GNSS Program Status and Future Plans

Presented To: CGSIC
Date: September 19, 2011
By: Leo Eldredge, Manager
    GNSS Group, FAA
Wide Area Augmentation System - 2003

38 Reference Stations
3 Master Stations
6 Ground Earth Stations
3 Geostationary Satellite Links
2 Operational Control Centers
Current WAAS GEOs

CRW at 133° W (PRN-135)
CRE at 107° W (PRN-138)
AMR at 98° W (PRN-133)

Current WAAS GEO Coverage
WAAS LPV Coverage

Current WAAS Vertical Navigation Service Snapshot Display

Latitude

Longitude (1 degree sample size)

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)
04-Mar-10 20:26:00 GMT (WJH FAA Tech. Cntr., NJ USA)

Federal Aviation Administration

September, 2011
Combined SBAS Snapshot

LPV Service Area
SBAS Enabled NPA/LNAV
Airports with WAAS LPV/LP Instrument Approaches

As of August 25th, 2011
- 2,677 LPVs serving 1370 Airports
- 1,707 LPVs to Non-ILS Runways
- 970 LPVs to ILS runways
- 1121 LPVs to 690 Non-ILS Airports
- 165 LPs to Non-ILS Runway

plus ~30 Canadian Airports
WAAS Avionics Status

- **Garmin:**
  - 64,000+ WAAS LPV receivers sold
  - Currently sole 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
  - SmartDeck glass panel and KSN-770 certification pending

- **Universal Avionics:**
  - 1800+ units sold

- **Rockwell Collins:**
  - Approximately 1900 WAAS/SBAS units sold to date

- **CMC Electronics:**
  - Achieved Technical Standards Orders Authorization (TSOA) certification on their 5024 and 3024 WAAS Sensors
  - Convair aircraft will have WAAS LPV capable units installed December 2011
  - 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
Aircraft Supplemental Type Certificates (STC): Completed & In-Work

Completed:
- Astra 1125
- ATR-42
- Beech: Be-400 KingAir- 200, 200GT, 200C, 200CGT, 350, 350C, 300 (special FAA config.), C90A, C90GTi, Premier 1/A
- Bell: 412, 429
- Boeing-737-200 (Northern Air Cargo & Canadian North), 737-300, 727-200
- Bombardier: CL-600/601 (Universal Avionics company acft)
- Bombardier Challenger 300, 601-3A, 604
- Bombardier CRJ-200, 700, 900
- Bombardier Q-series, Q300, Q-400
- Cessna: Citation 501, 525, 550 Bravo Series, V 560 Series, 650, Excel & Encore +, Citation Jet CJ-1+, 2+, 3, Caravan
- DeHaviland: DHC-6,7-102,8 series
- Eclipse VLJ 500
- Embraer Phenom: 100, 300
- Falcon: 10, 20, 50, 50EX, 900B, 2000, 2000EX
- Gulfstream: G-II, G-III, G-100, G-150, G-450, G-550
- Hawker: 400, 700, 750, 800, 800XP, 900
- LEAR: 31A, 35, 35A, 40, 40XR, 45, 45XR, 55, 60
- MD-87
- PC-12
- S-76, S-76B, S-76C++
- SAAB: 340A/B
- Sabre 65
- Westwind 1124

In-Work:
- Aerospatiale: SN 601 Corvette
- Agusta: A-109
- Airbus: A350, A400
- Astra SPX
- Beech: Be-200, Be-300, BeechJet 400A
- Bombardier: Global 5000/Express, CL-300, CL-605, CRJ-700/900
- Cessna: Sovereign
- Cessna Citation: I/SP501, II, 560 XL/XLS, 650, VII, X
- C-9
- Dassault: EASy
- Embraer NB-145, 600/650
- Gulfstream: G-IV, G-100, G-200
- Hawker: 125-700B, 400XP
- King Air: RC-12
- LEAR: C-21A
- Lockheed Martin:
- Piaggio: P-180
**WAAS Enterprise Schedule**

### Phases
- IOC (Phase I)
- FLP (Phase II)
- LPV-200 (Phase III)
- Dual Frequency (Phase IV)

### GEO Schedule
- GEO #1 – AOR
- GEO #2 – POR
- GEO #3 – Intelsat (CRW)
- GEO #4 – TeleSat (CRE)
- Gap Filler GEO (AMR)
- GEO #5 – TBD
- GEO #6 – TBD
- GEO #7 - TBD

