distance Measuring Equipment (DME) and ATC Vectors will not be required to fly an approach at the identified airports
- All VORs will be retained in Alaska, the Western U.S. Mountainous Area (WUSMA), and U.S. Islands and territories
- Total Number of VOR's to remain is approximately **497**
  - Western US Mountainous Area (232), Alaska (40), Hawaii (11), Puerto Rico and U.S. Virgin Islands (6), Guam, Samoa, and Grand Turk (1 each) (3), International Routes [Atlantic and Pacific] (20), Support for ILS approaches (192), Support for VOR approaches (57)



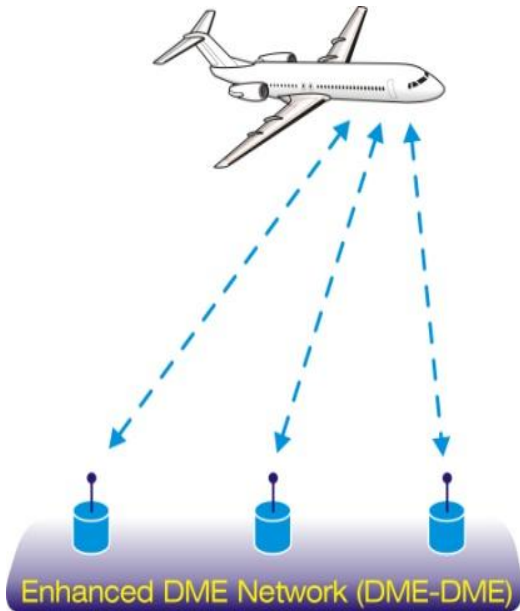
# Alternative Positioning, Navigation & Timing (APNT)

- **The transformation of the National Airspace System to the Next Generation Air Transportation System dependent on the availability of GPS-Based PNT services and suitable alternate PNT services**
  - RNAV and RNP procedures for trajectory-based operations (TBO)
  - Current ATC system cannot be scaled up to handle 2X traffic
  - 2X traffic is more than a controller can handle using radar vectors
  - Procedural separation with Conformance Monitoring will separate aircraft performing trajectory based operations (TBO)
  - Controllers intercede to provide “control by exception”
- **TBO Operations may require PNT performance that exceeds DME/DME/IRU**
- **GPS vulnerability to radio frequency interference (RFI) requires mitigation**
  - Waiting for the source of the interference to be located and turned off is not an acceptable alternative

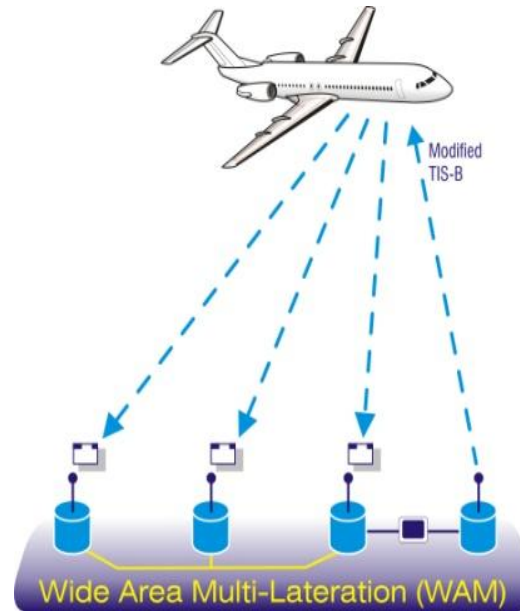
# APNT Background

- **Maintain Safety and Security while minimizing economic impacts during GPS interference**
- **The legacy navigation and surveillance systems are not capable of meeting the PNT performance requirements necessary to avoid significant disruption and loss of capacity and efficiency benefits during a GPS outage.**
  - **VORs and NDBs cannot support RNAV/RNP**
  - **Estimated increases in traffic by 2025**
- **Support NextGen operational improvements during a GPS outage**
  - **TBO, RNAV/RNP, and Performance Based Navigation**
- **Performance Requirements to support performance based navigation**
  - **En-route 5nm, Terminal 3nm**
  - **Zones 1 En-route High (FL180 ~ FL600)**
  - **Zone 2 En-route Low (5,000 AGL ~ FL180)**
  - **Zone 3 Terminal (135 Candidate Airports)**

