WAAS NOTICES TO AIRMEN OPERATIONAL CONCEPT

Jimmy Snow
Consultant to WAAS Program Office
June 25, 2008

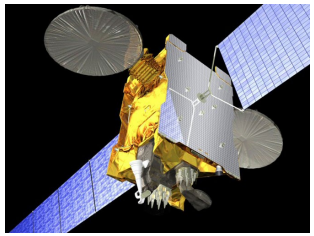
FAA Satellite Navigation Vision

WAAS Architecture

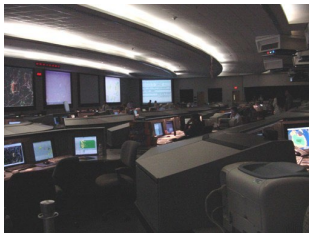
38 Reference Stations

3 Master Stations

4 Ground Earth Stations



2 Geostationary Satellite Links



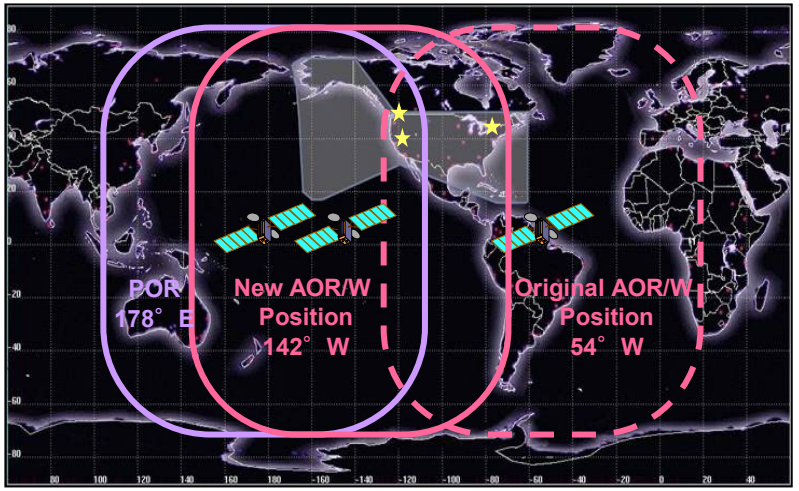
2 Operational Control Centers

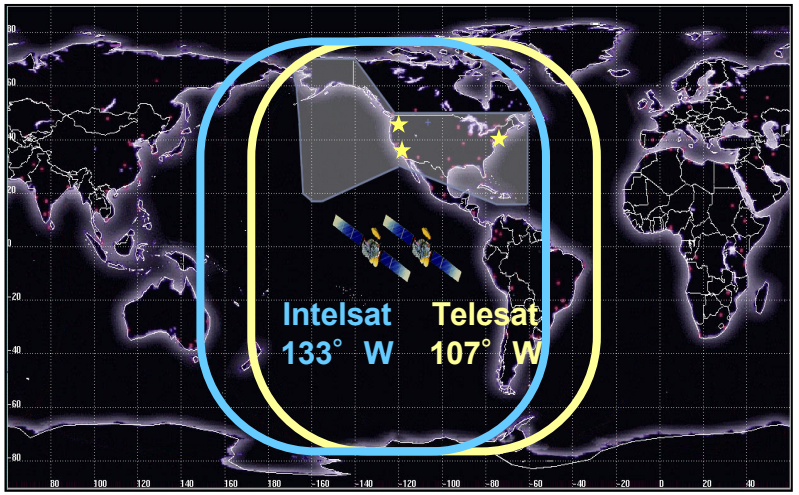
WAAS Phases:

- **Phase I: IOC (July 2003)**
  - **Provided LNAV/VNAV/Limited LPV Capability**
- **Phase II: Full LPV (2003 – 2008)**
  - **Improved LPV availability in CONUS and Alaska**
  - **Consists of additional WRS, hardware updates, software optimization, improved human factors, and GEO replacement**
- **Phase III: Full LPV-200 (Cat I ILS Equivalent) Performance (2009 – 2013)**
  - **Development, modifications, and enhancements to include tech refresh**
  - **Steady state operations and maintenance**
- **Phase IV: Dual Frequency Operations (2014 – 2028)**
  - **Scheduled to align with DoD's GPS Modernization Program (L5)**
  - **Provide additional protection against unintentional GPS interference**
  - **Will significantly improve availability and continuity during severe solar activity**
  - **WAAS will continue to support current single frequency users**

GEO Satellite Improvements:

