Flight Testing of GBAS in Tianjin Airport

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During the past 4 years, Flight Inspection Center of CAAC has made several flight tests for the certification of GBAS ground equipment LGF-1A (at Tianjin airport) and SLS-4000 (at Pudong airport).

The flight tests theory and method are the same, and the flight tests at Tianjin airport is introduced here.
Contents

01 GBAS Flight Testing Standards
02 GBAS Flight Testing Theory
03 Flight Testing Procedure and Method
04 Conclusion and Data Analysis
01 GBAS Flight Testing Standards
Standards

- ICAO ANNEX 10
- ICAO DOC-8071 Volume II
- FAA DOC-8200.1D
- Testing Requirements for GBAS (Cat-I PA) CAAC
- Technical Requirements for GBAS ground equipment (Cat-I PA) CAAC
1.1 Flight tests of GBAS are required when:

- Commissioning
- Interference
- Procedure modification or the introduction of a new procedure
- Changes occur to the GBAS configuration
- Site changes
- Following certain maintenance activities

- Certification
1.2 Preparation for flight testing

1. Measure runway coordinates, VDB antenna position, and verify the coordinates and height of the DGPS station reference point required by the inspection aircraft.

<table>
<thead>
<tr>
<th>Runway length</th>
<th>Magnetic variation</th>
<th>VHF frequency</th>
<th>GLS channel</th>
<th>VDB position</th>
<th>RTK reference point</th>
</tr>
</thead>
</table>

2. GBAS Procedure

3. FAS DATA

<table>
<thead>
<tr>
<th>Data Content</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport ID</td>
<td></td>
</tr>
<tr>
<td>Runway Number</td>
<td></td>
</tr>
<tr>
<td>LTP Latitude</td>
<td></td>
</tr>
<tr>
<td>LTP Longitude</td>
<td></td>
</tr>
<tr>
<td>LTP Height</td>
<td></td>
</tr>
<tr>
<td>FPAP Latitude</td>
<td></td>
</tr>
<tr>
<td>FPAP Longitude</td>
<td></td>
</tr>
<tr>
<td>Approach Threshold</td>
<td></td>
</tr>
<tr>
<td>Crossing Height (TCH)</td>
<td></td>
</tr>
<tr>
<td>Glide Path Angle (GPA)</td>
<td></td>
</tr>
</tbody>
</table>
## 1.3 Parameters

### Table II-4-4. Summary of minimum flight test requirements — GBAS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FAS data</td>
<td>App. B 3.6.4.5</td>
<td>4.3.4</td>
<td>FAS path</td>
<td>Consistent with FAS design</td>
<td>N/A</td>
<td>C, Sp</td>
</tr>
<tr>
<td>Procedure Validation</td>
<td>(none)</td>
<td>5.3</td>
<td>N/A</td>
<td>N/A</td>
<td>Subjective</td>
<td>C, Sp</td>
</tr>
<tr>
<td>Resistance to Interference (Ranging Signal)</td>
<td>App. B 3.7</td>
<td>4.3.6</td>
<td>Interference signal level</td>
<td>&lt; interference mask definitions</td>
<td>±3 dB</td>
<td>C, Sp</td>
</tr>
<tr>
<td>VDB Coverage</td>
<td>3.7.3.5.4.4</td>
<td>4.3.7 to 4.3.10</td>
<td>Field strength</td>
<td>&gt;-99 dBW/m² to 35 dBW/m²</td>
<td>±3 dB</td>
<td>C, Sp</td>
</tr>
<tr>
<td>GBAS/H field strength</td>
<td>3.7.3.5.4.4</td>
<td>4.3.10</td>
<td></td>
<td>&gt;-99 dBW/m² to 35 dBW/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GBAS/E field strength</td>
<td>Horizontal</td>
<td>3.7.3.5.4.4</td>
<td>4.3.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message block header (GBAS identification only)</td>
<td>App. B 3.6.3.4.1</td>
<td>4.3.14</td>
<td>Facility Identification</td>
<td>Exact Match</td>
<td>N/A</td>
<td>C, Sp</td>
</tr>
<tr>
<td>Data content (operational)</td>
<td>App. B 3.6.4</td>
<td>4.3.15 to 4.3.16</td>
<td>Message Data Content</td>
<td>Exact Match</td>
<td>N/A</td>
<td>C, Sp</td>
</tr>
<tr>
<td>Position Domain Accuracy (optional)</td>
<td>App. B 3.6.4</td>
<td>4.3.17 to 4.3.18</td>
<td>Position</td>
<td>4 m vertical / 10 m lateral</td>
<td>1m</td>
<td>C, Sp</td>
</tr>
</tbody>
</table>

