ESA INFORMATION DAY
ON THE
EUROPEAN GNSS EVOLUTION
PROGRAMME (EGEP) 2013-15

Warsaw, Poland
11 April 2013
• EGEP Phase 1
• EGEP Phase 2 - 2013-15
  • EGNOS - Drivers and Roadmap
  • Galileo - Directions and Roadmap
  • Accompanying Activities
• Results of the ESA Ministerial Conference, Naples, Nov 2012
• Overall Workplan 2013-15
• EGEP Workplan 2013 - Batch 1 and 2
EGEP Objectives

ESA Optional Programme fully funded by ESA MS in line with the principles and guidelines of the EU/ESA framework agreement

Programme Objectives:

- Enable technical readiness for upgrades and evolution of EGNOS and Galileo caused by mission evolution, operability improvements and/or technology obsolescence
- Maintain technical European know how, competences and infrastructures at par internationally
- Sustain competitiveness and innovation capabilities

The activities are focusing on infrastructure technology R&D, and system development activities covering Phase A/B
EGEP 2008-12

- 18 Participating States
- Initiated in 2007
- ~ 100 M€
EGEP Activities 2008-12

- **SYSTEM**
  - Exploratory System Studies (MRS, C-band,..)
  - Future Applications
  - EGNOS V3 Phase A
  - ARAIM System Study

- **SPACE SEGMENT**
  - Breadboarding (Cs, PHM clocks)
  - Engineering Models (clocks, IDU,..)

- **GROUND SEGMENT**
  - Multi-Constellation Receiver Dvpts.
  - Advanced Ground Antenna Dvpts.

- **VERIFICATION VALIDATION**
  - Test-Bed Core Platform Developments (SPEED)
  - Test-Beds Devpt and Operation

- **GNSS SCIENCE**
  - C-band, S-band Propagation Studies and Interference
  - Ionosphere Campaign
  - GNSS Science (GNSS-R, AO) and Education

**TODAY**
Achievements 2008-12

• Definition of a Multi-Constellation Regional System (MRS) concept used as a basis for EGNOS V3

• Identification of possible trends for a future architecture of Galileo
  – Separation of navigation signal chains to improve flexibility
  – Inter-satellite link based architecture to reduce dependence from ground segment and to improve autonomy
  – Improvement of robustness of system elements
  – Use of new frequency bands

• New atomic clock technology line initiated: optically-pumped Cs clock
  – RAFS - Cs - PHM    Industrial diversity

• Concept  P/L Self-Equalization unit

• Development of future multi-constellation sensor stations initiated

• RIMS core receiver technology

• Advanced antenna developments

• Core technology of up-link station for future EGNOS V3

• SPEED and testbeds
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For what regards the preparatory activities for EGNOS:
Preparation of the preliminary design and technology for EGNOS V3 with the following objectives:
• Ensure provision of the single frequency service after the announced discontinuation in 2020 of the guaranteed codeless use of GPS L2P(Y) signal after 2020.
• Introduce new Safety-of-Life (SoL) service based upon a multi-frequency and multi-constellation mode.

For what regards the preparatory activities for Galileo:
Prepare the definition and technology for a 2nd generation of Galileo (Galileo 2G) responding to the needs for evolutions identified in coordination with the EC and the various stakeholders, consistent with the Galileo Mission Evolution Roadmap and ready in time for the replenishment of the Galileo constellation.

For what regards GNSS in general:
• Sustain, evolve and broaden the GNSS-related technological know-how in Europe.
EGNOS V2-V3 OVERALL ROADMAP

Operational EGNOS

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
<th>Description</th>
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<td>2011</td>
<td>EGNOS V2.2 &amp; V2.3.1 (APV ECAC)</td>
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<td>2013</td>
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<td>V2 Infra-structure Decommissioning</td>
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EGEP (EGNOS V3 Definition)

- V3 Phase A
- B1
- Phase B2
- Support activities (Testbeds, Technology)

EC Program EGNOS V3 Implementation (still to be Approved)

