State of play of European GNSS (EGNOS and Galileo) & Institutional Arrangements for non-EU countries

Euro-Mediterranean Transport Cooperation
Under the auspices of the co-presidency of the Union for the Mediterranean
7th Euromed GNSS Working Group meeting
11th Euromed Aviation Working Group meeting
Brussels, 15 October 2014
Ugo Celestino (European Commission)
2014-2020: New framework

- A stable 7 years perspective
- A substantial budget
- A new governance scheme driven by exploitation

2014-2020

- 1,930 B€ for Galileo Deployment
- 3 B€ for Galileo Exploitation
- 1,580 B€ EGNOS Exploitation
In EU and beyond
All EGNOS services are operational

EGNOS services are delivered on a long-term basis (> 20 years)

<table>
<thead>
<tr>
<th>Service</th>
<th>Accuracy</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open Service (OS)</strong></td>
<td>Accuracy ~1m, free</td>
<td>Available since October 2009</td>
</tr>
<tr>
<td><strong>Safety of Life Service (SoL)</strong></td>
<td>Accuracy ~1m, integrity, compliant to aviation standards</td>
<td>Available since March 2011</td>
</tr>
<tr>
<td><strong>EGNOS Data Access Service (EDAS)</strong></td>
<td>Accuracy &lt;1m, corrections provided by terrestrial networks</td>
<td>Available since July 2012</td>
</tr>
</tbody>
</table>
Open Service (OS)

Availability
(OS Service Definition Document)

Nov 2009

March 2013
Availability

March 2011

June 2013
EGNOS SoL features

- **Safety of Life** service has been declared operational in March 2011

- EU committed to keep it **free of charge** (letter to ICAO), for at least 20 years and with 6-years notice

- ESSP has been certified based on the Single European Sky Regulatory package

- EGNOS landing procedures being developed around EU for their benefits:
  - Very precise vertical guidance
  - Safer landings at airports not equipped with ground-based navigation aids (e.g. ILS)
  - Increased airports capacity
Airports: LPV precision landing procedures using EGNOS

Around 100 LPV procedures
Publish by March 2014

More than 150 LPV procedures foreseen for end 2014

More than 460 LPVs planned by 2018

Vert: aéroports totalement couverts par Egnos
Bleu: aéroports partiellement couverts par Egnos
Orange: Aéroports dont les procédures EGNOS sont publiées durant l'année 2014
EGNOS extensions possible within satellite footprints…

EGNOS Core Service Area

ENPI East

ENPI South

Africa
...with expansion of EGNOS Ground Segment
EGNOS extensions: activities funded to date

**Funded by DG DEVCO (ENPI):**
- 2006-09: METIS (2.5M)
- 20011-14: Medusa (2.1M)
- 2007-: infrastructure (3.6M)

**Funded by DG DEVCO (ENPI):**
- 2014 -: UKRAINE (5M)*

(*) AAP: Annual Action Programme

Four areas covered:
1) Users needs, real life trials and service demo (OS, SoL)
2) GNSS skills building
3) System infrastructure
4) Governance, regulatory analysis & roadmap to adoption
EU and ENP South countries* have been working since 2006 to extend the EGNOS SoL coverage over N.Africa/M.East

**Objective**
- Leveraging the EGNOS core service area V2 infrastructure to extend coverage to 10 Mediterranean countries.

**Implementation**
- Commission’s Communication Mar./2011, position by Ministerial Transport Conference of the Union for the Mediterranean (UfM) Nov. 2013: the area of Satellite Navigation is being pursued as field of technical cooperation, for its impact on transport efficiency, safety (e.g. civil aviation) and regional cooperation.
- Euromed GNSS I & II (METIS, MEDUSA, ESA): CBA per country, initial infrastructure, technical demonstrations, service demo in aviation and logistics, definition of legal/regulatory framework for the long term. Two RIMS still to be deployed (Israel, Algeria?)
- Roadmap to provide EGNOS SoL coverage to be defined in Q4 2014

(*) Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, Palestine, Israel, Lebanon, Syria
EGNOS SoL signal extension: countries priorities

Priority Area 1 (green airports)
Priority Area 2 (yellow airports)
Priority Area 3 (red airports)

Source: MEDUSA consultation, 21 Jan 2014
To cover a country, a network of few RIMS is required, normally in the south-eastern regions (i.e. just one installed in own territory is not enough)

Estimate: 5 new RIMS
What is needed for EGNOS SoL service in non-EU (ENP South countries)?

