



European
Global Navigation
Satellite Systems
Agency

Webinar “Galileo for Surveying”



NAVIGATION SOLUTIONS
POWERED BY EUROPE

Reinhard Blasi and Alina Hriscu
Market Development
European GNSS Agency (GSA)

10 September 2018

Agenda



GSA: Who we are and what we do



European GNSS: State of Play



Market and Technology Trends



E-GNSS for Surveying and Mapping



R&D and Funding Opportunities

Agenda



GSA: Who we are and what we do



European GNSS: State of Play



Market and Technology Trends

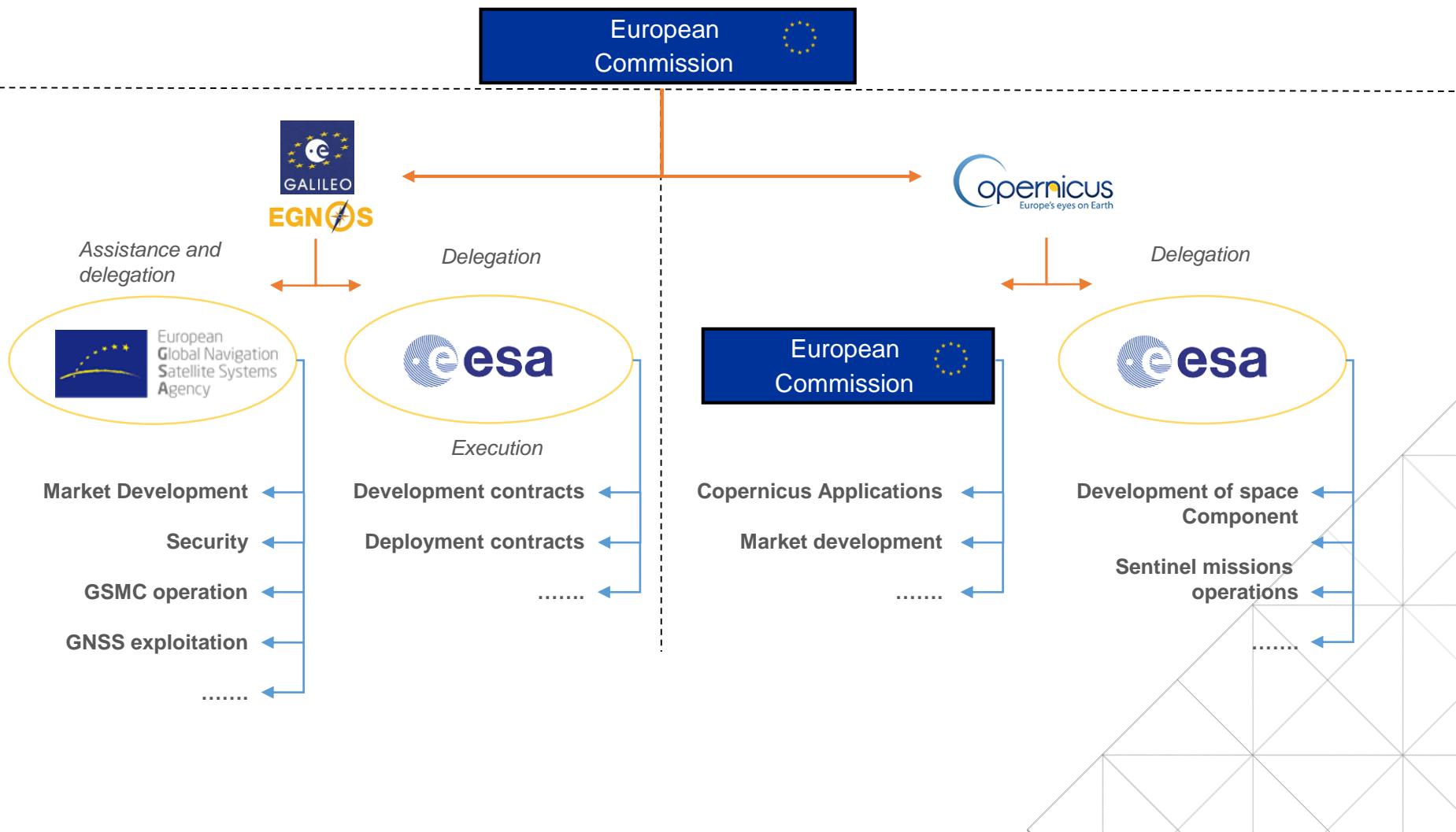


E-GNSS for Surveying and Mapping



R&D and Funding Opportunities

European Commission is the owner of EGNOS / Galileo and Copernicus programmes



The European GNSS Agency (GSA) is responsible for market development and management of Galileo and EGNOS

