Introduction to the EGNOS System and performances

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European Space Agency
• **United States of America:**
  – Fully operational with 30 satellites operational
  – Selective availability switched off in May 2000
  – Millions of civil users already
  – Upgrades on-going: GPS IIF, GPS III

• **Russian Federation:**
  – 16 satellites operational
  – Constellation being replenished
  – Upgrades on-going: GLONASS-M,-K.
• Both systems developed for military applications although now recognized as dual-use: civil/military.

• No service guarantees and no Integrity.

• For high demanding applications (e.g. Aviation or for high accuracy) need to be complemented with Satellite Based Augmentation systems (SBAS):
  – USA: WAAS
  – Europe: EGNOS
  – Japan: MSAS
  – Elsewhere: planning stage
• **Step 1: EGNOS: European SBAS**
  – Complement to GPS/GLONASS over large European area.
  – Improves GPS accuracy and provides integrity
  – First time Europe develops a satellite navigation ground segment.

• **Step 2: GALILEO**
  – Autonomous European civil GNSS.
  – First time Europe develops a satellite navigation space segment.
  – A system for the 21st century incorporating the latest technologies.
  – Signals for civilian use.
  – Service guarantees.
**Why Galileo?**

- Satellite navigation users in Europe have no alternative other than GPS or GLONASS.
  - Under military control
  - No guarantee to maintain an interrupted service

- European independence is the chief reason for developing Galileo:
  - Under civilian control
  - Guarantee of operation at all times
  - Better coverage at high latitudes, which are not well covered by GPS (e.g., northern Europe).

- Europe will be able to exploit the opportunities provided by satellite navigation to the full extent.
  - Application providers
  - Service operators
  - Large number of business opportunities.

- Galileo will guarantee availability of the service under the most extreme circumstances and will inform users within seconds of a failure of any satellite. This will make it suitable for applications where safety is critical.
- **Space Segment Specification**
  - 30 satellites (27 operational + 3 active spares),
  - 3 MEO planes at 23.222 km altitude above the Earth
  - Plane Inclination of 56 degrees
  - 9 SVs equally spaced per plane (one spare SV in each plane)

- **Ground Segment Specification**
  - A global network of Galileo Sensor Stations (GSSs)
  - Galileo Control Centres (GCCs) (*)
    - Control of the SVs and to perform navigation mission management
    - Use the data from the GSSs to compute the integrity information and to synchronise the time signal of all satellites with the ground station clocks
  - 15 Uplink Stations (ULS) (5 in S-band & 10 in C-band)
    - Exchange of the data between the control centres and the satellites

(*) For the agreed Control Centres Please refer to November 2007 EU Transport Council decisions on Galileo.
GIOVE-B: Second Galileo test Satellite to be launched on 27 April 2008
The EGNOS Services to users

GEO

GPS-like signals

Differential corrections

Integrity (Use / Don't Use)

+ ACCURACY
+ AVAILABILITY
+ CONTINUITY

+ SAFETY

Information can be also obtained through Non-GEO means (e.g. the Internet, via the ESA SISNeT technology)
EGNOS Service Area
• **Aviation**, maritime navigation, Railways,

• Road community: car navigation, fleet management, road pricing, autonomous vehicle guidance, etc

• Timing and telecommunications: synchronization of internet nodes; synchronisation of mobile base stations, etc

• Agriculture: precision farming, GIS applications, automation of mobile agriculture, etc

• Many others: fishery, search and rescue, land surveying, meteorology, land survey, leisure, etc
Examples of EGNOS Demonstrations (multimodal) made by ESA

- EGNOS/SISNET for public bus transportation (NAVOCAP, France; and also GMV, Spain)
- EGNOS dissemination through FM RDS in cars (TDF, France)
- EUROCOPTER (Helicopter Emergency Medical Services, Germany/France)
- EGNOS to support Precision Farming (Booz Allen, UK)
- DELTA hybridation test in airports (M3 systems, France, and Sweden)
- EGNOS disseminations through DAB radios (BOSCH/BLAUPUNKT, Germany)
- Internet EGNOS transmission: SISNET Pocket PC PDA receiver (Finish Geodetic Institute, Finland)
- EGNOS/SISNET to support blind pedestrian (GMV and ONCE Spain).
• 34 « eyes » for EGNOS, 41 to be available in 2009:
  – Three branch (A/B/C)
  – Made of GPS receiver, Atomic clock, core computer

• Main contractors:
  – Branch A: Indra (E) / Thales (F)
  – Branch B: Alenia (I) / Laben (I)
  – Branch C: Thales(UK) / Novatel (C)
Note: Source ESSP / AENA / ASQF under ESA EGNOS operations Contracts
Central Processing Facility (CPF)

- The « brain » of EGNOS
- Five redundant units
- One installed in each MCC (2 in Langen)
- Perform all real time processing and checks
- Main contractors: Tales Alenia Space (F) / GMV (E) / Logica (UK) / IFEN (D)
• The « arms » of EGNOS

• Equip each Mission Control Center

• Remotely monitor and command all EGNOS Elements

• Main contractors: Alenia (I) / SSI (I) / Indra (E)
• The « mouth » of EGNOS
• Transfer EGNOS messages to Geo satellites towards broadcast to users
• Six uplink Stations
  – Two per GEO Satellite
  – Three Satellites
• Main contractors: Astrium (D),
  – Telespazio (I), Indra (E), Thales (F), Cap Gemini (F)
EGNOS Signal Availability:
100% signal availability reached

Accumulative SIS

% SIS of last 28 days

Note: Source ESSP / AENA / ASQF under ESA EGNOS operations Contracts
Typical EGNOS APV Aviation Availability

HPL < HAL and VPL < VAL Percentage for Measured Availability

2008/04/02 00:00:00 - 2008/04/02 23:59:59 GEO: 120

Note: Source ESSP / AENA / ASQF under ESA EGNOS operations Contracts
Typical performances:
Example on 21 April 2008, in Rome (Italy)

EGNOS typical achieved accuracies are in Europe 1 to 2 m HNSE (95%)
Typical performances:
Example on 21 April 2008, in Rome (Italy)

Avail. APV-I: 100.00%  April. APV-II: 100.00%  # Samples: 50198

Graph created at: 21-Apr-2008 16:12:24
• EGNOS test-bed available to all European Users since February 2000

• EGNOS ORR successfully passed June 2005, leading to the start of EGNOS Initial Operations Phase (IOP).

• Today, April 2008, EGNOS signal in Space is available 100% of the time

• Available SIS:
  – PRN 120 (INMARSAT AOR-E): used by the EGNOS Operator (ESSP) as part of the Initial Operations Phase.
  – PRN 126 (INMARSAT IOR-W): used by the EGNOS Operator (ESSP) as part of the Initial Operations Phase.
  – PRN 124 (ESA Artemis Satellite): used by EGNOS Industry Contractor for tests of EGNOS system releases.

• EGNOS V2.2 (Certifiable Release) Technical qualification to be achieved by July 2008

• EGNOS V2.2 final formal Certification (led by GSA) expected by the end of 2009
EGNOS is an integral part of 3 inter-regional systems

EGNOS is fully interoperable with other existing GNSS-1 systems
EGNOS Contributing to a true worldwide SBAS

And other near future International SBAS …
ESA has produced an EGNOS Book aiming at providing information on the EGNOS Mission, EGNOS system, architecture and related applications. Includes also a dedicated Chapter on Galileo.

Available from www.esa.int/publications