Status of EGNOS and Galileo Projects

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GALILEO: Satellite constellation and ground mission and control segments

Local Components

SERVICE CENTERS

Regional Components

EGNOS

SAR

USER SEGMENT
EGNOS • The first step of the European GNSS Strategy leading to Galileo.
• EGNOS is the first component of the European SatNav infrastructure.
• EGNOS provides early benefits to users and it is a precursor of Galileo services (e.g. integrity).

+ ACCURACY + AVAILABILITY + CONTINUITY

+ SAFETY

Integrity (Use / Don't Use)

GEO

GPS-like signals

Differential corrections
- 47 EGNOS elements deployed onto 41 sites in 22 countries
- 34xRIMS, 4xMCC, 6xNLES, 3xGEO
EGNOS GEO Satellites

Triple coverage over Mediterranean and Africa

December 2004
• Deployment practically completed
  • 4 MCCs, 6 NLES, 30 out of 34 RIMS;
  • All 3 EGNOS Geostationary satellites are transmitting successfully: AOR-E, IOR-W and ARTEMIS

• EGNOS test transmissions since July 2004.
• Signals available for non-safety of life users in early 2005.
• Signals available for safety-of-life users in 2006.
• Gradual introduction of EGNOS evolutions (e.g. extension of coverage area) to be initiated in 2005.
EGNOS Measured Accuracies

- Less than 1 m horizontal accuracies recorded in EGNOS quite often;
- Excellent vertical accuracies 1-2m (well below the 7.6 m specification)

<table>
<thead>
<tr>
<th></th>
<th>Lisbon</th>
<th>Toulouse</th>
<th>Rome</th>
<th>Brussels</th>
<th>Paris</th>
</tr>
</thead>
<tbody>
<tr>
<td>HNSE</td>
<td>1.2 m</td>
<td>0.9 m</td>
<td>1.1 m</td>
<td>0.8 m</td>
<td>1.0 m</td>
</tr>
<tr>
<td>VNSE</td>
<td>1.7 m</td>
<td>1.4 m</td>
<td>1.2 m</td>
<td>1.7 m</td>
<td>1.3 m</td>
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</tbody>
</table>
Service Coverage

SBAS Availability for APV1 (HAL: 040m VAL: 50m) on cmt 000001:300:86401 Seconds of GPS Week 1287 - 5x5 Grid (Start Time: 09/05/04 00:00:01) MSG: prn126-04sep05.bin Max Availability: 0.97578

Sep 5, 2004 (24 h)
26 RIMS out of 34

December 2004
Vertical Position Error and Protection Level vs Time

50% VPE: 0.45626 95% VPE: 1.4387 Bias Up: 0.33497 95% VPL: 11.915

Copyright ESA

Graph created at: 01-Dec-2004 23:01:24

SBAS PRN Used - 100

# SUsed for SBAS Solution

DOY

336.3 336.4 336.5 336.6 336.7 336.8 336.9

ESA/ESTEC (NL)
Dec 1, 2004
30 out of 34 RIMS
EGNOS Evolution

- No disruption of operational service
- Step-wise Implementation.
- Step 1 (2006):
  - EGNOS GEO data for dissemination over non-GEO links.
  - Extension of coverage area: South of Mediterranean area and East Europe.
- Step 2 (2007-2008)*:
  - Extension in Africa
  - L5 capabilities
  - Search and Rescue Return Link

*) to be confirmed in 2005
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GALILEO Constellation

Walker 27/3/1
plus 3 in-orbit spares

altitude 23222 km

inclusion 56 deg

*) passive spares
Orbit Determination & Time Synchronisation

Orbitography and Synchronisation Processing Facility

- Batch processing with history
- Scheduled uplink of satellite data

OSPF

December 2004
Integrity Processing Facility

Instantaneous processing without history

Continuous uplink of full-system data

Integrity Determination
External Region Integrity Service

“ERIS Control Centre”

External Region

ECC
GALILEO Implementation
Steps

GSTB – V1

GSTB – V2

IOV SYSTEM

TEST RECEIVERS

FULL OPERATIONAL SYSTEM

USER EQUIPMENT

PROTOTYPING AND EXPERIMENTATION

IN-ORBIT VALIDATION

FULL DEPLOYMENT

2002-2005

2003-2007

2006-2008
Critical technology developments completed:
(i.e clocks Rubidium, H-Maser (1ns in 100min), Satellite Navigation Antenna, GSS Antennas, GSS Receiver PreDev, …)

Galileo System Test-Bed (GSTB-V1) developed to experiment with Galileo-like processing algorithms based on GPS Observables. Six months of results.