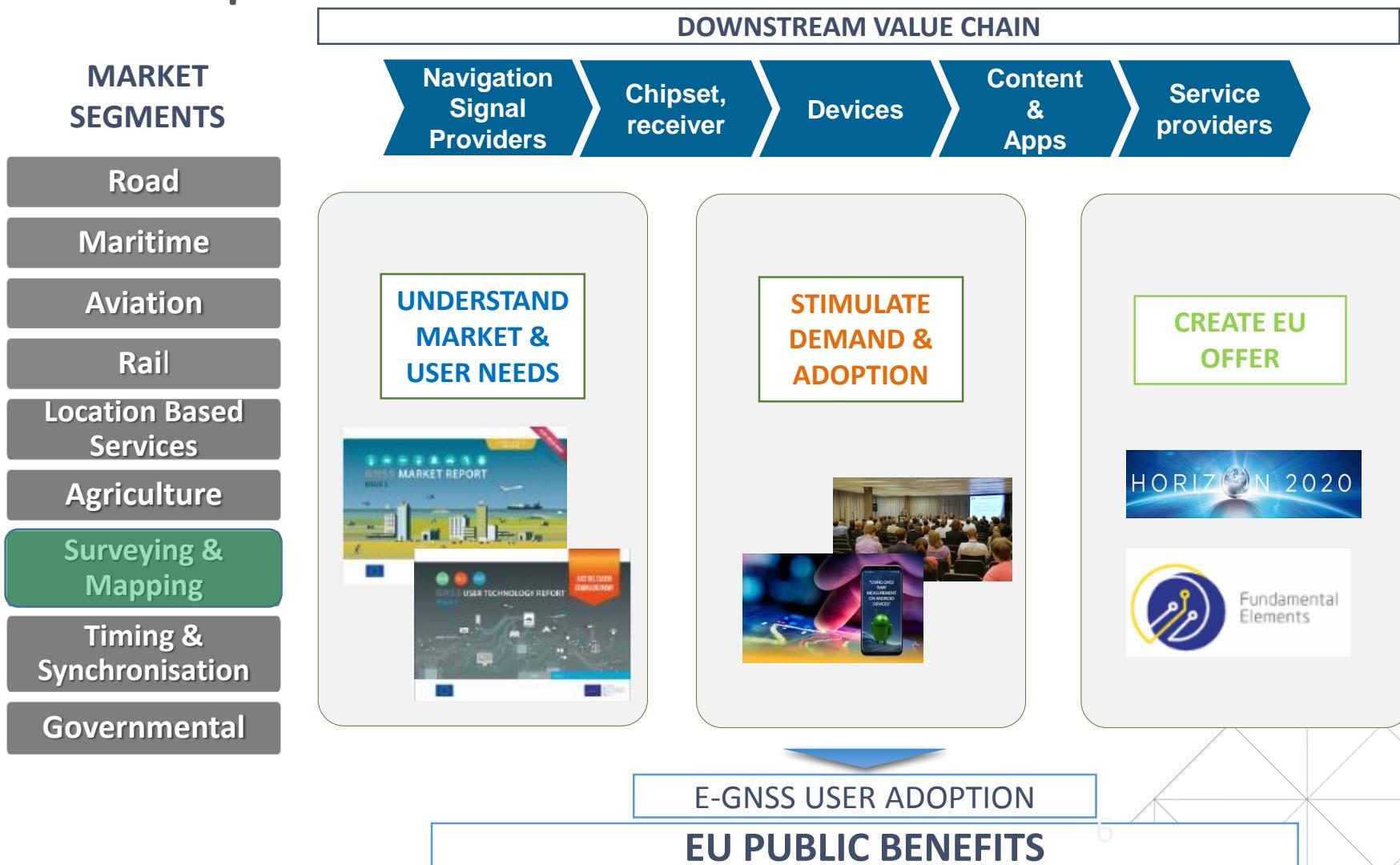


160
Staff

21
Nationalities

Prague, CZ Rep – HQ
St. Germain en Laye, FR – GSNC
Swanwick, UK – GSNC
Torrejon, ES – GSC
Noordwijk, NL – GRC
Toulouse, FR – EGNOS

GSA's role: Understand the users and market, stimulate the demand, create a competitive EU offer



Agenda



GSA: Who we are and what we do



European GNSS: State of Play



Market and Technology Trends



E-GNSS for Surveying and Mapping



R&D and Funding Opportunities

Galileo deployment is progressing



| 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|--|------|------|------|------|---|------|------|------|------|