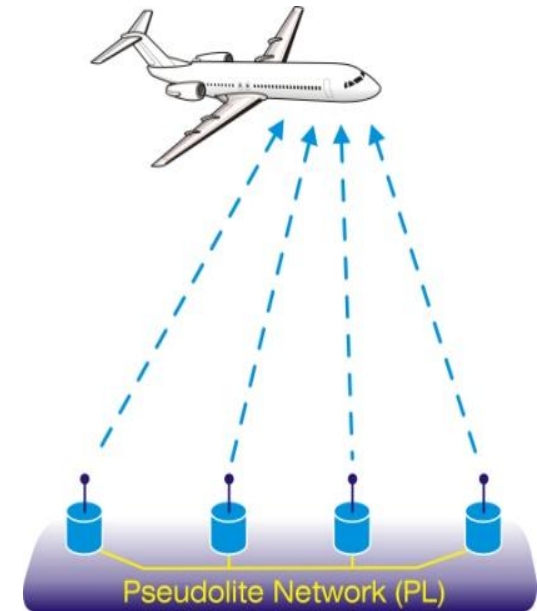
# APNT Alternatives



- Leverage existing technology and system
- Least Impact on Avionics
- Evaluating technology opportunities



- Aircraft Uses Own-ship Position for Navigation
- Potential leverage of planned and existing technology and ground infrastructure
- Some impact on Avionics



- Unlimited Capacity
- No existing FAA Standards
- Highest impact on Avionics
- Longest lead time in implementation

# Summary

- **WAAS Phase 3 Development Completed**
- **WAAS Continues Development Activities for Dual Frequency Upgrade to Align w/GPS Modernization**
- **GBAS Cat-I System Design Approved**
- **GBAS Cat-II/III R&D Underway**
- **Federal Acquisition of GBAS On Hold**
- **VOR Sites to be Divested Currently being Identified**
- **Ongoing talks between DoD and FAA concerning TACAN sustainment**
- **FAA Assessing Alternatives for Alternate PNT**



# Questions

# Project Newark

- **History**
  - Newark GBAS installed November 2009, owned by the Port Authority of New York/New Jersey (PANYNJ)
  - RFI detected during installation testing
  - Determined to be mobile Personal Privacy Devices (PPDs)
- **Solutions**
  - Software and siting modifications developed to provide safe and continuous operation when PPDs present
  - Modifications required a new System Design Approval (SDA) for the SLS-4000
- **Activities**
  - SRMD Panel meeting for the update (Block I) was completed
  - PANYNJ completed site modification work June 18
  - FAA conducted an additional flight inspection; periodic check passed
  - PANYNJ requested a 1000hr verification test prior to operational approval
    - More that 2000 hours had been prior to July without RFI interruption
    - Several outages occurred in July, suspected RFI source violated siting assumptions, enforcement action was taken
- **Expected Outcome**
  - Operational Approval at Newark prior to September 30, 2012

