Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) Update

Presented to: CGSIC
By: Leo Eldredge, FAA
Date: September 24, 2008
Agenda

• WAAS Architecture
• WAAS Services Overview
• WAAS Program Status
  – Phase II – Full LPV Performance
  – Phase III – Full LPV-200 Performance
  – Phase IV – Dual frequency Operations
• WAAS User Segment Status
• LAAS Status
WAAS Architecture

38 Reference Stations
3 Master Stations
4 Ground Earth Stations
2 Geostationary Satellite Links
2 Operational Control Centers
WAAS Navigation Services

• **En Route and Terminal Area Navigation Services**
  – For Aircraft Departure, Arrival, and Domestic Airspace
  – Supports All RNAV Categories

• **Instrument Approach Services**
  – Lateral Navigation (LNAV)
    • Non-Precision Approach Guidance for Lateral Only Use
  – Lateral Navigation with Vertical (LNAV/VNAV)
    • Non-Precision Approach Service with Vertical Guidance Capable of Providing Service to ~350 Feet Above Runway Surface
  – Localizer Performance with Vertical (LPV)
    • Equivalent to Instrument Landing System (ILS)
    • Precision Approach Service With Vertical Guidance as Low as 200 Feet Above the Runway Surface
Instrument Approach Services

- **GPS**: 400 – 600 ft MDA
- **WAAS**: 350 – 400 ft DA
- **LAAS**: 200 – 0 ft
- **Cat II/III**: 200 – 300 ft DA
- **NPA**:
- **LNAV/VNAV**:
- **LPV**:
- **GLS**: 200 – 0 ft

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Federal Aviation Administration

September 24, 2007
# WAAS LPV Performance

<table>
<thead>
<tr>
<th></th>
<th>GPS Standard</th>
<th>GPS Actual</th>
<th>WAAS LPV Standard</th>
<th>WAAS LPV Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal 95%</td>
<td>36 m</td>
<td>2.74 m</td>
<td>16 m</td>
<td>1.08 m</td>
</tr>
<tr>
<td>Vertical 95%</td>
<td>77 m</td>
<td>3.89 m</td>
<td>20 m</td>
<td>1.26 m</td>
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</tbody>
</table>

*WAAS Performance evaluated based on a total of 1,761 million samples (or 20,389 user days)*
WAAS Program Phases

• Phase I – Initial Operating Capability (IOC)
  – Completed July 2003

• Phase II - Full LPV Performance
  – On Track to Complete by September 2008

• Phase III - Full LPV-200 Performance
  – Planned for FY2009-2013

• Phase IV - Dual Frequency Operations
  – Planned for FY2014-2028
WAAS Phase II Status

- Expand LPV Service to all of CONUS and Significant Portions of Alaska, Canada, Mexico
  - Install 13 Additional WAAS Reference Stations (WRS)
    - 4 Alaska – Complete
    - 4 Canada – Complete
    - 5 Mexico - Complete
    - Software Modifications - Underway
- Provide Redundant GEO Coverage
  - Replace Both GEO Satellites - Complete
- Improve Service Reliability
  - Add Third WAAS Master Stations (WMS) - Complete
  - Software Improvements To Broadcast Corrections - Underway
- Approve LPV Service Down to 200 Feet
  - Complete Safety Analysis to Approve WAAS Users For ILS Equivalent Service - Complete
GEO Satellite Improvements

- **Phase I – IOC**
  - Inmarsat Satellites
    - AOR-W – 54W
    - POR – 178E
  - AOR-W Moved to 142W
  - Leases Expired July 2007

- **Phase II**
  - New GEOs
    - Panamsat (Galaxy XV) – 133W
    - Telesat Canada (Anik F1R) – 107W
  - Operational July 2007
Phase II Software Release 5
(Completed 2007)

- 62% of Alaska has 95% LPV Availability
- 90% of CONUS has 100% LPV200 Availability
- 48% of CONUS has 100% LPV Availability
- 95% LPV Availability

VPL Sensitivity

99% VPL

LPV200

LPV

20m VPL
25m VPL
30m VPL
35m VPL
40m VPL
45m VPL
50m VPL
65m VPL
Phase II Software Release 6/7 (Underway)

80% of Alaska has 95% LPV Availability
80% of CONUS has 100% LPV200 Availability
100% of CONUS has 100% LPV Availability

Percent of Alaska
Percent of CONUS

Release 6/7

80% of Alaska has 95% LPV Availability
100% of CONUS has 100% LPV200 Availability

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September 24, 2007
Phase II Software Release 8/9
(Planned for 2008)

86% of Alaska has 95% LPV Availability
42% of Alaska has 100% LPV Availability

84% of CONUS has 100% LPV200 Availability
100% of CONUS has 100% LPV Availability
WAAS LPV Coverage
WAAS LNAV Coverage

Current WAAS NPA Navigation Service Display

NPA Service Contour (dashed black line HDOP = 4)