| From Baïkonour | | | | | From Kourou | | | | |
|  "GIOVE-A"  "GIOVE-B" | | | | |  1-2  3-4  5-6 | | | | |

4 Galileo satellites successfully launched on a customized Ariane 5 on 25/07, 2018



2015 2016 2017 2018 2019 2020/21

9-10 11-12 13-14 15-16 17-18

19-20 21-22

23-24 25-26

27-28

29-30

31-32

26 satellites already launched
more satellites already bought

Galileo Initial Services

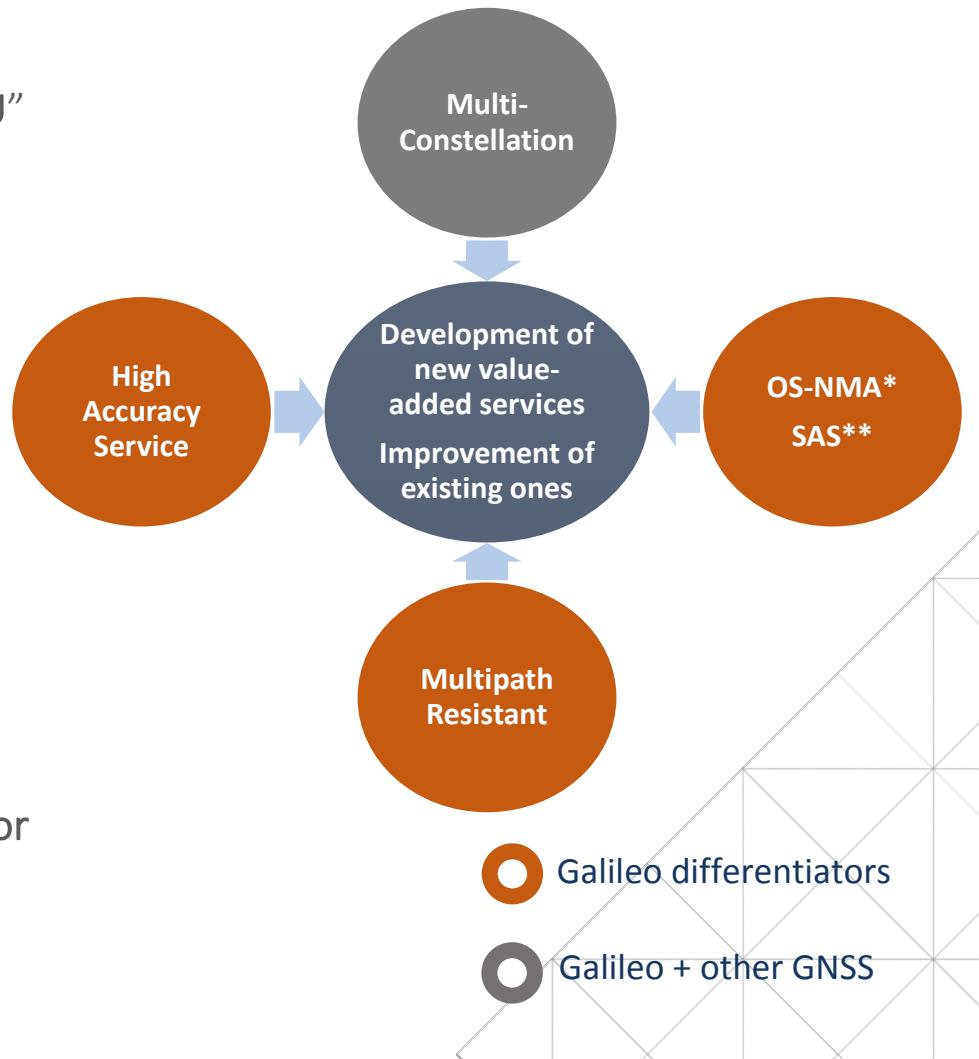
**26 satellites already launched,
more satellites already bought and
under preparation**