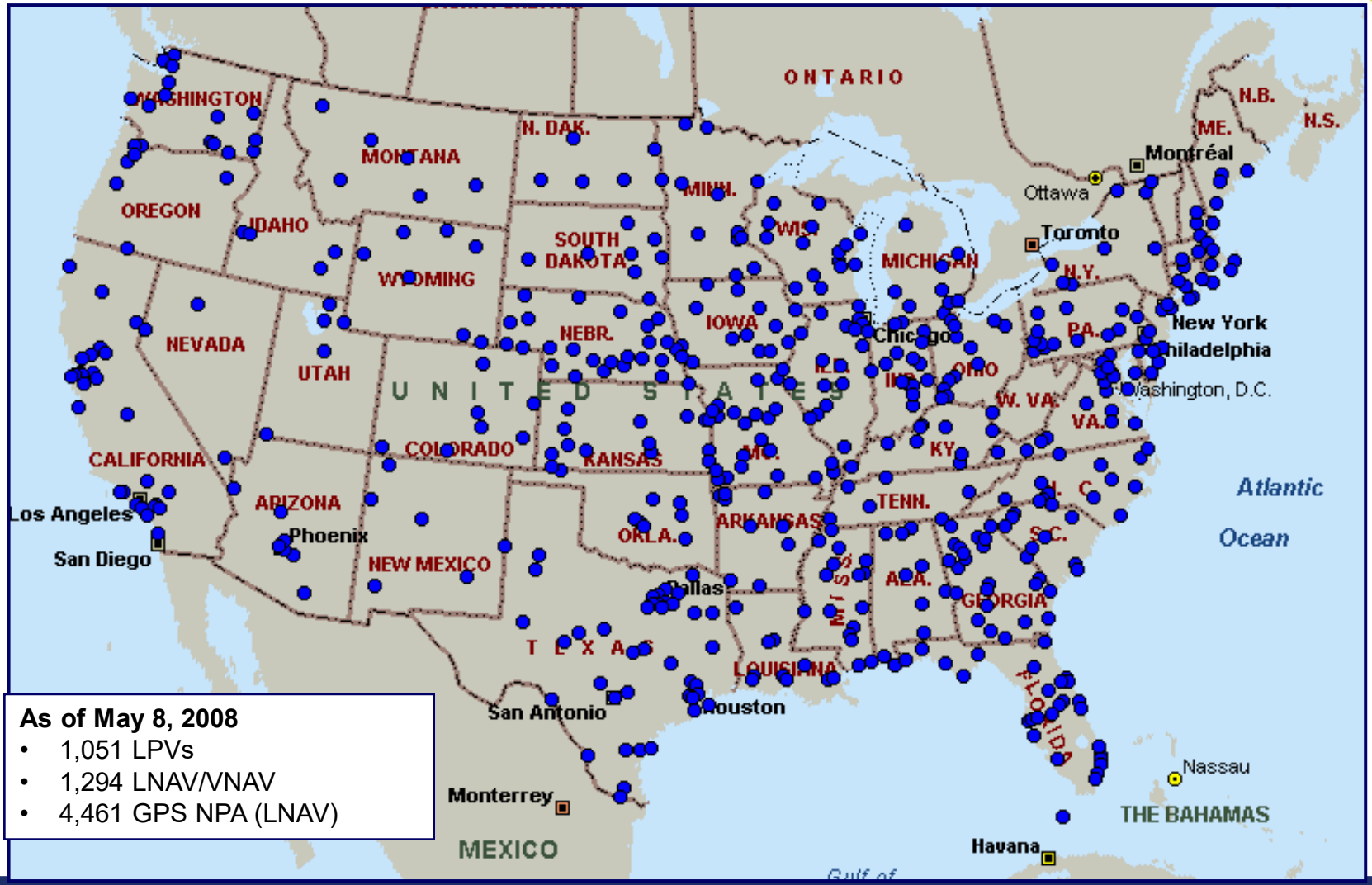
- **IOC WAAS (Commissioned system) utilized two Inmarsat satellites**
  - Provided single satellite coverage over the majority of the U.S.
  - Inmarsat satellites removed from operational WAAS July 2007
- **Replacement satellites launched in 2005**
- **Intelsat (Galaxy XV)**
  - Operational November 2006 (Datalink Only)
- **Telesat Canada (Anik F1R)**
  - Operational July 2007, for corrections & ranging





Airports with WAAS Approaches

(LPV and/or LNAV/VNAV minima)



As of May 8, 2008

- 1,051 LPVs
- 1,294 LNAV/VNAV
- 4,461 GPS NPA (LNAV)

