SBAS/EGNOS Programme

PBN TF/4 Meeting
ICAO EUR NAT
Paris, 30 November-1 December 2010
Step 1: EGNOS to provide civil augmentation to GPS and GLONASS
• Interoperable with WAAS-US/ MSAS-Japan
• Operational Validation from 2004
• Open Service declared by EC in Oct 2009
• Certified in July 2010

EGNOS is a joint initiative of European Commission, Eurocontrol and ESA

Step 2: Galileo to achieve:
• European GNSS independence
• Complementarity to GPS
• Global System under civil control

GALILEO is a joint initiative of European Commission and ESA
European GNSS Programme Essentials

★ EGNOS is the first pan-European public venture contributing to GNSS, meeting the most challenging safety requirements

★ Galileo is one of the largest and most complex systems being realized by European industries

★ EGNOS and Galileo, Europe's contribution to the future GNSS, although founded on state-of-the-art technology, are service-oriented navigation systems
EGNOS for Aviation

EGNOS planned to be available for aviation usage by end 2010 upon SoL service declaration.

EGNOS enables the use of GNSS down to approach and landing.
Development Phase Organisation

TRIPARTITE AGREEMENT

EGNOS

INDUSTRY

AENA
DFS
DGAC
ENAV
NATS
NAV-EP
Skyguide

CNES
NMA

EGNOS
Interoperability Standards
(ICAO SARP’s and Interoperability Working Group)

EGNOS is an integral part of a multi-regional system
EGNOS: the European SBAS

GBAS
Ground Based Augmentation Systems

ABAS
Aircraft Based Augmentation Systems

Local Area Systems

GPS

GLONASS, Galileo

EGNOS

GNSS-1

MSSAS

GBAS

User Equipment Hybridisation & Processing

SBAS
Space Based Augmentation Systems

WAAS
EGNOS: Space Segment

- Semi-major axis: 29600 km
- Inclination: 56°
- Period: 14 hr 22 min
- Ground track repeat about 10 days
- Orbit Graveyard at MEO +300 km
EGNOS: Ground Segment

- **Users**
- **6 NLES Navigation Land Earth Stations**
- **2 Support Facilities**
- **4 MCC Mission Control Centers**

- **34 RIMS Ranging & Integrity Monitoring Stations**

EGNOS Wide Area Network (EWAN)
EGNOS Performance 01/2007-08/2008

Accumulative Monthly SIS

% SIS of last 28 days vs. Date

EGNOS Performance 01/2007-08/2008

Source: EUROCONTROL
EGNOS Coverage Status

Release V2.3.1 (Qualified in June 2010)
Certification requirements baseline - Single European Sky Regulatory package

• Interoperability Regulation (EC No 552/2004)

• Service Provision Regulation (EC No 550/2004) – Provision of air navigation services in the Single European Sky

• Commission Regulation (EC No 2096/2005) – ANSP certification process

• Safety Oversight Regulation (EC No 1315/2007)
<table>
<thead>
<tr>
<th>GNSS Technologies vs Aviation Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RNP</strong> (&lt;99.0% Availability)</td>
</tr>
<tr>
<td>Accuracy (95%)</td>
</tr>
<tr>
<td>Alert limit (10^-7)</td>
</tr>
<tr>
<td><strong>En Route</strong></td>
</tr>
<tr>
<td>10 nm</td>
</tr>
<tr>
<td>4 nm</td>
</tr>
<tr>
<td>2 nm</td>
</tr>
<tr>
<td><strong>Terminal</strong></td>
</tr>
<tr>
<td>1 nm</td>
</tr>
<tr>
<td><strong>LNAV</strong></td>
</tr>
<tr>
<td>0.3 nm</td>
</tr>
<tr>
<td><strong>RNP</strong></td>
</tr>
<tr>
<td>0.1 nm</td>
</tr>
<tr>
<td><strong>APV LNAV/VNAV</strong></td>
</tr>
<tr>
<td>0.3nm/20m</td>
</tr>
<tr>
<td><strong>APV I (LPV)</strong></td>
</tr>
<tr>
<td>16m/20m</td>
</tr>
<tr>
<td><strong>LPV-200</strong></td>
</tr>
<tr>
<td>16m/4m</td>
</tr>
<tr>
<td><strong>GLS Cat-I</strong></td>
</tr>
<tr>
<td>16m/4m</td>
</tr>
<tr>
<td><strong>GLS Cat-III</strong></td>
</tr>
<tr>
<td>16m/2m</td>
</tr>
<tr>
<td><strong>ABAS:</strong></td>
</tr>
<tr>
<td>GPS+RAIM</td>
</tr>
<tr>
<td><strong>ABAS:</strong></td>
</tr>
<tr>
<td>GPS + RAIM+ Baro +INS</td>
</tr>
<tr>
<td><strong>SBAS(EGNOS)</strong></td>
</tr>
<tr>
<td>GBAS</td>
</tr>
</tbody>
</table>
EGNOS : 2010 programme status