# Project Houston

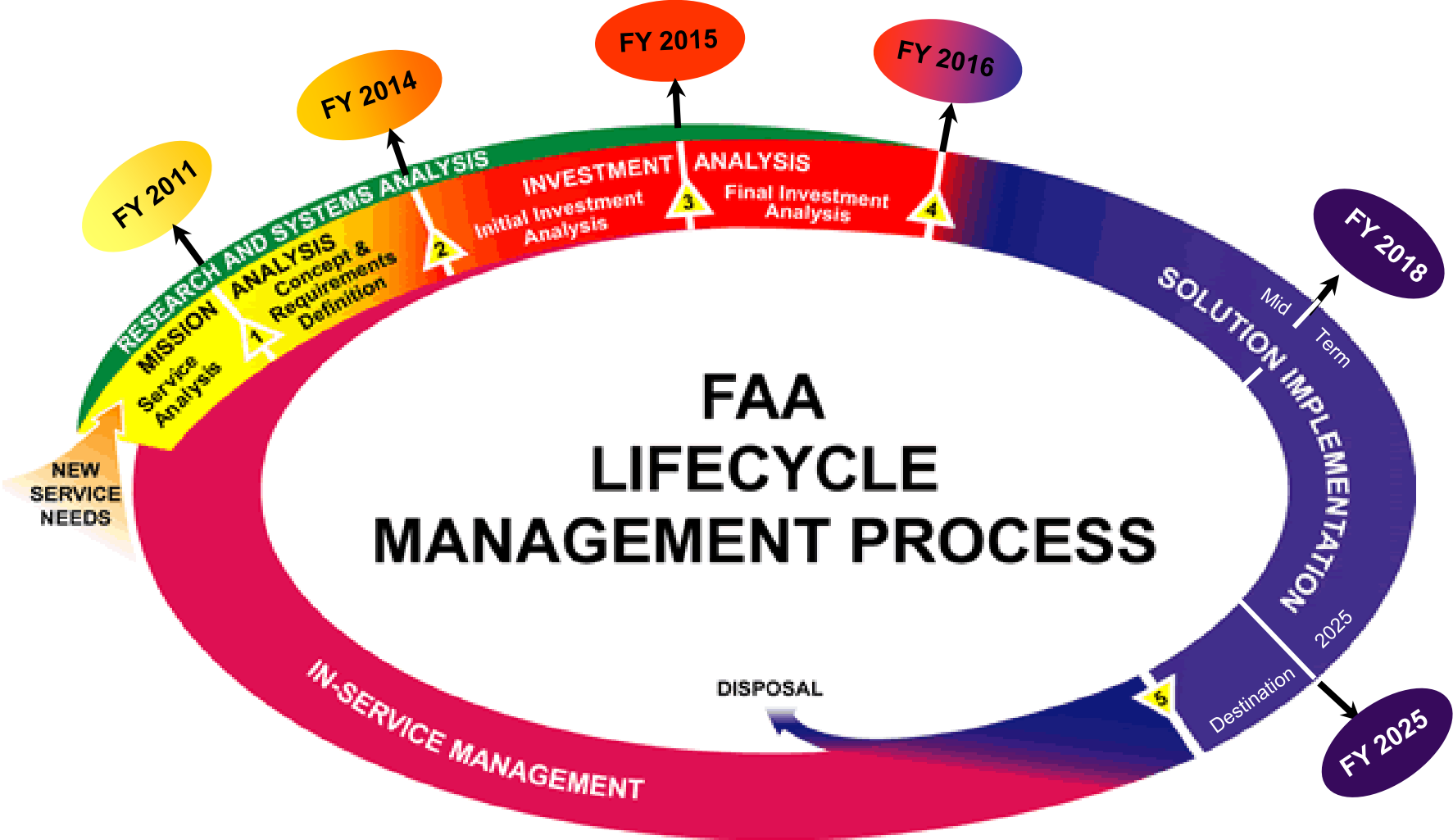
- **History**
  - FAA SATNAV team decision to provide a GBAS at Houston yielding a city-pair for GBAS operations
  - Plan included moving Memphis GBAS to Houston, development of advance procedures, and simulation testing
    - This is a non-Fed GBAS installation owned by the Houston Airport System
- **Activities Completed**
  - Remove system from Memphis, GBAS factory refurbishment, site studies including RFI testing, installation, site acceptance testing, flight inspection, non-fed coordinator training, predictive tool training, SDA revision
- **Modification to the System Design Approval (SDA) was addressed a Signal Distortion Monitor (SDM) integrity issue**
  - Some receiver designs allowed within the standards (MOPs, SARPS, TSO) were not protected
- **A new Safety Risk Management Document (SRMD) was required**
  - Director of Enterprise Services (AJM-3) is approved the document on June 7<sup>th</sup>.
- **Currently awaiting Operational Approval (was expected May 31, 2012)**

# CAT III Funding Issue

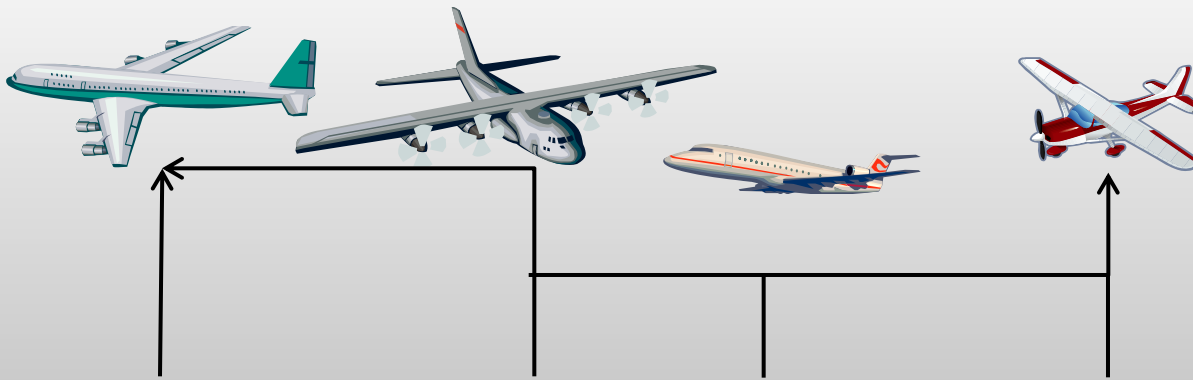
- **Due to funding cuts in FY12, VHF data broadcast (VDB) validation work can not be completed as planned**
  - Work included testing and analysis to determine if the current CAT I VDB configuration can provide sufficient coverage through touchdown and rollout
  - Shortfall was identified at RTCA as well as at ICAO and here at the IGWG
    - Develop a plan through those groups to identify an alternate validation strategy



