Operational Performance of the EGNOS AOC System for Civil Aviation

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The EGNOS AOC System
(AOC = Advanced Operational Capability)

EGNOS Augments GPS and GLONASS Performance for multi-modal Users
For Civil Aviation Users it will support operations in all phases of flight down to CAT-1
Precision Approach
Performance is expressed in terms of Required Navigation Performance (RN)
parameters specified by ICAO in terms of:

Accuracy, Integrity, Availability, Continuity
**Operational Performance of the EGNOS AOC System for Civil Aviation**

**EUROCONTROL**

**European Tripartite Group**

**GNSS 2000**

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**EGNOS BROADCAST AREA**

**INMARSAT AOR-E**

**INMARSAT IOR**

**ARTEMIS**

**ECAC Land Mass Area**

**Precision Approach Services**

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**EGNOS ECAC Service Area**

All performances to be met for En-route down to NPA
## Expected Performance

EGNOS AOC Operational Performances with at least 2 GEOs Visible

<table>
<thead>
<tr>
<th>Phase of Flight</th>
<th>EN ROUTE</th>
<th>TMA/NPA</th>
<th>NPV 1</th>
<th>Precision Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNP TYPE</td>
<td>RNP 12.6 to RNP 1</td>
<td>RNP 0.3</td>
<td>RNP 0.3/125</td>
<td>RNP 0.03/50 to RNP 0.02/40</td>
</tr>
<tr>
<td>Space Segment</td>
<td>GPS + EGNOS</td>
<td>GPS + EGNOS</td>
<td>GPS+ GLONASS+ EGNOS</td>
<td></td>
</tr>
<tr>
<td>Accuracy (95%)</td>
<td>100m (H)</td>
<td>100m (H)</td>
<td>7.7m (H)</td>
<td>5m (H)</td>
</tr>
<tr>
<td></td>
<td>20m (V)</td>
<td>7.7m (V)</td>
<td>5m (V)</td>
<td></td>
</tr>
<tr>
<td>Integrity Risk</td>
<td>10^{-7}/hr</td>
<td>2.10^{-7}/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected Alarm Limit</td>
<td>1 n.mile</td>
<td>556m</td>
<td>556m (H)</td>
<td>20m (H)</td>
</tr>
<tr>
<td></td>
<td>50m (V)</td>
<td>20m (V)</td>
<td>13m (H)</td>
<td></td>
</tr>
<tr>
<td>Time to Alert</td>
<td>10s</td>
<td></td>
<td>6s</td>
<td></td>
</tr>
<tr>
<td>Availability</td>
<td>0.999999 [1]</td>
<td>0.99999 [1]</td>
<td>0.9999 (H)[1]</td>
<td>0.9999 (V)</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>TBD[2]</td>
</tr>
</tbody>
</table>

[1] Assuming GIC/RAIM combination with GPS
[2] GLONASS constellation not stable

- Performance within the ECAC Area (even with only 1 Geo visible)
- Performance within the ECAC Area (with 2 GEOs visible)
- Performance within the ECAC Land Mass Area

### OPERATIONAL ASSUMPTIONS

- **EGNOS used as Primary Means of Navigation**
- **GPS with RAIM approved to support Basic-RNAV**
- **En-Route to NPA Operations - RAIM/FDE Can be used as back-up if EGNOS Signal is unavailable.**
- **Alternate Destination Airports have Landing capability independent from EGNOS (e.g. ILS)**
Potential EGNOS Extensions

Entire GEO Footprint Area

• Extension of the provision of the SARPS NPA service over the full footprint of EGNOS GEOs could be provided by connecting a few additional reference stations (RIMS).
• NPV-I service level could be provided assuming the computation and transmission of some level of IONO corrections.
• Different possible architectural approaches have been identified for an EGNOS extension.
• Further work concentrates on the NPV-I feasibility (using the ESTB) and on the selection of the most convenient architecture.

Extension over Africa and Indian Ocean

• ICAO / APIRG Strategic Decision made in June 1999 for the introduction of SBAS in the AFI Region.
• AFI Priority User Needs focus on NPV-I over Land Masses. NPV 2 (or Cat 1 if necessary) to be provided only in specific areas at a later stage either by SBAS or GBAS.
• AFI SBAS Test Bed Arrangements and Objectives, supported by ESTB Extension, have been preliminarily defined.
• Data collection and simulations have demonstrated the feasibility of NPV 1 in terms of signal capacity.
Interoperability

SBAS Geostationary Broadcast Areas

What is Needed for SBAS Interoperability?

SBAS Interoperability at user level implies:
- Compliance of SBAS Signal-In-Space with ICAO GNSS SARPs
- Compliance of SBAS receiver with RTCA D0229 standards
- Harmonization of the system certification process
- Compliance of GNSS/SBAS procedures with the rules developed by ICAO

Obstacle Clearance Panel (OCP)

In addition, SBAS Interoperability at system level implies:
- Provision of a minimum combined operational service in intermediate regions between SBAS Initial Service Areas
Interoperability Areas of Interest

- Identification of traffic flows in the intermediate regions between SBAS Initial Service Areas
- Quantification of the significant traffic flows
- Analysis of the ATS and Airlines operational conditions
- Identification of user priority needs

EGNOS/WAAS Intermediate Area
- Transatlantic NAT MNPS Airspace
- Regional Caribbean Airspace

EGNOS/MSAS Intermediate Area
- Intercontinental Europe/South and Southeast Asia Routes (Northern and Southern Himalayas Routes)
- Intercontinental Europe - North East Asia Routes (Northern Siberian routes)
Conclusions on Interoperability

Provision of NPA Service Level
- Through simple EGNOS-WAAS and EGNOS-MSAS interoperability, NPA service, compliant with SARPS requirements could be provided in the SBAS intermediate areas

- UDRE degradation factor has been analysed considering the proposed message Type 27 (Described in RTCA DO 229 B). The degradation factor used (i.e. 10) produced good results in all the simulations.

Provision of NPV-I Service Level
- For all real measurements, it can be observed that large margins exist between the actual errors and the required protection level to meet the integrity requirement.
- NSE 95% accuracy is achievable
- NPV-I protection level (VPL) outside the initial service area could be achievable assuming the introduction of limited ionospheric corrections
- Ongoing EGNOS/WAAS real time interoperability tests are concentrating on analysis of this important issue.