- EGNOS system development and initial operational phase successfully accomplished by ESA in March 2009
- EC has been managing the EGNOS Operational Phase since April 2009
- EGNOS OS service declared available in October 2009

- EGNOS certification for first pan-European GNSS services achieved in July 2010, according to SES Regulation
- Performance issues detected in August 2010 are debugged and fixed
- EGNOS SoL service declaration planned by beginning 2010, after a further performance assessment period

- ESSP is the certified EGNOS service provider
- ESA in charge of further system design enhancements and procurement
- European National Air Traffic Service Providers are developing actions to enable EGNOS-based services for aviation
Estimated no. of capable aircraft
(total=16975)

- Capable A/C: 45%
- Potentially capable A/C: 14%
- Non capable A/C: 15%

Estimated no. of capable flights
(total=9196310)

- Capable A/C: 52%
- Potentially capable A/C: 15%
- Non capable A/C: 33%
SBAS for APV

- The objective: enabling APV operations for the very many aircraft that do not have barometric vertical navigation (Baro-VNAV) capabilities

### Baro-VNAV Capable Operations

**MITRE Estimates**

<table>
<thead>
<tr>
<th>Airline Classification</th>
<th>Number of Aircraft</th>
<th>Number of FMS</th>
<th>Number of VNAV Capable FMS</th>
<th>FMS (%)</th>
<th>Baro-VNAV Capable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Major Airlines</td>
<td>3642</td>
<td>3466</td>
<td>3003</td>
<td>95%</td>
<td>82%</td>
</tr>
<tr>
<td>Regional Airlines</td>
<td>2325</td>
<td>2151</td>
<td>179</td>
<td>93%</td>
<td>8%</td>
</tr>
<tr>
<td>Other Part 121 Airlines</td>
<td>405</td>
<td>316</td>
<td>262</td>
<td>78%</td>
<td>65%</td>
</tr>
<tr>
<td>Part 121 Cargo Airlines</td>
<td>1077</td>
<td>610</td>
<td>538</td>
<td>57%</td>
<td>50%</td>
</tr>
<tr>
<td>Business Jet Operators</td>
<td>709</td>
<td>640</td>
<td>135</td>
<td>90%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td><strong>8158</strong></td>
<td><strong>7183</strong></td>
<td><strong>4117</strong></td>
<td><strong>88%</strong></td>
<td><strong>50%</strong></td>
</tr>
</tbody>
</table>

* CAASD does not have a comprehensive avionics database of Business Jet Operators. These data reflects a very small portion of this classification, and may not accurately depict the capability of this classification.

The solution: using vertical guidance from SBAS
Nominal AR Architectures

Current

GPS Sensor
TSO C129
Or equivalent

(x, y)
HAL

FMS
(Baro-VNAV)

Baro Altimetry

Proposed

SBAS Sensor
TSO C145
Class Beta 2, Beta 3

(x, y, z)
HAL, VAL

FMS

HAL, VAL

FMS: Flight Management System
HAL: Horizontal Alert Limit
VAL: Vertical Alert Limit
SBAS on-board capability status

SBAS-capable on-board avionics is steadily wide-spread and becoming the de-facto GNSS standard, also in large aircraft (e.g. Airbus A350)

SBAS Avionics Status

- **Garmin:**
  - 43,000+ WAAS LPV receivers sold
  - Currently sole GA panel mount WAAS Avionics supplier
- **AVIDYNE & Bendix-King:**
  - SmartDeck glass panel and KSN-770 projected to market summer 2009
- **Universal Avionics:**
  - 700+ units sold (est. 500+ aircraft configured)
- **Rockwell Collins:**
  - Multiple recent (fall '08) WAAS Sensor/Rcvr & FMS avionics Technical Standards Orders Authorization (TSOA)
- **CMC Electronics:**
  - Achieved Technical Standards Orders Authorization (TSOA) certification on both their 5024 & 3024 WAAS Sensors
- **Honeywell:**
  - Multiple FMSs to achieve WAAS acft cert. in 2009
- **NextNav:**
  - TSO-145c/DO-229D approved WAAS (mini) Beta1 and (Max) Beta 1,2,3 sensors

Satellite Landing System

Allows to fly RNAV (GNSS) approaches with vertical guidance down to 200ft without any xLS ground station

**First step: A350XWB EIS**
- Targeted procedures: RNAV GNSS with LPV minima (down to 200')
- Technical enable: GPS+SBAS
- Coverage: multi regional
- Cockpit integration (HMI, NDB, ..)

