EGNOS and Galileo services and applications

Carmen Aguilera, Daniel Lopour. Market Development, GSA

Vienna, 8th October 2019
Every aspect of our lives leverage GNSS

**European GNSS helps us move......**

- 80,000 flight delays and 20,000 diversions avoided in Europe
- Galileo saves at least 15M tonnes of CO₂
- At least 3.5 billion litres of fuel saved

**European GNSS helps us work.....**

- 4,500 tonnes of pesticides and 1.5mln tonnes of fertiliser saved
- At least 800mln hours saved for Europe’s consumers and professionals
- Nearly 50,000 annual jobs supported in the downstream GNSS industry in Europe

**European GNSS helps us play.....**

- Tourism made easy
- Cycling, hiking, running
- ... Catching Pokemons!

**Examples**

Source: GSA EGNSS CBA – timeframe 2015-2025
Integrated approach towards EGNSS adoption

At all levels of the value chain

**Market & User Knowledge**
- Market and technology monitoring and forecasting (i.e. market and tech reports)
- User and industry consultations (i.e. user consultation platform, receiver workshops)
- User satisfaction monitoring (i.e. EGNOS and Galileo surveys)

**Demand Support**
- Definition of roadmaps with key stakeholders
- Cooperation with receivers and apps developers
- Technical support to EC to ensure EGNSS use in regulated applications

**Offer Creation**
- Creation of new “made in Europe” products and services

For each market segments

Bodies influencing the market
Navigation Signal Providers
Chipset, receiver
Devices
Content & applications
Service providers
EGNOS SoL Service coverage – SDD 3.3
Galileo is the European GNSS offering a wide range of services

- **Open Service (OS)**: Galileo open and free of charge service set up for positioning and timing services.
- **High Accuracy Service (HAS)**: A service complementing the OS by providing an additional navigation signal and added-value services in a different frequency band. The HAS signal can be encrypted in order to control the access to the Galileo HAS services.
- **Search and Rescue Service (SAR)**: Europe’s contribution to COSPAS-SARSAT, an international satellite-based search and rescue distress alert detection system.
- **Public Regulated Service (PRS)**: Service restricted to government-authorised users, for sensitive applications that require a high level of service continuity.
Galileo and EGNOS differentiators enable innovative applications. Examples

- **Dual frequency, with E5 as second frequency**
  - E5 especially effective in urban areas, bringing new levels of accuracy (sub-meter level) and robustness. Now available in smartphones (see Xiaomi Mi8) and automotive

- **Authentication**
  - **Data level:** Open Service Navigation Message Authentication (OSNMA)
    
    Integrated in the E1-B band for OS. Aimed at mass market users and offered for free. Already prototyped and under testing.
  
  - **Range level:** Signal Authentication
    
    Based on the E6-C Spreading Code Encryption to protect against more sophisticated attacks.

- **High Accuracy Service (HAS)**
  - Provision of PPP corrections via E6B (and terrestrial link tbc), offering high accuracy (decimeter level) for mass market and professional users
  
  - FREE provision of service
72% of EU tolled roads are GNSS-based.

- Regulated applications: eCall and Digital Tachograph regulations leveraging EGNSS
- Galileo recognized by the IMO as a “World Wide Radio Navigation System” for the use in regulated domains
- >630 EGNOS based approach procedures in 360 airports in 19 EU countries
- 60 drone receiver models with EGNOS/Galileo available in the market
- 72% of EU tolled roads are GNSS-based.
- Regulated applications: eCall and Digital Tachograph regulations leveraging EGNSS

+600 M smartphones with Galileo (major high level brands including Apple, Samsung, …)
- 1 billion users

Increasing interest towards Galileo by critical infrastructures owners

50% of GNSS receivers are Galileo capable
EGNOS within 85% of farmers using GNSS

>50% of RTK network providers upgraded or being upgrading to Galileo
Galileo is used today on majority of professional devices and consumer platforms

<table>
<thead>
<tr>
<th>Chipsets adoption</th>
<th>Devices</th>
<th>Applications &amp; Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Chipsets adoption" /></td>
<td>More than 750 millions phones use Galileo now! First dual frequency smartphone launched in May 2018</td>
<td>GSA hackathons organised to develop Galileo-based applications for smartphones</td>
</tr>
<tr>
<td><strong>LBS</strong></td>
<td><img src="image" alt="LBS devices" /></td>
<td><strong>IoT</strong></td>
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<tr>
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<td><img src="image" alt="IoT solutions" /></td>
</tr>
</tbody>
</table>
Aviation
EGNOS approaches for all EU airports and airspace users