- Draft (L1-L5) Multi-constellation SBAS ICD
- SARPS, RTCA MCPS
- Robust LPV200, CAT 1 autoland, CAT 2 (TBC), Extended Coverage
- Avionics L1/L5 multi-constellation devpt

IWG, Eurocae, RTCA, Avionics Manufacturers

- IWG, Dual Freq Multi-constellation Standardisation

WAAS

- Phase III – LPV200 Tech Ref
- Early Dev. (Rx, SC)
- Phase IV – Dual Frequency Full LPV200 Tech Ref
- Phase IV OPS WAAS L1/L5

Legend:
- ▲ Service evolution milestone (WAAS or EGNOS).
- ⬷ Major Milestone (PDR, CDR, QR, draft standard, consolidated standard).
- ⬤ Activities supporting the production of international standards (SARPS, MOPS) and of associated avionics.
EGEP Activities related to EGNOS V3

EGEP Phase 2
- V3 Phase A
- Phase A Ext & B1
- G/S Techno Pre-dev.
- MLU test bed
- High Integrity System test bed
- Arctic test bed

EGEP Extension
EGNOS V3 related activities
- 2 // Phase B2
- Implementation Phase (EU funding)
- PDR
- High integrity System test bed (TAS-F)
- New Integrity System test bed (ATS-D)
- 2 // contracts V3 Station Receiver Pre-dev.
- EGNOS V3 User technology Pre-dev.
- ARAIM test bed

Project Participants:
- IWG, Eurocaen,
- RTCA, Avionics
- Manufacturers

Draft (L1,L5) Multi-cons SBAS ICD

- IWG, Dual Frequency Multi-cons Standardisation
Upgrade Ground Segment to GPS/Galileo improves current EGNOS L1 service

APV-I Coverage Performance for EGNOS GPS L1 users

Current Performance                          Future Performance: GPS+Galileo G/S

Longitude (deg)                          Latitude (deg)
-40                                    -30
-20                                    -10
  0                                     10
  20                                    30
  40                                    50
  60                                    70
  80                                    90

Availability for HAL: 40 VAL: 50
MinDOC: 3 MinIPP: 2 PullInRadIPP: 400km
< 50% > 50% > 75% > 85% > 90% > 95% > 99% > 99.5% > 99.9%
LPV-200 L1/L5 GPS Only

- Availability for HAL: 40m
- VAL: 35m
- MinDOC: 5
- MinIPP: 3
- PullInRadIPP: 500km

- Longitude (deg)
- Latitude (deg)

- L1/L5 Service / 24GPS Satellites / GEOs set to monitored / RIMS Elevation Mask 15deg / MT28 Implemented
- Timestep 300s / Duration 1 day / Gridsize 2.5x2.5deg

- > 99.9%
- > 99.5%
- > 99%
- > 95%
- > 90%
- > 85%
- > 75%
- > 50%
- < 50%
LPV-200 L1/L5 GPS+Galileo
Complete Coverage of Africa

L1/L5 Service / 24GPS+27GAL Satellites / GEOs set to monitored / RMS Elevation Mask 15deg / MT28 Implemented
Timestep 300s / Duration 1 day / Gridsize 2.5x2.5deg

Availability for HAL: 40m VAL: 35m
MinDOC: 5 MinIPP: 5 PullInRadIPP: 500km
< 50%
> 50%
> 75%
> 85%
> 90%
> 95%
> 99%
> 99.5%
> 99.9%
> 99.95%
> 99.99%

Longitude (deg)
Latitude (deg)
-180 -120 -60 0 60 120 180
-90 -60 -30 0 30 60 90

Availability for HAL: 40m VAL: 35m
MinDOC: 5 MinIPP: 5 PullInRad: 500km

< 50%
LPV-200 L1/L5 GPS+Galileo Multi-Regional

L1/L5 Service / 24 GPS + 27 GAL Satellites / GEOs set to monitored / RIMS Elevation Mask 15deg / MT28 Implemented
Timestep 300s / Duration 1 Day / Grid 2.5 x 2.5 deg

Longitude (deg)

Latitude (deg)

-90 -60 -30 0 30 60 90

-180 -120 -60 0 60 120 180

 Availability for HAL:40m VAL:35m MinDOC:5

< 50% > 50% > 75% > 85% > 90% > 95% > 99% > 99.5% > 99.9% > 99.95%
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Galileo Drivers

- **Drivers stemming from the envisage evolution of the current Mission:**
  - Non-compliance with baseline mission requirements; an example being the decision to stop the implementation of the originally foreseen Galileo Safety of Life (SoL) service.
  - Emerging new mission requirements, such as improvement of the PRS service.