- **Signal coverage (i.e. delta infrastructure)**
  - Required performance (e.g. coverage)
  - V2 and/or V3 options
  - Funding needs (capex, opex)

- **Definition of service implementation**
  - Technical table ongoing with ESSP, other experts (e.g. EASA), authorities in non-EU countries, to define operational agreement

---

**Two Agreements:**

1. **An International Agreement between EC and the non-EU countries**

2. **A working level agreement (EGNOS Working Agreement for non-EU countries) between ESSP and the non-EU country’s ANSP**
Key issues will have to be defined

- **System Mission & Architecture**
  - ...
  - ....

- **Funding**
  - Capex
  - Opex

- **Governance**
  - ...
  - ....

- **Liability**
  - ....
  - ....

- **Security**
  - ....
  - ....

- **Certification**
  - ....
  - ....

- **Industrial layer**
  - ....
  - ....

- **Service Provision**
  - ....
  - ....
EU Commission envisages an 'Horizontal Agreement' to define all key issues for a specified set of countries (ENP South, East)

- **System Mission & Architecture**
  - ....
  - ....

- **Funding**
  - Capex
  - Opex

- **Governance**
  - ....
  - ....

- **Liability**
  - ....
  - ....

- **Security**
  - ....
  - ....

- **Certification**
  - ....
  - ....

- **Industrial layer**
  - ....
  - ....

- **Service Provision**
  - ....
  - ....
...Subject to technical and financial constraints and on the basis of international agreements, the geographical coverage of the services provided by the EGNOS system could be extended to other regions of the world, in particular to the territories of candidate countries, of third countries associated with the Single European Sky and of countries in the European Neighbourhood Policy...

... In view of the global nature of the systems, it is essential that the Union enter into agreements with third countries and international organisations in the context of the Galileo and EGNOS programmes under Article 218 TFEU, in particular to ensure their smooth implementation, deal with certain questions relating to security and charging, optimise the services provided to citizens of the Union and meet the needs of third countries and international organisations...

... The geographical coverage of the EGNOS system may be extended to other regions of the world, in particular to the territories of candidate countries, of third countries associated with the Single European Sky and of countries in the European Neighbourhood Policy, subject to technical feasibility and on the basis of international agreements. The cost of such extension, including the related exploitation costs, shall not be covered by the resources referred to in Article 9. Such extension shall not delay the extension of the geographical coverage of the EGNOS system throughout the Member States' territories geographically located in Europe...
RTAP (Regional Transport Action Plan): EU Assistance for GNSS

Action 16: Implementation of GNSS Aviation

i) **Extension of the EGNOS Safety of Life signal via infrastructure deployment** to achieve coverage of the ENP South Countries airspace according to the priority set in the "Recommendations on priorities for the EGNOS SoL geographical coverage needs across the Euromed region" (21 January 2014, MEDUSA). **Active support from ENP South Countries in achieving rapid installation of EGNOS RIMS in their territories will be key, as well as enabling their smooth operations.**

ii) **Signature of International Agreement:** as envisaged by GNSS Regulation 1285/2013, non-EU countries can enter in such agreements to participate to EGNOS programme. We envisage an 'Horizontal International Agreement' to which all ENP Countries can adhere, as in other air transport cases. This agreement will define among other, governance, liability, funding issues related to EGNOS SoL service provision.

iii) **Signature of EGNOS Working Agreement (non-EU EWA):** following the International Agreement, such non-EU EWA will have to be established between the local ANSP and the European EGNOS Service Provider (currently ESSP) to provide for all operational needs required for actual service provision.