December 2013
117 EGNOS procedures at 66 airports

Today
647 EGNOS procedures at 337 airports

By 2024
All airports with EGNOS approaches

Dedicated funding
22 M€

Cost Benefit Analysis

Regulation
Airbus

**Customer Option in A350**
Available since EIS

**Baseline in A220**
48 units in service in EU;
83 orders
Under development
**A319/20/21** (Q2 2020)
>1700 in-service in EU
à 5,700 NEO worldwide orders

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Boeing

**B777X**
Customer option. Available by EIS (mid-2020)
325 orders

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Embraer

**ERJ-135/140/145**
Customer Option

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ATR 42, 72

**-600 series**
Customer Option, STC developed

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Boeing

**737MAX**
Customer option (Q3 2020)
à 4,600 orders

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Embraer

**E-170/175/190/195**
Customer Option, STC developed

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Bombardier

**Q series / CRJ**
Customer Options

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+ STCs for Avro RJ85/100
+ STCs for Fokker 50
+ Baseline in most business jets: Cessna Citation, Dassault Falcon, Gulfstream G’s, Bombardier Globals, Challengers...

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Boom of EGNOS solutions coming to the market
EGNOS and Galileo enable safe drone operations

- **Availability**
- **Accuracy**
- **Integrity**
- **Security**

Airbus commercial parcel delivery drone
Skyways

Lillium air taxi

Galileo already present in more than 27% of receiver models suitable for UAV integration
Maritime
Maritime

Navigation
- SOLAS/Non-SOLAS vessels
- Inland Waterways (IWW)

Positioning
- Search and Rescue (SAR)
- Traffic management and surveillance
- Port Operations
- Marine Engineering

Navigation and SAR are the applications with more GNSS Rx Shipments
- GNSS is the primary means of obtaining PNT information at sea.
- SAR beacon manufacturers are ready for the Return Link Service.
EGNOS in Maritime and Inland Waterways: EGNOS contributes to resilient PNT, by providing a source of differential corrections

- IALA, with GSA contribution, published Guidelines for the use of SBAS as a source of differential corrections in IALA beacons and AIS stations to provide a DGNSS service.
  - 6 Countries have implemented this solution
  - All SOLAS vessels in their waters can benefit from this service, with an IALA beacon Rx or a AIS Rx on board
  - Pilot Project website → egnosforaton.eu

- 90% of manufacturers have a SBAS-enabled product
- 85% of GNSS receivers are EGNOS enabled (not following specific standard for the use of integrity)
EGNOS as an enabler of resilient navigation: a stepwise approach

EGNOS complementing Differential GNSS shore infrastructure for inland and coastal waters (L1/2019)

EGNOS complementing Differential GNSS infrastructure providing integrity information for inland and coastal waters (compliant with IMO Res. A1046)
- Successful test campaign in Norway
- Ongoing test campaign in Finland

EGNOS enabled in shipborne receivers’ models with integrity (L1/2022)
- SBAS Guidelines for shipborne receivers including tests specifications acknowledged by manufacturers and maritime authorities at RTCM.
- Ongoing proposal for standardization at IEC
- Kongsberg is implementing the guidelines in 2 commercial receivers

DFMC SBAS enabling safety of life applications and maneuvering in ports
Galileo support to Navigation

- Galileo contributes to resilient PNT in a multiconstellation approach
  
  ✓ Galileo is recognised by IMO as part of the World Wide Radionavigation System, which allows its use in merchant shipping.

  ✓ Galileo is available in 15% of receivers following a multiconstellation implementation with GPS at least. Most of them non-SOLAS.

  ✓ IMO performance standards for SOLAS vessels Rx are published

  ✓ IEC test standards for type approval for SOLAS vessels Rx are published

  ✓ Testing Campaign with JRC with 5 manufacturers on-going to verify their readiness to get the type approval following IEC tests.