# NextGen APNT Roadmap



# Pseudolite Technologies



DME (RNAV)

DME PL

SM PL

UAT (PL)

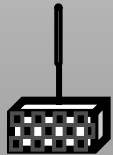
Enhanced

978-1215 MHz

960-977 MHz

978 MHz

978-1215 MHz



DME



Ground Based  
Transceivers

- APNT can use existing systems + new avionics
- DME PL+UAT PL can use single antenna

# Combined Network of DMEs and GBTs

DME's ~1100

GBTs ~ 800

CGSIC

September 18, 2012



Federal Aviation  
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# USAF Ultra High Accuracy Reference System (UHARS)

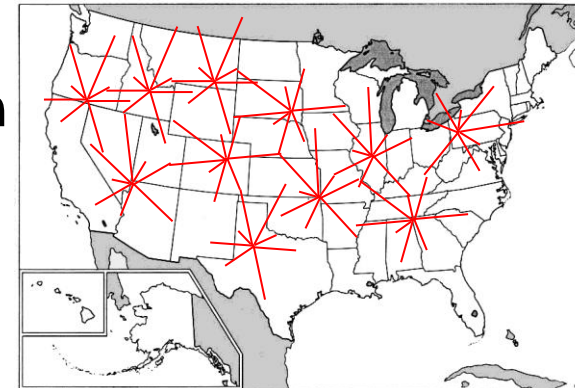
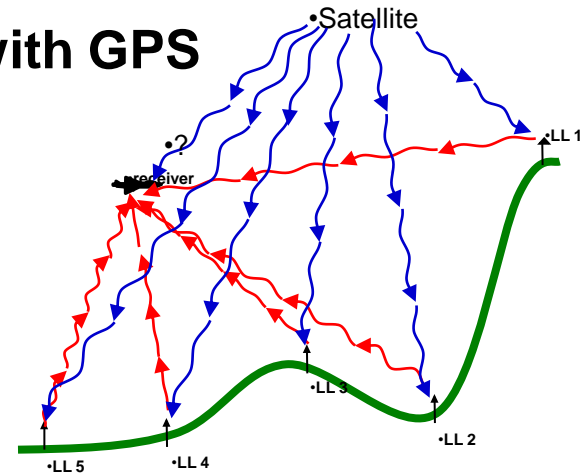
- USAF 746 Test Squadron Non-GPS Based Positioning Locata System
- Testing at White Sand Missile Range (WSMR) with GPS jamming over 2,500 sq. miles

## – Solution 1: Satellite-based synchronization

- One or two master PLs for entire network
- No ground-based line-of-sight required, since satellite is always visible
- Potential for additional navigation signal at aircraft

## – Solution 2: Land-line-based synchronization

- One or more nationwide master nodes
- Fiber-optic or other signals for time synchronization
- No single point of failure





# TACAN Issue

- **FAA in the process of implementing a “reduced service” program for Very High Frequency Omnidirectional Range (VOR’s)**
- **Currently 575 FAA owned and maintained VOR’s collocated with Tactical Air Navigation (TACAN)**
- **Decreased commercial and civil requirements for VOR’s resulted in significantly limited funding for FAA to support VORTAC (VOR/TACAN) sites**
- **April 5<sup>th</sup>, 2012 Teri Bristol (FAA VP Technical Operation Services) delivered a letter to Steven Pennington, Executive Director DoD Policy Board on Federal Aviation**
  - Letter stated that “Effective immediately if a TACAN system is currently out of service, it will no be repaired or returned to service.”
  - However if a Distance Measuring Equipment (DME) is collocated at a TACAN, that function will be restored by the FAA
  - If the DoD required selected TACAN’s to be repaired/restored the FAA’s NAS Defense Program (NDP) would transfer funding to the DoD to effect repairs

# TACAN Issue (Cont.)

- **June 2, 2012 Steven Pennington responded to the FAA letter concerning the FAA’s position on TACAN drawdown**
- **DoD identified (49 U.S.C. § 44505) that the FAA “has the statutory responsibility to meet the needs for safe and efficient navigation and traffic control of civil and military aviation.”**
  - The letter went on to state that FAA has been provided funding by Congress to provide these services to DoD when the DoD operates “similar to civil traffic.”
- **DoD stated the implementation of a new advanced operation or the removal of compatible NAVAIDs as discussed in FAA’s *NextGen Transition to Performance Based Navigation* do not meet the requirements of determining the operational requirement of a NAVAIDS continued operation and maintenance.**
- **Ongoing coordination between DoD and FAA continues**