iv) **Adoption of ICAO procedures on GNSS and Implementation of the identified GNSS National Strategy (civil aviation and other transport domains).**
EGNOS priorities for EU

- Ensure that EGNOS is **used**
  - Long term SoL mission roadmap
  - Fostering procedures and receivers in aviation
  - Communication & EGNOS awareness in other domains

- Ensure the **continuity** of the services
  - Maintain the certificate of Safety of Life service
  - Authorisation to deploy/declare each new system version
  - Continuity of Performances and Operations
  - Master evolution, e.g. multi-constellation (GPS, GLONASS, Galileo)

- Extend EGNOS **coverage**
  - Complete full EU/ECAC Coverage
  - Extension to neighbouring regions (ENP South / East, Africa)
    - signal coverage (infrastructure)
    - service provision (agreements)
Conclusion & next steps for the ENP South countries

- Roadmap for EGNOS SoL coverage to be defined in priority Area 1 (Q4 2014 / Q1 2015)
  - Capex, Opex
  - RIMS location
  - Funding decision

- Regulatory analysis for EGNOS SoL service provision to be shared with CAAs (Nov-Dec 2014)
  - Key building block for International and EWA agreements

- EC to obtain a mandate to negotiate International Agreements (Q1 2015)
  - Start negotiation with interested countries
  - Other interested countries to contact formally Commission

- Complete negotiations and signing of International Agreements (2015-16)
  - 10 countries
State of Play
European GNSS programmes

EGNOS

★ Improve GPS performances
★ Continental coverage
★ 3 services

Galileo

★ Autonomes infrastructure
★ Similar performances with GPS
★ World coverage
★ 5 services, under development

GPS: Global Positioning System
‘It’s there, use it’
EGNOS system architecture and service area

- 2 Support Facilities
- 4 Mission Control Centres
- 6 Navigation Land Earth Stations
- 39 Ranging & Integrity Monitoring Stations (RIMS)
- GPS signals
- EGNOS Satellite Footprints
- EGNOS Service Area
- 3 Geostationary satellites

GEO: Geostationary Earth Orbit
Early services for OS, SAR and PRS will be provided from 2015*

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Service (OS)</td>
<td>Freely accessible service for positioning, navigation and timing</td>
</tr>
<tr>
<td>Public Regulated Service (PRS)</td>
<td>Encrypted service designed for greater robustness and higher availability</td>
</tr>
<tr>
<td>Search and Rescue Service (SAR)</td>
<td>Assists locating people in distress and confirms that help is on the way</td>
</tr>
<tr>
<td>Commercial Service (CS)</td>
<td>Delivers authentication and high accuracy services for commercial applications</td>
</tr>
</tbody>
</table>

The former "Safety-of-Life" service is being re-profiled:

| Integrity Monitoring Service    | Provides vital integrity information for life-critical applications         |

(*) To be confirmed after launch anomaly enquiry
Galileo is implemented in a step-wise approach

- **2003**
  - Galileo System Testbed v1
    - Validation of critical algorithms

- **2005/2008**
  - GIOVE A/B
    - 2 test satellites

- **2013**
  - In-Orbit Validation
    - 4 fully operational satellites and ground segment

- **2015**
  - Initial Operational Capability
    - Early services for OS, SAR, PRS, and demonstrator for CS

- **Full Operational Capability**
  - Full services, 30 satellites
Galileo system architecture

5 mission uplink stations

5 TT&C stations

2 control centres

2 launch and early operations centres

Constellation of 30 MEO satellites

Users & service providers

16-20 Galileo sensor stations

MEO: Medium Earth Orbit

TT&C: Telemetry, Tracking and Command

IOT: In-Orbit Testing
The deployment plan of the Galileo constellation has been secured

★ 26 satellites in total have now been ordered

★ 4 IOV + 22 FOC

★ The launcher service contracts for the full constellation have been signed with Arianespace:

★ Soyuz: 7 launches for 14 satellites (incl. the launches in 2011, 2012 and 2014)
★ Ariane 5: 3 launches for 12 satellites

Photo: ESA, Arianespace
New satellite design on track

★ FOC Satellites built by OHB with navigation payload from Surrey Satellite Technology Ltd

★ Thermal and Vacuum testing of satellites in ESA premises

★ Shipping to Kourou

★ Satellite Qualification and Acceptance

★ Subsequent satellites production proceeds at a good rate
Several ground infrastructures have been deployed around the globe

TTC: Telemetry, Tracking and Command
Photos: ESA

GSS: Ground Sensor Station

ULS: Uplink Station

GSS/ULS Papeete

GSS/ULS Svalbard

TTC Kiruna

GSS Redu
Galileo control centres

Galileo launch pad is located in Kourou, French Guyana

Photo: ESA
Galileo control centres

Oberpfaffenhofen, Germany

Fucino, Italy
Set up for Service Delivery

**Core Infrastructure**
- Launch and Early Orbit Phase (2x)
- In Orbit Testing
- Control Centre (2x)
- Time and Geodesy

**Service Infrastructure**
- PRS & Security Monitoring Centre (2x)
- SAR Galileo Data Service Provider
- GNSS Service Centre
- Galileo Reference Centre

**Exploitation Headquarters**
- European GNSS Agency (GSA)
23rd January: First Galileo Search And Rescue Transponder put into service

12th March - First Position Fix with Galileo

3rd May 2013: First broadcast of time offset parameters between GPS and Galileo

1st July 2013: First secured Public Regulated Service fix by EU Member States in the UK
2014 – Ups [and Down]

★ New governance for the programme put in place

★ Galileo In Orbit Phase successfully concluded

★ Ground infrastructure deployment finalized for initial operations

★ New satellite design qualified

★ Soyuz Launch Anomaly

★ Preparation of service delivery and system exploitation
The grain of sand...

- 1st launch of Galileo FOC satellites on August 22nd
- Satellite Injection Anomaly detected shortly after the end of the mission
- Satellites under control but in elliptical orbit and different plane inclination

- Inquiry Board established by Arianespace to investigate source of launch anomaly
- EC-ESA analysing the best options for adaptation of mission for those two satellites
- Follow-up launch sequence will be confirmed once the full results of Enquiry Board are available

Photos: Arianespace
Galileo Launch Profile

1. Soyuz stages I to III
2. 1st Fregat burn
3. Ballistic trajectory
4. 2nd Fregat burn
5. Satellites separation
6. Fregat passivation
# Galileo Orbit

**Nominal Orbit**

<table>
<thead>
<tr>
<th>ORBIT</th>
<th>Circular</th>
<th>Elliptic</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTITUDE</td>
<td>23 200 km</td>
<td>13 200 - 25 900 km</td>
</tr>
<tr>
<td>INCLINATION</td>
<td>56°</td>
<td>49.8°</td>
</tr>
</tbody>
</table>

**Orbit after incorrect injection**

![Diagram showing a circular orbit and an elliptical orbit with Earth.]
# Galileo launch schedule

<table>
<thead>
<tr>
<th>Year</th>
<th>26 satellites constellation</th>
<th>Early services</th>
<th>Precise dates TBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Ariane 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Soyuz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
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<tr>
<td>2014</td>
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<tr>
<td>2015</td>
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<tr>
<td>2016</td>
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<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Early services will be provided from Q1 2015 with a gradual transition towards full services as more satellites become available.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open Service</strong></td>
<td></td>
<td></td>
<td>Early service Combined with GPS</td>
<td>Enhanced service</td>
</tr>
<tr>
<td><strong>Public Regulated Service</strong></td>
<td></td>
<td></td>
<td>Early service</td>
<td>Enhanced service</td>
</tr>
<tr>
<td><strong>Search and Rescue Service</strong></td>
<td></td>
<td></td>
<td>Early service</td>
<td>Full service</td>
</tr>
<tr>
<td><strong>Commercial Service</strong></td>
<td></td>
<td></td>
<td>Demonstrator</td>
<td>Early service</td>
</tr>
</tbody>
</table>