- Galileo support to resilient navigation: Galileo shipborne receivers with authentication (DF/2023)
Rail
E-GNSS value proposition for rail applications

<table>
<thead>
<tr>
<th>Low traffic lines</th>
<th>Main lines</th>
<th>Safety relevant applications</th>
<th>Non-safety relevant applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Combination of E-GNSS with sensors for precise train positioning for use within ETCS Level 2 and Level 3 or with conventional communication technologies for other, non-safety relevant applications.</td>
<td>Improve monitoring of the railway assets both for operators and infrastructure managers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improve safety and reduce the cost of signalling (requires very few or no lineside infrastructure components)</td>
<td>Improve the availability and accuracy of vehicle tracking</td>
</tr>
</tbody>
</table>
|                   |            | Reduce the number of physical balises and to improve the odometry accuracy | Improve availability of the supply chain visibility information to the LSP/LSC:  
  - Georeferenced cargo status monitoring  
  - Corridoring  
  - Geofencing |
|                   |            |                                                                          | Improve accuracy and availability of positioning for on board passenger information systems |
Galileo ramping up in traffic/asset management applications

- **250 TGV units** equipped by January 2019 in France with Galileo enabled receivers
- E-GNSS already supports SNCF passenger information traffic management within daily operations
- It is foreseen that the same system will be rolled out also beyond the core TGV high-speed network, reaching out to the main and low density lines
...and also in cargo tracking/logistics solutions

- **DB Cargo AG rail car fleet will be equipped** with smart sensors tracking on a continuous basis the rail car location and provide additional information about the load conditions.

- **Galileo enabled chipsets will be used** to support the localization function of the telematics solution provided, improving availability and accuracy of the solution.

- **Siemens Mobility AG** as supplier of the solution confirmed this to be so far the largest order for digitalization of rail car fleet (>30 000 Galileo enabled receivers already provided).

- Other providers like RailCargo Austria with approximately 13 000 wagons or wagonkeepers like TWR, VTG etc follow with Galileo functionality ready for the FOC.
GNSS enabled cargo tracking overview

- **DB Cargo**
  - 68,000 smart cars
  - Siemens CTmobile positioning sensor powered by GALILEO+GPS

- **VTG**
  - 80,000 smart cars
  - nexxiot positioning sensor compatible with GALILEO+GPS+GLONASS

- **SBB Cargo**
  - 750 smart cars
  - SAVVY FleetTrac positioning sensor powered by GPS+EGNOS

- **HUPAC**
  - 1,000 smart cars
  - nexxiot positioning sensor powered by GALILEO+GPS

- **Rail Cargo Group**
  - 13,700 smart cars
  - SmartCargo positioning sensor powered by GALILEO+GPS

- **ScandFibre**
  - 7,500 smart cars
  - SAVVY CargoTrac positioning sensor powered by GPS+EGNOS

- **ASTO Compact**
  - 750 smart cars
  - TRAXENS-BOX positioning sensor powered by GPS

- **SASOL**
  - 1,000 smart cars
  - SAVVY FleetTrac positioning sensor powered by GPS+EGNOS

- **SnCF**
  - 13,700 smart cars
  - SmartCargo positioning sensor powered by GALILEO+GPS
In rail signalling applications, the common objectives shared between GSA and Shift2Rail are to:

To coordinate the R&D and associated stakeholder initiatives leading towards inclusion of European GNSS within ERTMS achieving:

- end user satisfaction by providing the best possible, fully interoperable and stable solution
- overall reduction of ERTMS capital and operational expenditures
- improvement of flexibility and attractiveness of ERTMS for users in Europe and abroad
GSA User Consultation platform 2017/2018

Ongoing

Launched in August 2019

Rail receiver R&D planned (Galileo grants plan 2018)

Certification process for the Pinerolo/Sangone line opened within the H2020 ERSAT GGC project

2018

2019

2020

THE EUROPEAN GNSS AGENCY IS WORKING TOGETHER WITH RAIL AND SPACE INDUSTRY STAKEHOLDERS TO ENABLE THE USE OF SATELLITE-BASED POSITIONING FOR RAILWAY SIGNALLING

At the heart of this multi-stakeholder initiative lies the European Train Control System (ETCS), which is now being adopted both in Europe and beyond, as one of the components of the European Rail Traffic Management System (ERTMS). As projects in ETCS, the positioning of the train is based on “beacons”, a physical element mounted at specific intervals along the railway track. The goal is to ensure that, wherever possible, the physical beacon can be replaced by virtual ones, based on precise, GNSS-based positioning without any operational or safety implications on the ETCS. The roadmap below the main projects currently running and planned, as well as the involvement of the various stakeholders interested in achieving the objective of E-GNSS enabled ETCS together with the GSA.
European R&D on GNSS in rail signalling – fully synchronised
Public Transport
GNSS applications in public transport

**ITS: Fleet management**
Provides a clear overview of all buses and where they are located throughout the city/bus routes.