Summary of RNAV - Minima

LNAV - Lateral Navigation

Formerly the GPS ‘straight-in’ minima

LNAV is a Non-Precision Approach (NPA)

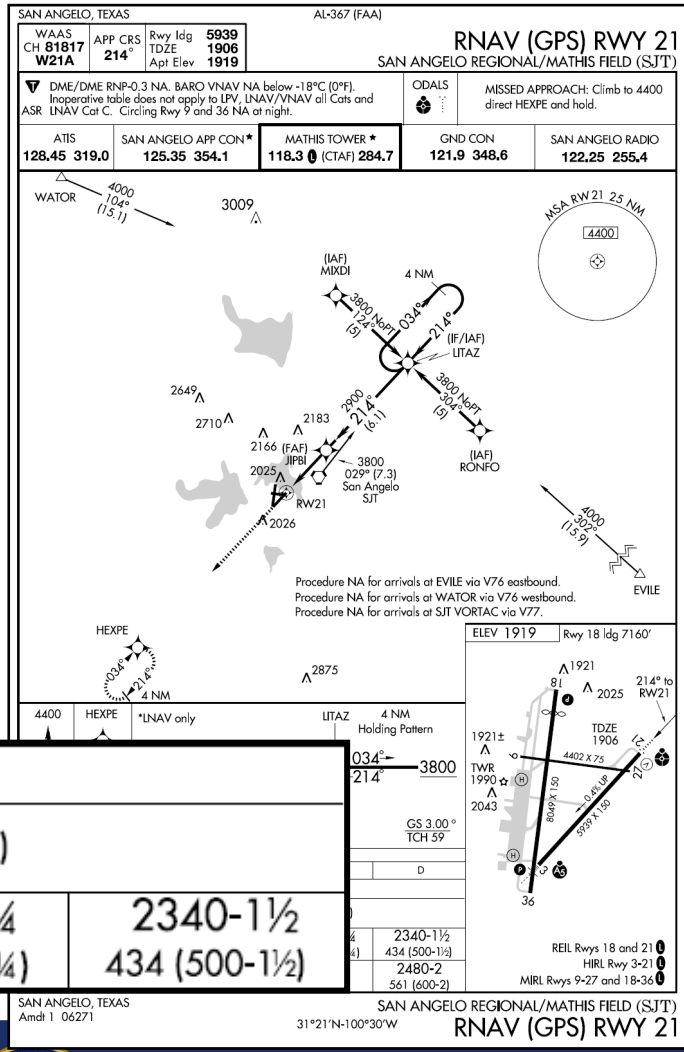
LNAV/VNAV – Lateral Navigation & Vertical Navigation

Minima for Baro-VNAV, or WAAS avionics

LPV - Localizer Performance with Vertical Guidance

WAAS avionics minima

LPV DA	2156-¾ 250 (300-¾)		
LNAV/VNAV DA	2325-1½ 419 (500-1½)		
LNAV MDA	2340-¾ 434 (500-¾)	2340-1¼ 434 (500-1¼)	2340-1½ 434 (500-1½)