Color Scale is Horizontal Dilution of Precision (HDOP)

24-Aug-07 12:00:21 GMT (WJH FAA Tech Ctr, NJ USA)

Latitude

Longitude (5 degree sample size)

HDOP
WAAS Program – Phase III (2009-2013)

Full LPV-200 Performance
- Continue To Improve Service For LPV-200

- Support Transition Of WAAS Maintenance And Development Capabilities To The FAA

- Planned WAAS Algorithm Updates For Phase III
  - Acquisition Of Additional GEO Satellite
  - Continued GIVE Algorithm Tuning to Maximize Availability During the Approaching Solar Maximum

- Conduct Planning and Engineering Analysis to Prepare for Dual Frequency Operations
  - GPS Evolutionary Architecture Study (GEAS)
WAAS Program – Phase IV
(2014-2028)

• Dual Frequency Operations
  – Maintain a robust, reliable, and sustainable LPV-200 capability
  – Support Single frequency WAAS users through end of Phase IV (2028)
  – Implement WAAS Changes Needed for Dual Frequency (L1/L5) GPS Operations
WAAS Avionics Status

- Approximately 40% of Est. 140,000 GA Aircraft Are Equipped With Garmin Receivers
  - Total WAAS Equipped Users ~15,000

- Rockwell-Collins: FAA Flight Inspection Challenger Aircraft Approval – August 2007

- Canadian Marconi: Contract To Integrate WAAS Sensor Into FAA Global 5000 Aircraft To Complete In 2008

- Universal Avionics: Developing WAAS Enabled Capability In Dual Thread UNS-1 Flight Management System Expected in 2007
WAAS Procedure Production

Type of Approach

- Total GNSS Approaches: 4225
- LNAV/VNAV: 1121
- LPV: 925

Cumulative Procedures

- FY03: 3
- FY04: 39
- FY05: 263
- FY06: 614
- FY07: 925
- FY08: 1214
- FY09: 1514
- FY10: 1814

LPV to NON-ILS RWY ENDS
- FY03: 1
- FY04: 10
- FY05: 106
- FY06: 328
- FY07: 516

LPV to ILS RWY ENDS
- FY03: 2
- FY04: 29
- FY05: 157
- FY06: 286
- FY07: 409

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Local Area Augmentation System (LAAS)

- Precision Approach For Category I, II & III
- Multiple Runway Coverage At An Airport
- Terminal Area Procedures for Arrival and Departure
LAAS Status

• **Integrity Analysis and Prototype Development**
  – FAA GBAS prototype work under Honeywell Contract
  – Hazardous Misleading Information (HMI) Analysis underway to validate GBAS architecture/design

• **GBAS CAT I Approval Process**
  – System Design Approval for Honeywell architecture (SLS 4000) Planned to Complete by 2008

• **GBAS Avionics**
  – GBAS/LAAS Standards (MASPS / MOPS / TSO / SARPS) completed
  – Boeing 737-800 series GBAS equipped
  – Airbus A320, A380 certification planned for 2007

• **CAT-III Research & Development Activities**
  – Continuing Work to Develop Requirements Compatible with Aircraft Operations and Approval Process

• **International GBAS Cooperation**
  – International GBAS Working Group
  – FAA Memorandum of Cooperation established with Australia, Brazil, Spain, Germany
Questions
## Service Requirements

<table>
<thead>
<tr>
<th></th>
<th>En Route (RNAV-2)</th>
<th>Terminal (RNAV-1)</th>
<th>LNAV (NPA)</th>
<th>LNAV/VNAV</th>
<th>LPV</th>
<th>LPV 200</th>
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<tbody>
<tr>
<td>Time To Alarm (TTA)</td>
<td>15 s</td>
<td>15 s</td>
<td>10 s</td>
<td>10 s</td>
<td>6.2 s</td>
<td>6.2 s</td>
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<tr>
<td>Horizontal Alert Limit (HAL)</td>
<td>2 nm</td>
<td>1 nm</td>
<td>556 m</td>
<td>556 m</td>
<td>40 m</td>
<td>40 m</td>
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<tr>
<td>Vertical Alert Limit (VAL)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>50 m</td>
<td>50 m</td>
<td>35 m</td>
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<tr>
<td>Probability of Misleading Information</td>
<td>$10^{-7}$/hour</td>
<td>$10^{-7}$/hour</td>
<td>$10^{-7}$/hour</td>
<td>$2 \times 10^{-7}$/approach</td>
<td>$2 \times 10^{-7}$/approach</td>
<td>$2 \times 10^{-7}$/approach</td>
</tr>
<tr>
<td>Horizontal Accuracy (95%)</td>
<td>0.4 nm</td>
<td>0.4 nm</td>
<td>220 m</td>
<td>220 m</td>
<td>16 m</td>
<td>16 m</td>
</tr>
<tr>
<td>Vertical Accuracy (95%)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>20 m</td>
<td>20 m</td>
<td>4 m</td>
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