**ITS: Passenger information**
Provides real-time information to the passengers concerning the transport location and the estimated time of arrival at designated stops.

**Driver advisory systems**
Provides real-time information to the driver regarding the external and/or internal conditions of the vehicle to facilitate the decision-making regarding the optimal driving control of the vehicle.

**Traffic signal prioritization**
The system provides public transportation with green lights in order to keep the operations/traffic smooth-running and according to the schedule.

**In-vehicle signage**
A static or dynamic sign information is displayed to the driver without infrastructure interaction, just taking into account the localization and direction of the vehicle.

**Floating vehicle data**
Collection of localization, speed and time information produced by the vehicle’s onboard devices to be used by service providers and infrastructure operators to produce traffic information.

**GNSS application tasks**
- Coordination of public transport fleet/traffic
- Provision of passenger information
- Gas emission reduction
- Scheduling and optimization of passenger travel
- React to real-time information
E-GNSS value proposition for public transport applications

• Thanks to its **superior performance in urban environments** (improved accuracy, faster positioning fix) EGNSS fulfils urban transport requirements

• Being **interoperable and compatible** with GPS and most other technologies, EGNSS can be seamlessly integrated into the foreseen service offering

• Multi-constellation, EGNSS-enabled receivers (to be used on board buses, trams, cars, bicycles) are widely available in the market for **no or marginal extra cost**
Measurement campaign recently conducted by Faculty of electrical engineering - CTU in Prague

Importance of field testing:

Most important is the **continuous availability** of a **sufficiently accurate** positioning under **typical operating conditions**.

- Actual performance is never found in literature.
- Lab testing cannot cover all aspects. Vehicle characteristics and environmental aspects affect the performance.
- The goal is to find the simplest and the most cost-effective solution for the particular problem.
- Results provide a sample of real operation performance.
Operational conditions are key influencing factor for GNSS success in urban conditions

Performance:

<table>
<thead>
<tr>
<th>In the receiver datasheet:</th>
<th>In the public transport:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Open sky conditions</td>
<td>• Obstructed sky:</td>
</tr>
<tr>
<td></td>
<td>• Not enough satellites</td>
</tr>
<tr>
<td></td>
<td>• Multipath errors</td>
</tr>
<tr>
<td>• Stationary receiver</td>
<td>• Moving receiver</td>
</tr>
<tr>
<td>• No interference</td>
<td>• Vulnerable to interference</td>
</tr>
<tr>
<td></td>
<td>• Interference from vehicle systems</td>
</tr>
<tr>
<td>• Accuracy mostly specified as CEP (50% is worse than the specified value)</td>
<td>• Jamming (illegal, but possible)</td>
</tr>
<tr>
<td></td>
<td>• At least 95% confidence of the information is required</td>
</tr>
</tbody>
</table>
Multi-constellation combined with IMU provided so far best results fit for purpose

Performance in dense urban area

GPS+Galileo
L1/E1
Without IMU
89.2% availability
4.3 m accuracy

GPS+Galileo
L1/E1+L2/E5b
Without IMU
95% availability
6.1 m accuracy

GPS+Galileo
L1/E1+L2/E5b
With IMU
100% availability
2.3 m accuracy
How to improve applications performance within public transport

Public transport operators need to ask from the solution providers:

- Multi-constellation receivers supporting GPS L1 and Galileo E1 as a minimum to achieve improvements in positioning availability and accuracy
- **Dual frequency support GPS+Galileo L1/E1/L5/E5** (optional - in case of need for further improvement of positioning accuracy, especially with regards to multipath)
- **SBAS L1: EGNOS** in case of increased requirements towards positioning integrity and accuracy

- Tailored position paper from GSA available for public transport authorities and operators
- Possibility of consultations with GNSS experts
Road
Galileo is used today in the majority of professional devices and consumer platforms.