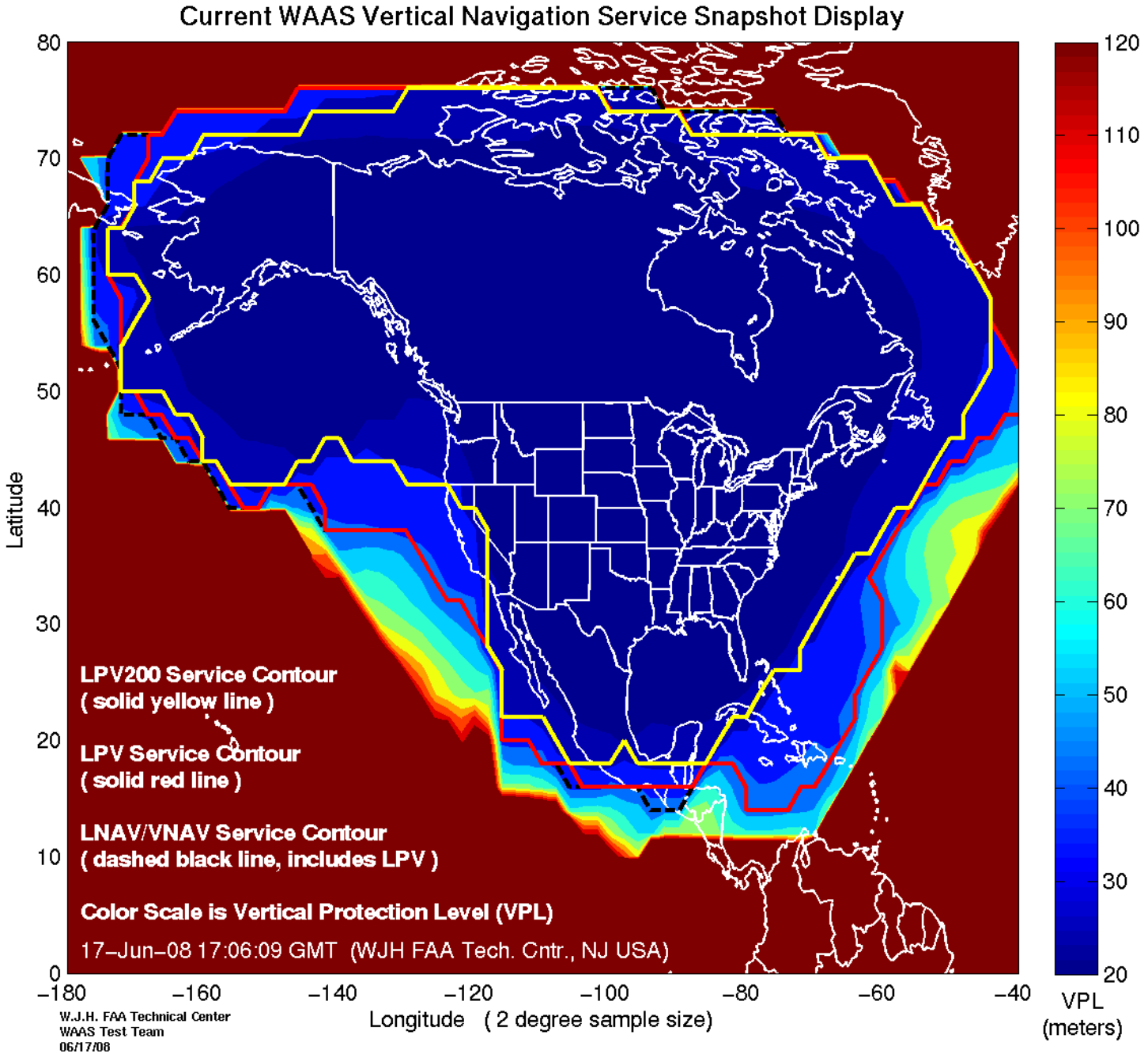


New WAAS Procedures:

- **LPV-200' Minimum**
  - Minimum decision height of new LPV approaches lowered 250' → 200'
  - First approach published in June 2006 (ATL)
  - Will re-evaluate LPVs' for lower decision height after flight inspection aircraft upgrade (2011)
- **LP Approach**
  - Flown like a Localizer approach
  - Can be developed at approaches that fail to meet LPV criteria due to obstacle clearance surface (OCS) penetrations (same TERPS for ILS)
  - Criteria development in formal coordination; Publication starting in 2008
  - Unlike an ILS, will have LPV or LP on approach chart, but not both.
  - If WAAS correction is lost, avionics defaults to LNAV procedure

Why WAAS

- **Improves Accuracy, Availability & Integrity**
- **Accuracy:**
  - Provides 2-3 meters lateral guidance
  - Provides for 2-3 meter vertical guidance
- **Availability:**
  - Adds two more satellites for navigation solution
- **Integrity:**
  - GPS navigation solution monitored from the ground; corrections sent to the cockpit
  - Eliminates need for RAIM and RAIM predictions
  - Pilots only need to check WAAS NOTAMs to ensure availability
  - Alerting: Warns within 6 seconds, versus 30 seconds for GPS alert.


Current WAAS Vertical Navigation Service Snapshot Display
LPV200 Service Contour
(solid yellow line)
LPV Service Contour
(solid red line)
LNAV/VNAV Service Contour
(dashed black line, includes LPV)
Color Scale is Vertical Protection Level (VPL)
17–Jun–08 17:06:09 GMT (WJH FAA Tech. Cntr., NJ USA)
Latitude
Longitude (2 degree sample size)
VPL
(meters)
W.J.H. FAA Technical Center
WAAS Test Team
06/17/08

NOTICES TO AIRMEN (NOTAMS) :
FAA Order 7930.2L

Information on unanticipated or temporary changes to components of or hazards in the National Airspace System (NAS) until the associated aeronautical charts and related publications have been amended.