- **Drivers stemming from bottom-up system level considerations:**
  - System design-to-cost optimization (incl. technology improvement).
  - Management of obsolescence.
  - Risk mitigation.
Horizontal Directions

1. Cost Efficiency of the Galileo System

Space Segment Directions

2. Replenishment Flexibility and Introduction of new Platform Capabilities
3. Guarantee availability of diversified and independent European GNSS technologies
4. Allow (early) introduction of new Services

Ground System Directions

5. Reduce dependence from Ground Segment
Frequencies, Signals and Services Directions

6. Increase Robustness and Operational Capabilities of the Galileo Public Regulated Service (PRS)
7. Mitigate Vulnerability of Galileo (and GNSS) Signals to Interference
8. Increase Service Performance in Comparison with other GNSS
9. Increase Utilization of Galileo with Respect to Integrity Applications
High priority directions:
1. Cost benefit of Galileo system.
2. Replenishment flexibility and introduction of new platform capabilities.
3. Guarantee the availability of diversified and independent European GNSS technologies.
4. Reduce dependence from ground segment.
5. Increase Robustness and Operational Capabilities of the PRS.

Medium priority directions:
6. Mitigate vulnerability of Galileo (and GNSS) signals to interference.
7. Increase service performance in comparison with other GNSS.

Low priority directions:
8. Increase utilization of Galileo with Respect to Integrity Applications.
9. Allow introduction of new services.
POSSIBLE GALILEO 2G IMPLEMENTATION
• EGEP Phase 1
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Accompanying Activities

- Testbeds

- Tools and Complementary Activities to support the Executive preparing the future GNSS.
  - System tools.
  - Complementary activities.
  - Common Ground Technology.

- System Support Services.
  Ad hoc support to the Executive in its system level activities.
CONTENT

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### EGEP Subscription at CM 2012

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<th>Financial Contribution Extension M€</th>
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EGEP SUBSCRIPTION AT CM 2012
MAIN HIGHLIGHTS

- Subscriptions for 2013-15: **117.8 M€**
- No contributions from Denmark, Greece, Ireland, Netherlands, Spain, Sweden, Canada
- Contributions from new MS (ROM and POL)

Overall:
- Level of subscription is a very positive support from MS to the EGEP programme, allowing to reach the main goals of the programme

However:
- Workplan had to be adapted to the subscribed financial envelope (150 M€ > 117.8 M€)
- Specific situation of Spanish contribution (EGNOS)
EGEP 2013-15

- 18+2 Participating States
- ~ 118 M€
- Activities related to EGNOS & Galileo
- Only R+T necessary to it
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<table>
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## Proposed Activities for the 2013-15 Extension of the EGEP (Cost in M€)

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## 2013-15 EGEP Work Plan - 3

### Proposed Activities for the 2013-15 Extension of the EGEP (Cost in M€)

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## Proposed Activities for the 2013-15 Extension of the EGEP (Cost in M€)

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<th>Grand Total</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tr>
<td>2150</td>
<td>Internal cost</td>
<td>24.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>Internal cost Total</td>
<td>24.0</td>
<td>8.0</td>
<td>8.0</td>
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</table>
## Proposed Activities for the 2013-15 Extension of the EGEP (Cost in M€)

