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 Architecture

- WAAS Reference Stations
- TERRESTRIAL CON Network (TCN) is divided into two separate and diverse networks designated Ring 1 and Ring 2. The backbone of each ring consists of high-reliability dual TY circuits with enough capacity to ensure that every message is delivered on each ring even if one leg goes down. Satellite links are used for remote sites.

User equipment is compatible with RTCA-D0229C or D. Various user configurations:
- Delta – Beta system plus a navigation function which provides path deviations relative to the selected path
- Gamma – Beta system plus a navigation function but no pilot controls and can not be used for RNAV.
- All configurations support RAIM operations if WAAS is not available or an insufficient number of WAAS satellites are in view. Similarly, if WAAS ionospheric corrections are unavailable, the user can use ILS/LOC data.
- User equipment must track the GEO satellites if available. Corrections can be mixed across GEOs for enroute navigation, but not precision approach. Each WAAS message includes a 24 bit CRC to ensure that garbled messages do not result in NMI.

### WAAS System Performance

<table>
<thead>
<tr>
<th>WAAS Requirement</th>
<th>Horizontal 95% Accuracy</th>
<th>Vertical 95% Accuracy</th>
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</thead>
<tbody>
<tr>
<td>L1/L2</td>
<td>1.6 m</td>
<td>5.0 m</td>
</tr>
<tr>
<td>CONUS 99% LPV</td>
<td>100% of CONUS</td>
<td>100% of CONUS</td>
</tr>
<tr>
<td>Alaska 95% LPV</td>
<td>71% of Alaska</td>
<td>98% of Alaska</td>
</tr>
<tr>
<td>Alaska 5% LPV</td>
<td>No Requirement</td>
<td>91% of Alaska</td>
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WAAS Overview
October 2015

Federal Aviation Administration
FAA Organization

WAAS Overview
October 2015

Federal Aviation Administration
WAAS Program Organization

WAAS Program Office
- Responsible for overall technical and programmatic management of WAAS
- Funds external organizations
- Primary acquisition office
- Long term planning

Tech Center
- Operational test and evaluation lead
- Monitors WAAS system performance
- System architecture

Depot
- WAAS provisioner
- Manage contractor depot logistics support
- IRA analysis

National Enterprise Operations (NEO)
- Monitors real-time operational status
- Provides 24/7 support

National Airway System Engineering (NASE)
- Provides second level engineering (SLES) support
- System monitoring
- WAAS system integrator
- Develops FAA independent release
WAAS External Coordination

GPS Coordination Forums

APEC
Asia-Pacific Economic Cooperation

GIT
Global Navigation Satellite System (GNSS) Implementation Team

SBAS IWG
Space Based Augmentation System Interoperability Working Group

RTCA
Radio Technical Commission for Aeronautics

SC-159
Global Positioning System (GPS) Standardization

SC-227
Standards of Navigation Performance

International Civil Aviation Organization (ICAO)

Federal Aviation Administration (FAA)
WAAS Operations and Maintenance

- WAAS Operations Specialist @ Pacific Operations Control Center (POCC)
- Second Level Engineering
  - Baseline Management
  - Modifications
  - Logistics
  - Training
- WAAS Program Management Office
- WAAS Operations Specialist @ National Operations Control Center (NOCC)
- Test and Evaluation
  - Performance Monitoring
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
  - 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](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 FAA’s 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
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?