### Notes:

1. **N/A** = Not Applicable
   - C = Commissioning (and when published design changes to the procedure occur).
   - Sp = Special, e.g., when interference is suspected or a periodic interference check is desired.

2. If periodic checks are desired, parameters and intervals will be determined by individual States.
1.3 Parameters

**FAS Data Block Validation**
The FAS data received by the receiver is consistent with the published data.

**VDB Coverage**
Within the minimum required GBAS coverage volume of each final approach segment served, the minimum and maximum VDB field strength requirements must be met.

**Approach Procedure Validation**
Guide accuracy meets the requirements of precision approach.

**GNSS signals**
GPS satellite number, signal to noise ratio and DOP value during flight.
VDB Service volume

Plan view
- ±140 m (450 ft)
- ±35 degrees
- 28 km (15 NM)
- ±10 degrees
- 37 km (20 NM)
- LTP
- Final approach path

Profile view
- 3,000 m (10,000 ft)
- greater of 7 degrees or 1.75°
- θ: glidepath angle
- 10.3° - 0.45°
- GPIP
- glide path intersection point
- LTP
- landing threshold point
01 GBAS Flight Testing Standards

VDB field strength

8071 Requirements

<table>
<thead>
<tr>
<th>GBAS/H field strength</th>
<th>&gt;-99dBW/m² to -35dBW/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBAS/E field strength</td>
<td>&gt;-99dBW/m² to -35dBW/m²</td>
</tr>
<tr>
<td>Horizontal</td>
<td>&gt;-103dBW/m² to -39dBW/m²</td>
</tr>
<tr>
<td>Vertical</td>
<td>&gt;-103dBW/m² to -39dBW/m²</td>
</tr>
</tbody>
</table>
# GBAS Flight Testing Standards

## GPS Satellite Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Expected Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPLGBAS</td>
<td>≤ 40m (1), ≤ 69.15m Max</td>
</tr>
<tr>
<td>VPLGBAS</td>
<td>≤ 10m (1), ≤ 43.35m Max</td>
</tr>
<tr>
<td>HDOP</td>
<td>≤ 4.0</td>
</tr>
<tr>
<td>VDOP</td>
<td>≤ 4.0</td>
</tr>
<tr>
<td>HIL</td>
<td>≤ 0.3nm</td>
</tr>
<tr>
<td>FOM</td>
<td>≤ 22 meters</td>
</tr>
<tr>
<td>Satellites Tracked</td>
<td>5 Minimum</td>
</tr>
<tr>
<td>Signal-to-Noise Ratio (SNR)</td>
<td>30 dB/ Hz minimum</td>
</tr>
</tbody>
</table>

Note: There are no flight inspection tolerances applied to these parameters. However, they may provide useful information should GPS signal anomalies or interference be encountered.
The question proposed at the meeting yesterday:

Could you provide more detailed explanation on "Check GNSS Signal Quality" in p.5 and 6 (Requirements of GBAS and SBAS)? Could you specify which part of Doc 8071 requires this?
In-flight activities

Procedure validation

Resistance to interference (ranging signal)

4.3.6 GBAS receiver standards require that receivers not provide hazardously misleading information in the presence of radio frequency interference. Excessive ranging signal interference will therefore affect continuity and availability, rather than integrity. The loss of GBAS correction signals and/or the loss of guidance have proven to be good indicators of probable GNSS and/or GBAS interference. If interference is suspected, further investigation should be conducted. Some States may require a pre-commissioning survey of the interference environment. The suspected area should be probed and spectrum analysis accomplished to define its geographical extent. GNSS and GBAS parameters such as carrier-to-noise density (C/No), horizontal and vertical protection levels, satellites tracked, and DOP should be documented to aid further investigation. If interference is confirmed, the appropriate action should be taken,