**Future steps:**
- Technical enablers: all new GNSS means capable of LPV200'
- Coverage: worldwide

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IWG 18 Meeting
June 17, 2009
EUROCONTROL projects
- Work Description -

- Identification of airport(s) where the EGNOS APV procedures can provide benefits
- Identification of aircraft operator(s)
- Design SBAS APV procedures
- Implementation Safety Case
- Equipping aircraft with SBAS avionics
- Airworthiness certification and operational approval
- Flight demonstration of the procedures
- Business case for the airport(s) and the operator(s)
- Awareness and dissemination of results
EUROCONTROL projects
- France -

- **Partners:**
  - EGIS AVIA
  - DSNA
  - Airbus Transport Industry (ATI)
  - Pildo

- **Aircraft:** 1 (+4)
  - Beluga – Airbus A 300-600ST

- **Airports/Procedures:**
  - (Clermont-Ferrand)
  - Pau

- **Receiver:** CMC Electronics both FMS and sensor.

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HElicopters Deploy GNSS in Europe

- **Partners:**
  - Helios
  - REGA
  - PANS A
  - Hellieo
  - Pildo
  - TAF Helicopters
  - Royal Star
  - Capital High Tech
  - Aeroclub de Sabadell

- **High Level Objectives**
  - To develop the helicopter SOAP (SBAS Offshore Approach Procedure) procedure (and necessary avionics) and then to successfully demonstrate it to the user community
  - To develop helicopter PINS (Point in Space) procedures for mountain rescue and HEMS (Helicopter Emergency Medical Services), and to then successfully demonstrate them to the user community
  - To develop and demonstrate an integrated navigation/surveillance concept

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EUROCONTROL projects
- UK -

- **Partners:**
  - NATS
  - Aurigny Airlines
  - Anglo Normandy Engineering
  - Pildo

  With the support of:
  - States of Guernsey
  - UK CAA

- **Nb Aircraft:** 1
  - Britten Norman Trislander

- **Airport/Procedures:**
  - Southampton
  - Alderney

- **Receiver:** Garmin 430

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Eurocontrol Projects
Poland

- **Partners:**
  - Pildo
  - PANS A
  - Royal Star-Aero
  - ANS Czech
  - Helios
  - ADV Systems

- **Aircraft:**
  - Piper PA-34 Seneca II

- **Airport/Procedures:**
  - Mielec
  - Katowice

- **Receiver:** Garmin 430
Future SBAS evolutions

★ Single frequency coverage is good within the countries fielding SBAS
★ Dual frequency extends coverage outside reference networks & allows LPV-200 operations in equatorial areas
★ Expanding networks into southern hemisphere could allow global coverage of land masses
★ Additional constellations allow even greater coverage with fewer stations
Current WAAS, EGNOS, MSAS Coverage

Availability as a function of user location

Latitude (deg)

Longitude (deg)

Availability with VAL = 35, HAL = 40, Coverage(99%) = 7.54%

Courtesy of Stanford University
Dual Frequency Coverage
(WAAS, EGNOS, MSAS)

Availability as a function of user location

Availability with VAL = 35, HAL = 40, Coverage(99%) = 28.64%
Expanded Networks

- WAAS
- WAAS Expansion
- EGNOS
- EGNOS Expansion
- MSAS
- MSAS Expansion
- GAGAN
- SDCM
Dual Frequency, Expanded Networks

Availability as a function of user location

Availability with VAL = 35, HAL = 40, Coverage(99%) = 67.57%
Dual Frequency, Dual GNSS, Expanded Networks

Availability as a function of user location

Availability with VAL = 35, HAL = 40, Coverage(99%) = 92.65%
Multi-regional SBAS: Cooperation issues

★ Coordination at infrastructure implementation level already on-going among SBAS providers (US, Canada, EU, Japan, India)

★ The implementation of a worldwide multi-regional SBAS will require a high degree of coordination among provider and non-provider States/Regions

★ Major issues at stake:
  ★ Multi-regional service provision organisation
  ★ Governance and funding
  ★ Liability

★ ICAO role will be key to facilitate/harmonise resolution of these major cooperation issues
Conclusions

★ The European SBAS service (EGNOS) will be declared available for aviation usage at the end of 2010

★ The EGNOS service provider (ESSP) is already certified according to SES regulations

★ APV-I performance is already available over European land masses

★ Opportunity of exploiting available SBAS/EGNOS capabilities when designing APV procedures