<table>
<thead>
<tr>
<th></th>
<th>CM 117.8 M€</th>
<th>Remarks</th>
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<tbody>
<tr>
<td></td>
<td>Grand Total</td>
<td>2013</td>
</tr>
<tr>
<td>EGNOS v3 Total</td>
<td>35.0</td>
<td>33.0</td>
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<tr>
<td>Galileo 2G Total</td>
<td>38.6</td>
<td>25.5</td>
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<tr>
<td>Test-beds Total</td>
<td>5.1</td>
<td>1.8</td>
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<tr>
<td>Tools and complementary Total</td>
<td>8.9</td>
<td>4.4</td>
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<tr>
<td>Internal cost Total</td>
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<tr>
<td>Support services Total</td>
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<tr>
<td>Management reserve</td>
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<td>0.6</td>
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<tr>
<td>Grand Total</td>
<td>117.8</td>
<td>75.8</td>
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</table>
IMPACT ON DRAFT WORKING PLAN 2013-15

Total amount of **117.8 M€** allows the Executive to reach the main goals of EGEP Extension:

**EGNOS**
- EGNOS V3 Phase B2
- RIMS V3 Prototype
- Continuation of main EGNOS testbeds

**Galileo**
- Galileo 2G system level work
- Galileo 2G Satellite Study Phase A/B1
- Electrical Propulsion Validation for Galileo
- Inter-Satellite Links Pre-development
- Further Technology Development of Key Equipment (incl. clocks)
• EGEP Phase 1
• EGEP Phase 2 - 2013-15
  • EGNOS - Drivers and Roadmap
  • Galileo - Directions and Roadmap
  • Accompanying Activities
• Results of the ESA Ministerial Conference, Naples, Nov 2012
• Overall Workplan 2013-15
• EGEP Workplan 2013 - Batch 1 and 2
In order not to delay the procurement of the most urgent activities, Workplan 2013 Batch 1 was already submitted at the PBNAV on 29./30. Nov. 2012 for approval:

- IPC approved end of Jan 2013
- ITT’s are planned for April-June 2013
- Target contracts signature: Early summer 2013

Workplan 2013 Batch 2 is presently in the AC/IPC approval loop.
## 2013 EGEP Workplan, revision 1

<table>
<thead>
<tr>
<th>Batch 1</th>
<th>ID</th>
<th>M€</th>
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<tbody>
<tr>
<td><strong>EGNOS Related</strong></td>
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<tr>
<td>EGNOS V3 System Study (B2)</td>
<td>93.01/93.02</td>
<td>23.00</td>
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<tr>
<td>Support to Standardisation</td>
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<tr>
<td>RIMS V3 Prototype Development</td>
<td>63</td>
<td>9.00</td>
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<tr>
<td>Ionosphere Characterisation</td>
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<td><strong>Total</strong></td>
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<td><strong>Galileo Related</strong></td>
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<tr>
<td>Galileo 2G Phase A/B1 Satellite Study</td>
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<td>16.00</td>
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<tr>
<td>Electric Propulsion subsystem Industrialisation and Thruster operational characterisation <em>(NOTE: This budget covers up to 3 parallel contracts. Additional 1.2 M€ will be kept as mgmt. reserve in case the TEB receives 4 excellent proposals (ref. IPC decision))</em></td>
<td>76</td>
<td>3.60</td>
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<td>Inter Satellite Link (ISL) Pre-development</td>
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<td><strong>Total</strong></td>
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<td><strong>Batch 1 Total</strong></td>
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### 2013 EGEP Workplan, revision 1

<table>
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<th>Batch 2 Activities of Workplan 2013</th>
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<tbody>
<tr>
<td><strong>Batch 2</strong></td>
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<tr>
<td><strong>EGNOS Related</strong></td>
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<tr>
<td>High Integrity System Testbed</td>
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<tr>
<td>New Integrity Concept for Dual-frequency SBAS</td>
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<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Galileo Related</strong></td>
</tr>
<tr>
<td>Enhancement of Orbit Determination and time synchronisation</td>
</tr>
<tr>
<td>PRS Signal Robustness</td>
</tr>
<tr>
<td>GNSS Technology &amp; Science Announcement of Opportunity</td>
</tr>
<tr>
<td>Ground Cs Clock Development</td>
</tr>
<tr>
<td>Galileo 2G Links</td>
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<tr>
<td>System Support Services</td>
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<tr>
<td><strong>Total</strong></td>
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<td><strong>Batch 2 Total</strong></td>
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