30/4/08
Corr.
02 GBAS Flight Testing Theory
GBAS Flight Testing Theory

VDB STATION

GBAS DATA
- GPS Differential correction data
- FAS DATA BLOCK

MMR Receiver

GNLU-930 Multimode Receiver

FIS Software
- Horizontal vertical deviation information
- FAS DATA
- Calculate deviation information
- Output The Result

RTK STATION (FIS)

DGPS DATA
Flight Testing Procedure and Method
Reasons for choosing Tianjin Airport:

1. The amount of flights is moderate.
2. The dual runway verifies the ability of a GBAS facility to cover multiple directions of multiple runways.
3. Airspace resources are relatively constrained, and GBAS can optimize flight procedures after installation, which can solve the problem of flight flow control that may be faced in the future.
4. Located in the plain, the transportation is convenient, there is no special demand for the construction of the project, which is conducive to the implementation of the project and equipment testing.
03 Flight Testing Procedure and Method

Ground taxiing

**Check item:**
FAS Data Validation, Verifying course Deviation
VDB Coverage

Orbit

**Flight method:**
Take the FTP/LTP (landing entry point) as the center, the flight height is 1500m, 3000m, and the radius is 20 NM.

**Check item:**
Coverage and interference of VDB signals.

Arcs

**Flight method:**
Fly an arc ±10 degrees across the extended Final Approach Segment course at 37 km (20 NM) from the FTP/LTP. Fly an arc ±35 degrees across the extended Final Approach Segment at 28 km (15 NM).

**Check item:**
Coverage of the VDB signal in the approach direction
Flight method:
The flight inspection aircraft flies towards the FTP at 3000m height, following the localizer center line, commencing at a distance of 23NM and ends at 2.5NM.
Check item:
VDB signal coverage in approach segment.

Flight method:
Proceed inbound along the final approach course following the procedure. Intercept the glidepath and fly to an altitude of 30 m (100 ft).
Check item:
VDB signal coverage and DGPS positioning accuracy in the approach direction. Validation of flight procedure and missed approach procedure.
GLS PROCEDURE
## Flight Testing Procedure and Method

### RWY 16R, 34L

<table>
<thead>
<tr>
<th>Flight method</th>
<th>Check item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Runway round-trip</td>
<td>1. Signal reception, record field strength</td>
</tr>
<tr>
<td>2. Taxiing along the centerline of the runway</td>
<td>2. FAS Data Validation, Verifying course deviation</td>
</tr>
<tr>
<td>3. S-Line Taxiing along the centerline of the runway</td>
<td>3. VDB Coverage</td>
</tr>
</tbody>
</table>

### RWY 16R, 34L

<table>
<thead>
<tr>
<th>Flight method</th>
<th>Check item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take the FTP/LTP (landing entry point) as the center, the flight height is 1500m, 3000m, and the radius is 20 NM.</td>
<td>Coverage and interference of VDB signals.</td>
</tr>
</tbody>
</table>

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**CAAC**

Flight Inspection Center of CAAC
RWY 34L

Flight method
Fly an arc ±10 degrees across the extended Final Approach Segment course at 37 km (20 NM) from the FTP/LTP. Fly an arc ±35 degrees across the extended Final Approach Segment at 28 km (15 NM).

Check item
Coverage of the VDB signal in the approach direction

RWY 16R、34L

Flight method
The flight inspection aircraft flies towards the FTP at 3000m height, following the localizer center line, commencing at a distance of 23 NM and ends at 2.5 NM.

Check item
VDB signal coverage in the approach segment.
Flight method
Proceed inbound along the final approach course following the procedure. Intercept the glidepath and fly to an altitude of 30 m (100 ft).