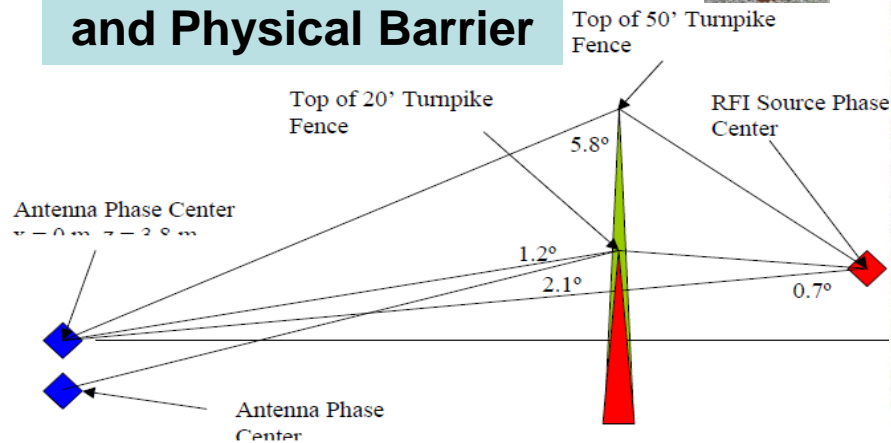
# Mitigations and Tests Completed

- Test plan developed to assess impact of proposed mitigations.
- Test configuration differed from proposed configuration to limit cost and airport changes during test period

## 2) Antenna Raising (RFI Rejection)



## 3) Antenna Lowering and Physical Barrier



## 1) RFI SW Robustness Upgrades

Honeywell		
AEROSPACE MINNEAPOLIS 2600 RIDGWAY PARKWAY MINNEAPOLIS, MINNESOTA 55413	CAGE CODE: DOCUMENT NUMBER:	94580 TBD
TITLE: <b>GBAS Block I System\Subsystem Specification (SSS)</b>		

## 4) Spatial De-correlation

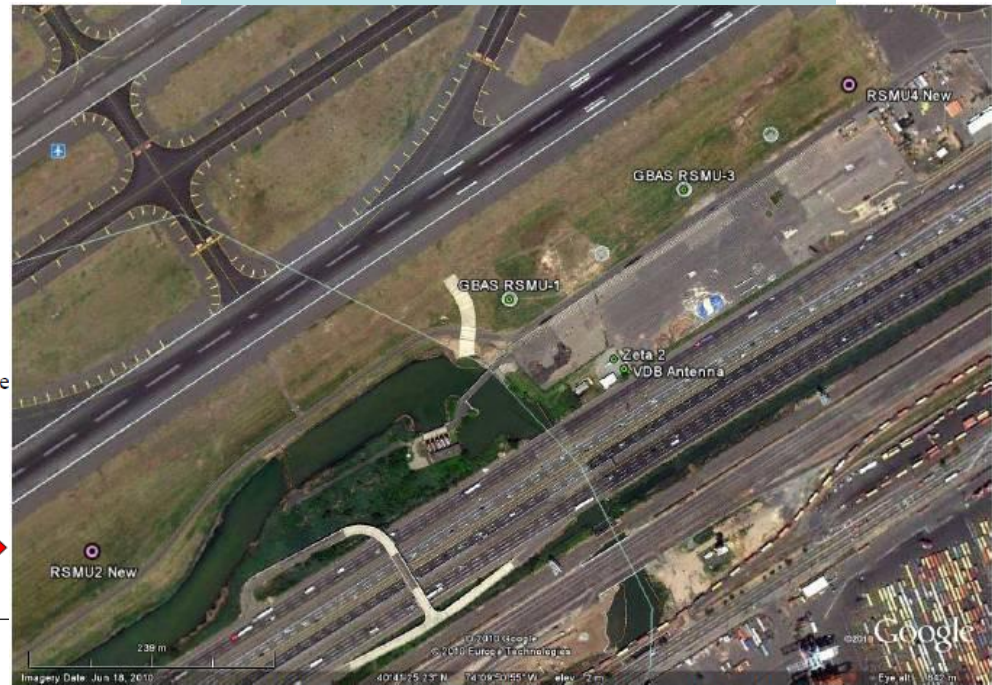


Figure 5-5 Conceived Minimum Baseline Reconfiguration