U.S. NOTAM System Modernization Goals:

- **Improve the quality of NOTAMs**
  - Provide meaningful information
  - Enhance NOTAM interpretation
    - Graphical depiction necessary
  - Improve reliability and accessibility
    - Digital data exchange will enhance filtering and sorting
- **Conform to ICAO standards**
- **Provide a single source for all NOTAMs**
  - One collection and distribution point for all information
  - Consolidate inefficient legacy systems for improved customer service
- **Balance diverse customer needs**
  - Airlines, ATC, General Aviation, International, Military

Summary of Changes

- **Reclassify civil Local NOTAMs**
  - All current local NOTAMs become D NOTAMs
- **Create keywords for all D NOTAMs for improved sorting and parsing**

– AD	AIRSPACE	APRON	COM
– NAV	OBST	(O)	RAMP
– RWY	SVC	TWY	(U)

- **Create central repository for all NOTAMs**
- **Standardize NOTAM policy Rewrite FAA Order**
- **Move WAAS Predictive NOTAMs to New Hardware and Update Software to Current WAAS Build**

WAAS Predictive NOTAMS

- **Purpose: To Predict When Horizontal and Vertical Alert Limits are expected to be exceeded for En Route, Terminal, and Approach**
- **Established Late 90's to Support WAAS Commissioning**
- **Inverse "W" Developed for Low Availability Airports**
- **Service Volume Model (SVM) Developed by VOLPE National Transportation System Center**

Predictive NOTAMs Criteria:

- Issues Predictive NOTAMs every 24 Hours for 30 Hour Period
- Based on Airport Reference Point Coordinates
- Approach HAL/VAL Calculated at One Minute Intervals
- Predictive NOTAMs Published for 15 Minutes Minimum
- Three Minutes Added to the Beginning and End of Each Outage
- A Minimum of 15 Minutes Between NOTAMs or They Are Combined Into Single Outage

WAAS NOTAM Terms/Symbol

- **Unavailable: Signal Won't Be There/Don't Use (Real-Time System)**
  - OKC 04/001 OKC NAV WAAS LPV WAAS LNAV/VNAV UNAVBL

- **Unreliable: Signal May Not Be There (Predictive)**
  - CMX **06/072** CMX NAV WAAS LNAV/VNAV AND LPV MNM UNREL WEF 0804010141-0804010215

(If WAAS is available at destination, pilot can fly LPV, or LNAV/VNAV Approach)

W Airport has predicted signal outages on daily basis… no Predictive NOTAMS Provided (Outage could be a few or several minutes per day)

WAAS Canned FDC NOTAMS:
(Issued by WAAS Operations Center)

All C&V's Faulted or Degraded. ZDC, ZLA, ZTL WMS out of service

FDC WAAS OTS VNAV/LPV UNAVBL

GEO Satellite Failure

(CRE-138 AND CRW-135 OTS)

FDC WAAS OTS VNAV/LPV UNAVBL

Operational Guidance:

- **Aeronautical Information Manual (AIM)**
- **Code of Federal Regulations Part 91**
- **U.S. Terminal Procedures Explanation of Terms**
- **ICAO Annex 10, Vol I, Radio Navigation Aids**

ICAO Annex 10, Vol I Guidance:

Attachment D, Paragraph 9.3 –

"For scheduled events, notification should be given to the NOTAM authority at least 72 hours prior to the event. For unscheduled events, notification should be given within 15 minutes. Notification should be given for events of 15 minutes, or longer, duration."

Recommendations:

- **Acquire New Service Volume Model that meets Study Specifications**
  - **Regenerate Predictive NOTAMs after System Outage in 15 Minutes**
  - **95% Accuracy Over 30 day Period**
  - **Provides Backup Hardware and Software for System**
- **Evaluate Predictive Criteria Changes**
  - **Report Only 15 Minute Predicted Outages**
  - **Evaluate Airports with 35 and 50 VAL Approaches for 35 VAL Only**

Conclusions:

- **WAAS Predictive NOTAMs Platform Moving From MILOPS to NAIMES (CY 08)**
  - New Computer Hardware
  - Run Time Reduced to One Hour (One Minute Outages)
- **Impact of Five Minute Outage Evaluation**
  - Run Time Reduced to 12 Minutes
  - Can Comply With ICAO Requirement For Reporting Unscheduled Outages Within 15 Minutes
- **Increased Use of the Inverse "W" Will Reduce WAAS Predictive NOTAMs to Near Zero**

Future Work:

- Harmonize WAAS NOTAMs with Canada and Mexico
- Work With the NOTAM Realignment Group to Establish Future GNSS NOTAM Requirements
- Review/Standardized Term “UNRELIABLE”
- Work With ICAO to Establish International Guidance

Questions

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