Aviation Augmentation Systems Update
International Committee on GNSS (ICG-5) October 2010

Arrivals and Departures At High Density Airports
Collaborative Air Traffic Management
Weather Impact
Safety, Security and Environmental Performance
Facilities
Flexibility In To Terminal Environment
Trajectory Based Operations

GNSS is a Key Enabler for NextGen
### RNP and ADS-B (RAD) Enabled with GNSS PNT

<table>
<thead>
<tr>
<th></th>
<th>Navigation (≥ 99.0% Availability)</th>
<th>Surveillance (≥99.9% Availability)</th>
<th>Positioning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy (95%)</td>
<td>Separation</td>
<td>GNSS PNT (99.0 – 99.999%)</td>
</tr>
<tr>
<td></td>
<td>Containment (10⁻⁷)</td>
<td>NACP (95%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 nm</td>
<td>NIC (10⁻⁷)</td>
<td></td>
</tr>
<tr>
<td>En Route</td>
<td>*10 nm</td>
<td>0.1 nm (7)</td>
<td>GPS</td>
</tr>
<tr>
<td></td>
<td>*4 nm</td>
<td>1 nm (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*2 nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminal</td>
<td>*1 nm</td>
<td>0.05 nm (8)</td>
<td></td>
</tr>
<tr>
<td>LNAV</td>
<td>*0.3 nm</td>
<td>0.6 nm (6)</td>
<td></td>
</tr>
<tr>
<td>RNP (AR)</td>
<td>*0.1 nm</td>
<td>2.5 nm DPA</td>
<td>SBAS</td>
</tr>
<tr>
<td></td>
<td>**0.1 nm</td>
<td>0.05 nm (8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 nm (7)</td>
<td></td>
</tr>
<tr>
<td>LPV</td>
<td>16m/4m</td>
<td>2.5 nm DPA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40m/50m</td>
<td>0.05 nm (8)</td>
<td></td>
</tr>
<tr>
<td>LPV-200</td>
<td>16m/4m</td>
<td>2.5 nm DPA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40m/35m</td>
<td>0.05 nm (8)</td>
<td></td>
</tr>
<tr>
<td>GLS Cat-I</td>
<td>16m/4m</td>
<td>2.0 nm IPA</td>
<td>GBAS</td>
</tr>
<tr>
<td></td>
<td>40m/10m</td>
<td>121 m (8)</td>
<td></td>
</tr>
<tr>
<td>GLS Cat-III</td>
<td>16m/2m</td>
<td>2.0 nm IPA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40m/10m</td>
<td>0.2 nm (7)</td>
<td></td>
</tr>
</tbody>
</table>

*Operational requirements are defined for total system accuracy, which is dominated by flight technical error. Position accuracy for these operations is negligible.

**Containment for RNP AR is specified as a total system requirement; value representative of current approvals.

Dependent Parallel Approach (DPA)   Surveillance Integrity Level (SIL)   Navigation Accuracy Category
Independent Parallel Approach (IPA)  Navigation Integrity Category (NIC)    for Position (NACp)
Wide Area Augmentation System (WAAS)

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

International Committee on GNSS (ICG-5)
October 2010
Current WAAS GEOs
Gap Filler GEO

International Committee on GNSS (ICG-5)
October 2010
Current WAAS LPV Performance

Current WAAS Vertical Navigation Service Snapshot Display

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October 2010
Current WAAS RNP .3 Performance

Current WAAS RNP 0.3 Navigation Service Display

RNP 0.3 Service: Dashed Black line HPL = 390 m
RNP 2.5 Service: Dashed Red line HPL = 485 m
Color Scale is Horizontal Protection Level (HPL)
09-Sep-10 15:14:11 GMT, WJH, FAA Tech. Ctr., NJ USA
WJH, FAA Technical Center
WAAS Test Team
09-Sep-10 15:14:11 GMT

International Committee on GNSS (ICG-5)
October 2010
WAAS Approach Procedures Today

As of Aug 26th, 2010
2,209 LPVs serving 1174 Airports
- 1,350 LPVs to non-ILS Runways
- 859 LPVs to ILS runways
- LPVs at 553 Non-ILS Airports
- 246 LPV-200
Universal Navigation Systems (UNS)

Completed Aircraft Approvals

- Astra 1125*
- Beech 400*
- Boeing B-737-200, B-727-200, B-737
- Bombardier Q-series, Q-300, Q-400
- Bombardier CL-600/60
- Bombardier DHC-8-400 series ‘Q-400’
- Citation 550 Bravo Series,
- Citation V 560 Series, & XL, , 525*, Fleet
- DeHaviland ‘Dash-8’
- Falcon 10, 20D, 50, 50*
- Gulfstream G-II*
- KingAir 200*, 350
- LEAR 31A, 35, 35A,
- LEAR 40, 40XR, 45, 45XR, 60
- MD-87
- S-76, S-76B, S-76C++
- Sabre 65