Stable good quality signals
Galileo Open Service Signal In Space Interface Control Document (OS SIS ICD)
- New version released on June 28 for public consultation until Sept 22
- It includes a new licensing agreement

Galileo Nequick Ionospheric Model
- Draft available to chipset/receiver manufacturers involved in testing campaign
- Public version soon to be released by EC

Galileo Service Definition Document
- Currently under preparation
- Public version to be released at early service declaration
## Benefits of the European GNSS programmes

<table>
<thead>
<tr>
<th></th>
<th>2010-2027 (Estimation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream market (direct)</td>
<td>€ 14 billion</td>
</tr>
<tr>
<td>Downstream market (indirect)</td>
<td>€29 billion</td>
</tr>
<tr>
<td>Upstream market &amp; spill overs (direct)</td>
<td>€ 17 billion</td>
</tr>
<tr>
<td>Socio-economic benefits</td>
<td>Between 60 -90€ billion</td>
</tr>
</tbody>
</table>

Source: Mid-term review of the European satellite radio navigation programmes – COM(2011) 5, 18/01/2014
Looking Around…

★ Galileo intends to deliver high quality and reliable services to the world and plans to continue introducing innovative features over time.

★ In the near future, most communities will be targeting service levels only available through multi-constellation services.

★ It is therefore important to:
  ★ Continue improving signal compatibility and service interoperability with other providers
  ★ Cooperate for multi-constellation service provision
International cooperation is crucial for the development of European GNSS

- **Objectives**
  - Compatibility and interoperability with other GNSS providers
  - Fostering uptake of EGNOS and Galileo worldwide
  - Support other EU policies (e.g. transport, aid & cooperation, neighbourhood)

- **Implementation**
  - Multilateral (e.g. IMO, ITU) and bilateral technical working groups
  - Funding R&D cross-border
  - Expansion of EGNOS to neighbouring regions
GNSS cooperation agreements help EU to achieve compatibility, interoperability and make the development of applications easier

★ **Agreements signed**
- P.R. of China (2003)
- USA (2004)
- Israel (2004)
- South Korea (2006)
- Ukraine (2006)
- Norway (2010)
- Switzerland (2013)
- Tunisia LoI, (2012)

★ **Agreements under discussion**
- Russia (ongoing discussions on agreement form)
- Brazil, Chile (mandates obtained in June 2011)
- Argentina (ongoing discussions)

★ **Main cooperation areas**
- Development activities
- Standardisation
- Galileo applications
- Research
- **SBAS and EGNOS extensions**
- Compatibility / Interoperability
- Security
- Trade matters

SBAS: Satellite Based Augmentation System
In 2015, Galileo will be facing the challenges of the early phase of service delivery…

★ Gradual service introduction approach

★ Strong interaction with users

★ Need to run early services with continued infrastructure deployment

…and

★ Conduct a service validation campaign

★ Finalize definition of Commercial Service

★ Develop a long term evolution plan for Galileo
Conclusions

- **EGNOS is operational**
  - EGNOS OS since October 2009
  - EGNOS SoL service since March 2011
  - EGNOS Data Access Service since July 2012

- **Galileo is taking off**
  - All procurement contracts awarded
  - First four operational Galileo satellites launched in October 2011 and in October 2012. Deployment being accelerated
  - Early Galileo OS/SAR/PRS services from 2015 (*)

- **International cooperation is key**
  - Ensure compatibility with other GNSS as a minimum, achieve interoperability when desired
  - Support to regional, neighbouring policy
  - Participation to EGNOS require active engagement from non EU countries (at government and civil aviation levels)
  - Horizontal approach to EGNOS agreements

(*) To be confirmed after launch anomaly enquiry
Thanks for your attention

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European Commission

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http://ec.europa.eu/egnos