The GSTB-V2 development was Kicked-off in July 03
- Two experimental satellites under development.
- First experimental satellite to be launched by end 2005.
- The GSTB-V2 is planned to be operated for a period of two years after launch (2006 & 2007)

In-Orbit Validation Phase on-going.
Rubidium Atomic Clock

- weight and volume: 3.3 Kgs and 2.4 l.
- time stability: better than 10 nsec per day

measured data
H-maser Atomic Clock

- weight and volume: 18 Kg and 45 l.
- time stability: better than 1 nsec per day.
Satellite Navigation Antenna

- Phase array.
- Isoflux pattern to equalize received power level on ground.
- Broadband frequency response to cover all the Galileo frequency bands with high performance.
GSTB-v2 A Satellite
(Surrey Satellite Technology Ltd)

- Lift-off mass 450 kg
- Power demand 660 W
- Stowed Dimensions 1.3 m x 1.74 m x 1.4 m
GSTB-v2 B Satellite
(Galileo Industries)

- Lift-off mass 523 kg
- Power demand 943 W
- Stowed Dimensions: 0.955 m x 0.955 m x 2.4 m
Experimental Ground Segment (GSTB-v1)

- Galileo demanding performance require:
  - Very precise satellite orbit prediction capability (65 cm).
  - Very precise satellite clock synchronization (1.5 nsec over 100 minutes)
  - Low integrity risk in detecting system failures (satellite or ground).
  - Overall high availability of service (99.5%)

- Requires advanced ground segment processing algorithms.

- Algorithms being experimented today with GSTB-v1 using GPS signals and a dedicated network of GPS ground stations.
GSTB-V1 Sensor Stations Network

The GALILEO network of reference stations will also be global.
GSTB-v1 Results: GPS Orbit and Clock Synchronization

- Contribution to range error due to orbit and clock errors.
- Comparison of the broadcasted GPS navigation msg with the E-OSPF computed one.
- Validity Time (2 hrs).
- Feasibility of meeting the GALILEO requirement (65 cm) proven.
• IOV to address in full Galileo design and development (FOC technical requirements)
  • GOAL:
    • qualification of space, ground and user segment through extensive test
    • Analysis of system performance with the view to refine the system prior to full system deployment
    • Verification of operational procedures
    • Deployment risk reduction
  • Based on manufacturing and deployment of a limited In-Orbit-Validation (IOV) System Configuration:
    • 1 experimental satellite (GSTB-V2) (early version of operational IOV Sat.)
    • 3-4 operation satellites (considered minimum number required)
    • Associated ground (20 GSS, 5 ULS, 2 TTC, 1 GCC) and test user segment

• IOV Transition to FOC
  • by recurring manufacturing / deployment / integration of IOV system components
IOV System
Configuration

Galileo IOV

3 to 4 SV's

Galileo Sensor Stations
Global Coverage

18 to 20 Galileo Sensor Stations (worldwide)

Control Centre (1 site)

Galileo receiver

OSS12
Rubidium
Experim.
receiver

Galileo receiver

OSS12
Rubidium
Experim.
receiver

Galileo Sensor
Stations
Global Coverage

Galileo receiver

Galileo Sensor
Stations
Global Coverage

ULS/TTC
Global

(2
1
3
Global
Global

3
ULS
Global

(3
ULS/TTC
Global

(at the same sites)

2
ULS/TTC
Global

December 2004
• Overall Spacecraft: 680 Kg / 1.6 kW class
• Launcher Options: Ariane, Proton, Soyuz, Zenit

• Navigation payload: 115 Kg / 780 W
• SAR transponder: appr. 20 kg / 100 W

• Dimensions: 2.7 x 1.2 x 1.1 m³
Further information

- Further information is available on the following websites:
  - http://europa.eu.int/comm/dgs/energy_transport/galileo
  - http://www.esa.int/export/esaSA/navigation.html

- Further information on the Joint Undertaking:
  - http://www.galileoju.com