Projected Aircraft Approvals

- ATR-42
- Beech Be-200, -300
- Boeing B-727-200 C&F, B-737
- Bell 412
- Cessna Citation II
- Cessna Citation 560XL/XLS, 650
- Cessna Citation VII, Encore
- C-9
- Northrop Grumman T-38
- Gulfstream G-II, G-III
- Falcon 20, 2000
- Hawker 125-700B
- King Air 300, RC-12, US Army
- PC-12
- Embraer NB-145

International Committee on GNSS (ICG-5)
October 2010
<table>
<thead>
<tr>
<th>Completed Aircraft LPV STCs:</th>
<th>Aircraft LPV STCs in work:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bombardier Challenger CL-604</td>
<td>Estimate completion w/in 6 months:</td>
</tr>
<tr>
<td>• Bombardier CRJ-200</td>
<td>• Bombardier CRJ-700/900</td>
</tr>
<tr>
<td>• Cessna Citation Jet CJ-1+, 2+, 3</td>
<td>• Beechcraft Premier 1 &amp; 1A</td>
</tr>
<tr>
<td>• King Air-300</td>
<td>• Beechcraft King Air</td>
</tr>
<tr>
<td>• Hawker 800XP</td>
<td>200,200GT,300,350,C90GTi</td>
</tr>
<tr>
<td>• Cessna Citation Encore+</td>
<td>• Hawker 400XP, 750, 850/XP, 900XP</td>
</tr>
<tr>
<td></td>
<td>• Beechjet 400A (est. 30 Sep for STC)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aircraft LPV STCs in work:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate completion w/in 12 months:</td>
</tr>
<tr>
<td>• Dassault Falcon 20, 50/EX, 2000/EX</td>
</tr>
<tr>
<td>• Piaggio P-180</td>
</tr>
<tr>
<td>• Gulfstream G-150, G-200</td>
</tr>
<tr>
<td>• Bombardier Lear 60XR</td>
</tr>
<tr>
<td>Estimate Completion w/in 18 months:</td>
</tr>
<tr>
<td>• Bombardier Challenger CL-300, CL-605</td>
</tr>
</tbody>
</table>
Honeywell/CMC

Approved Avionics LPV TSOs:
- Primus Epic FMS

Pending Avionics LPV TSOs:
- Primus 2000 (NZ-2000)
- APEX
- EPIC (in other airframes)
- KSN 770 (for GA aircraft)

Approved Aircraft LPV STCs:
- Gulfstream G-450 & -550

Pending LPV STC Approvals:
- Gulfstream G-IV, G-V
- F-900B,-900EXC
- Challenger CL-601
- Hawker 800
- Citation X
- PC-12
- Viking
- Dassault EASy
- Cessna Sovereign
International Committee on GNSS (ICG-5)

Local Area Augmentation System (LAAS)

- Precision Approach For CAT-I, II, III
- Multiple Runway Coverage At An Airport
- 3D RNP Procedures (RTA), CDAs
- Navigation for Closely Spaced Parallels
- Super Density Operations
GBAS Pathway Forward

- Cat-I System Design Approval at Memphis – Complete
- Cat-III Validation by - 2010
- Cat-III Final Investment Decision by - 2012
GBAS Facilities

- Current airlines GBAS equipped
  - Continental
  - Delta Airlines
  - Qantas
  - Air Berlin
  - TuiFly
  - Sonair
  - Air Vanatu
  - Emirates
- Over 15 countries have active GBAS programs
LAAS/GBAS International Efforts

- Rio De Janeiro, Brazil
- Agana, Guam
- Malaga, Spain
- Sydney, Australia
- Frankfurt, Germany
- Bremen, Germany

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October 2010
Commercially Available GPS Jammer
(so called “Personal Privacy Device”)
LAAS Antenna Location
Zeta “SnapShot” System Data

- Baseline/Nominal L1 RF
- Broadband RFI straddling L1
... 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

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October 2010
Summary

• WAAS implementation progressing on track
• Geostationary satellite procurement activities underway to mitigate recent failures
• LAAS program activities underway for Cat-III
• RFI challenges being investigated
Questions
NEXTGEN Domain

Navigation Services

Enroute Navigation

Terminal Navigation

Non-Precision Approach LNAV/RNP-0.3

Precision Approach Cat-I

Precision Approach Cat-II/III

PNT Systems

VOR

DME

ILS

LAAS

WAAS

GPS

RVR

ALS

Trajectory Based Operations

Increased Arrivals/Departures at High Density Airports

Increased Flexibility in the Terminal Environment

Improve Collaborative Air Traffic Management

Reduce Weather Impact

Increased Safety, Security, and Environmental Performance

Transform Facilities

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