**Commercial vehicles**

72% from the EU total tolled roads (+79,000 Km) correspond to a GNSS-based scheme.

**EU Regulations**

- Smart Tachograph regulation mandates EGNOS and Galileo to control driving time *from Jun. 2019*
- Updated EETS Directive mandates EGNOS and Galileo in free-flow tolling using satellite positioning in EU *from Oct. 2021*
  - 1.48 Million EGNOS (71% of total GNSS)
  - 1.28 Million Galileo (62% of total GNSS)

**Passenger cars**

Soon: Bulgaria, Czech Republic, Sweden, Greece, Poland...

eCall regulation (EU) mandates EGNOS and Galileo in every new type of car/van sold in Europe *from Apr. 2018*

- 3 Million vehicles (end-2019)
- 18 car brands, +25 models

Soon: Galileo being tested in 25 Autonomous Vehicle’s prototypes worldwide.
Galileo new features are crucial for Autonomous Driving

- GNSS is crucial to get decimetre/centimetre-level absolute location and timing synchronization in combination with inertial navigation, odometry, HD maps, Machine-Learning and Artificial Intelligence.

  **High Accuracy service** will bring a decimeter level error (≈20cm):
  - based on the Galileo E6b signal

- Authentication service will detect interference (spoofing) attacks:
  - Galileo E1 Navigation Message Authentication
  - Galileo E6 Spreading Code Authentication

- The UN World Forum for automotive regulations declared the need of clear cybersecurity rules, and GNSS authenticated messages are recommended.

BMW and General Motors/Cadillac autonomous vehicles models expected in 2021 will be Galileo compatible

... and the key European car makers (Mercedes-Benz, Fiat-Chrysler, Scania, Renault, Volkswagen, Volvo...) confirmed the interest to test the Galileo High Accuracy and Authentication once available
Horizon 2020
Framework Programme for Research & Innovation

Source: www.visionaryadvertising.co.uk
## New Call: EGNSS market uptake 2020  
H2020-SPACE-EGNSS-2020

<table>
<thead>
<tr>
<th>Type of Action</th>
<th>Topic</th>
<th>Indicative budget (EUR mln)</th>
<th>Funding rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>EGNSS applications fostering green, safe and smart mobility</td>
<td>10</td>
<td>70% (except for non-profit legal entities, where a rate of 100% applies)</td>
</tr>
<tr>
<td>IA</td>
<td>EGNSS applications fostering digitisation</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>EGNSS applications fostering societal resilience and protecting the environment</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PCP</td>
<td>EGNSS applications for public authorities’ pilot</td>
<td>3</td>
<td>90%</td>
</tr>
</tbody>
</table>

**Overall ind. budget: 21 mln EUR**

**Opening:** 05 November 2019  
**Deadline:** 05 March 2020

IA: activities aimed at producing plans and arrangements or designs for new, altered or improved products, processes or services  
PCP: Pre-Commercial Procurement actions aim to encourage public procurement of research, development and validation of new solutions that can bring significant quality and efficiency improvements in areas of public interest, whilst opening market opportunities for industry and researchers active in Europe. It provides EU funding for a group of procurers ('buyers group') to undertake together one joint PCP procurement, so that there is one joint call for tender, one joint evaluation of offers, and a lead procurer3 awarding the R&D service contracts in the name and on behalf of the buyers group.
LC-SPACE-EGNSS-1-2019-2020: EGNSS applications fostering green, safe and smart mobility

Scope: Proposals should contribute to efficient, climate and environmentally friendly transport that will be safe and seamless for all citizens.

Aviation
- Advanced navigation
- CNS
- Air Traffic Management
- Unmanned vehicles

Road
- Connected and autonomous vehicles
- eCall
- Cooperative ITS
- Mobility as a Service

Maritime
- Vessel navigation & Traffic Management
- Port operations
- Fisheries
- Autonomous vessels

Rail
- Train signalling/control
- Passenger-crew services
- Autonomous trains
- Multimodal logistics

Innovation Action
Project Indicative funding: 1 to 3 MEur - Total 10 MEur
Previous projects: have a look on GSA Web Site
Linking space to user needs

Get in touch:

www.GSA.europa.eu

EGNOS-portal.eu  GALILEO  GSC-europa.eu  UseGalileo.eu

The European GNSS Agency is hiring!

Apply today and help shape the future of satellite navigation!