Check item
VDB signal coverage and DGPS positioning accuracy in the approach direction
Validation of flight procedure and missed approach procedure
Conclusion and Data Analysis
Orbit flight real-time curve
## Conclusion and Data Analysis

### Arc Flight Real-time Curve and Results

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Status</th>
<th>ID</th>
<th>Type</th>
<th>Prof</th>
<th>Direction</th>
<th>LOC Width</th>
<th>LOC Symmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspection</td>
<td>31</td>
<td>ICAO</td>
<td>CrossOver</td>
<td>CW</td>
<td>3.43</td>
<td>49.86</td>
</tr>
<tr>
<td></td>
<td>Commission</td>
<td>3000 W</td>
<td>LAAS</td>
<td>Final</td>
<td>StopRing</td>
<td>58.26 deg</td>
<td>36.74 deg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility</th>
<th>VDB AGC</th>
<th>FacData</th>
<th>VDB AGC</th>
<th>FacData</th>
</tr>
</thead>
<tbody>
<tr>
<td>T24HL</td>
<td>MinAGC</td>
<td>46.00 dBm</td>
<td>T24SL</td>
<td>MaxAGC</td>
</tr>
<tr>
<td>34L</td>
<td>MeanAGC</td>
<td>1.82 v/k</td>
<td>20761</td>
<td>MeanAGC</td>
</tr>
</tbody>
</table>

### Level Run Flight Real-time Curve and Results

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Status</th>
<th>ID</th>
<th>Type</th>
<th>Prof</th>
<th>Direction</th>
<th>LOC Width</th>
<th>LOC Symmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspection</td>
<td>02</td>
<td>ICAO</td>
<td>Level run</td>
<td>Inbound</td>
<td>0.75 deg</td>
<td>49.86 deg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility</th>
<th>VDB AGC</th>
<th>FacData</th>
<th>VDB AGC</th>
<th>FacData</th>
</tr>
</thead>
<tbody>
<tr>
<td>T24SL</td>
<td>MinAGC</td>
<td>-67.00 dBm</td>
<td>T24SL</td>
<td>MinAGC</td>
</tr>
<tr>
<td>34L</td>
<td>MeanAGC</td>
<td>10.00 v/k</td>
<td>20761</td>
<td>RngToxTP</td>
</tr>
</tbody>
</table>

The graphs and tables above illustrate the real-time performance and data analysis for Arc and Level Run flights, respectively, highlighting key performance indicators such as AGC values and deviation measurements.
Conclusion and Data Analysis
### Conclusion and Data Analysis

In this section, we present the findings and conclusions derived from the data collected during the test. The results are analyzed to evaluate the performance of the system under various conditions. The data analysis includes statistical methods and visual representations to interpret the results effectively.

#### Table 1: System Performance Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Time</td>
<td>120 min</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>98.5%</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>System Reliability</td>
<td>99%</td>
<td></td>
</tr>
</tbody>
</table>

This table summarizes the key performance indicators of the system, showing a high level of accuracy and reliability.

#### Figure 1: Test Environment Setup

The figure illustrates the test environment setup, including the test equipment, test subjects, and test conditions. The setup is designed to simulate real-world scenarios to ensure the system's performance is evaluated under varied circumstances.

#### Figure 2: Data Analysis Flowchart

The flowchart outlines the steps involved in the data analysis process. It begins with data collection, followed by preprocessing, statistical analysis, and finally, result interpretation.

In conclusion, the system demonstrated excellent performance under the test conditions. Further research is recommended to explore the system's capabilities in more complex environments.

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**End of Document**
About US—CFIC(Flight Inspection Center of CAAC)

- Conduct flight inspection for more than 250 airports in China.
- 10,000 flight hours each year.
- IEC/ISO 17025 certification.
- 21 flight inspection aircrafts: 1 King Air 350, 5 Citation XLS, 11 Citation XLS+, 3 Citation Sovereign and 1 G450.
- ILS, VOR/DME, NDB, SSR/PSR, PAPI, VHF, PBN(RNP&RNAV), ADS-B, RFI, HUD, GBAS, VDL-2......
THANK YOU!