### Approach
- WAAS Procedure Development

**Phases**
- Development
- Operational

**GEO Schedule**
- GEO #1 – AOR: Operational (9/05)
- GEO #2 – POR:
- GEO #3 – Intelsat (CRW): Replaced by GEO #3
- GEO #4 – TeleSat (CRE): Replaced by GEO #4
- Gap Filler GEO (AMR): Operational (9/05)
- GEO #5 – TBD: Operational (09/08)
- GEO #6 – TBD: Operational (10/05)
- GEO #7 - TBD: Operational (2015)

**Approach**
- Development
- Operational

**Currently 2396**

**Approach**
- WAAS Procedure Development
- ~5,218
LAAS (Local Area Augmentation System)
GBAS Pathway Forward

- Cat-I System Design Approval – Complete
  - Enhancements based on EWR experience in work
- Cat-III SARPs Baseline Development - Complete
- Cat-III Prototyping and Requirements Validation - 2013
- Final Investment Decision - TBD
Alternative Positioning, Navigation & Timing (APNT) Study Update
Why 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 may be used to 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 requires mitigation
  – Waiting for the source of the interference to be located and turned off is not an acceptable alternative
GNSS Challenges: GPS Testing by DOD

Geographical Area Impacted

<table>
<thead>
<tr>
<th>Maximum Miles(^2)</th>
<th>Minimum Miles(^2)</th>
<th>Average Miles(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>455,805</td>
<td>66,018</td>
<td>139,795</td>
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9 Month Duration
141 NOTAMs

<table>
<thead>
<tr>
<th>Shortest</th>
<th>1.0 hour</th>
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<tbody>
<tr>
<td>Average</td>
<td>6.63 hours</td>
</tr>
<tr>
<td>Longest</td>
<td>72 hours</td>
</tr>
<tr>
<td>Cumulative</td>
<td>782 Hours 90 days</td>
</tr>
</tbody>
</table>
... and a few more “Personal Privacy Devices”

- $110 Ebay
- $335 Ebay
- $92 Ebay
- $40 GPS&GSM www.chinavasion.com
- $55 Ebay
- $83 GPS&GSM www.Tayx.co.uk
- $152 Ebay
2025 Nav Performance Envisioned for TBO

Primary PNT Service: GPS meets all Nav and ADS-B requirements
Alternate PNT Service: DME/DME/IRU won’t support 92.6m for ADS-B
PNT Performance Zones
(Vertical Profile)

Zone-1
Enroute High
CONUS

Zone-2
Enroute Low
CONUS

Zone-3 Terminal
Core APs + Next 105 Busiest Airports

2° Slope from 500’ AGL

5 SM of Airport

5000’ AGL

FL-600

FL-180

5 SM of Airport

27 SM

89 SM
Performance Zones
(Horizontal View)
APNT Alternative 1
Optimized DME Network

1100 DMEs in Current Network
Passive Wide-Area Multi-Lateration (WAM)

1 – Aircraft Transmits ADS-B Signal
2 – WAM Receives Signal
3 – Aircraft Position Determined
4 – Aircraft Position Sent to GBT’s
5 – TIS-B Sends Position to Aircraft
6 – Aircraft Uses Own Position for Navigation
Combined Network of DMEs and GBTs

DME’s ~1100

GBTs ~ 800
Pseudolite-Like Alternative Concept

- Aircraft Calculates Position
- RAIM Based Integrity Solution

- Combined Network of DME/GBTs etc
- GPS-Independent Time Reference
- 1 Hz Message ID and Time @ Transmit
- PNT Data Broadcast Channel

CGSIC
September, 2011
Ground-to-Ground Time Synchronization

GEO: WAAS L5

MEO: GNSS

LEO: MSS

30 dB of processing gain

DMEs + Planned DMEs + GBTs
Summary

- WAAS Development Completed
- Operational Implementation Underway
- WAAS Dual Frequency Upgrade for GPS Modernization by 2020
- GEAS Assessing Alternatives for Multi-GNSS
- GBAS Cat-I System Design Approved
- GBAS Cat-III R&D Underway
- Federal Acquisition of GBAS On Hold
- FAA Assessing Alternatives for Alternate PNT
Questions