Galileo is the European GNSS under civilian control, delivering unique features



- Worldwide navigation system “made in EU”
- Only constellation under civilian control
- Fully compatible with other GNSS constellations
- Open service free of charge, delivering multiple frequencies
- Only constellation that provide Signal authentication providing trustability for civilians and global high-accuracy service for free



*Open Service Navigation Message Authentication

**Signal Authentication Service

Galileo is used today on the majority of professional devices and increasingly many consumer platforms



ENGLISH (EN)

USEGALILEO.EU

FIND A GALILEO-ENABLED DEVICE TO USE TODAY

Galileo is Europe's Global Satellite Navigation System (GNSS), providing users with improved positioning and timing information.

Click on the icons to find Galileo-enabled devices.

| ON THE ROAD | ON THE WATER | ON THE TRAIN | IN THE AIR |
|--------------|--------------|--------------|---------------------|
| | | | |
| GOING MOBILE | ON THE FARM | ON THE MAP | DURING AN EMERGENCY |
| | | | |



The European GNSS Service Centre provides a single and unique interface with the users



GSC Nucleus

- Web portal
- Information on:
 - system status
 - almanacs
 - and user notifications
- Electronic Library
 - Iono Doc, OS SIS OSD, OS SIS ICD, future SDD
- Helpdesk:
 - User queries
 - Galileo incident reporting
- EGNSS Dissemination Platform
- User surveys
- Galileo performance reports

The screenshot displays the European GNSS Service Centre website. At the top, there is a navigation bar with links for 'GALILEO & GSC OVERVIEW', 'GNSS MARKET & APPLICATIONS', 'SYSTEM STATUS', 'ELECTRONIC LIBRARY', 'SUPPORT TO DEVELOPERS', 'MULTIMEDIA & NEWS', and a search icon. Below the navigation bar, there are three main sections: 'GALILEO HELP DESK' (with a sub-link 'OUR EXPERTS WILL PROVIDE ANSWERS TO YOUR QUESTIONS ABOUT GALILEO'), 'GALILEO SYSTEM STATUS' (with a sub-link 'CLICK FOR SATELLITE INFORMATION AND NOTIFICATIONS'), and 'GALILEO INCIDENT REPORT' (with a sub-link 'REPORT YOUR INCIDENT HERE'). The central part of the page features a large image of a satellite in space and two brochures titled 'How is Galileo performing?' and 'Galileo Incident Report'. Below this, there are two smaller sections: 'SUBSCRIPTION' (with 'REGISTER' and 'LOGIN' buttons) and a banner for 'www.usegalileo.eu' showing a computer monitor displaying the website. At the bottom, there is a 'Latest news' section with two articles: 'Agriculture a key beneficiary of EU' and 'Agriculture and Space Day: Space technology...'. The EGNOS logo is also visible in the bottom right corner.

Galileo Open Service outperforming Minimum Performance Level (MPL) targets



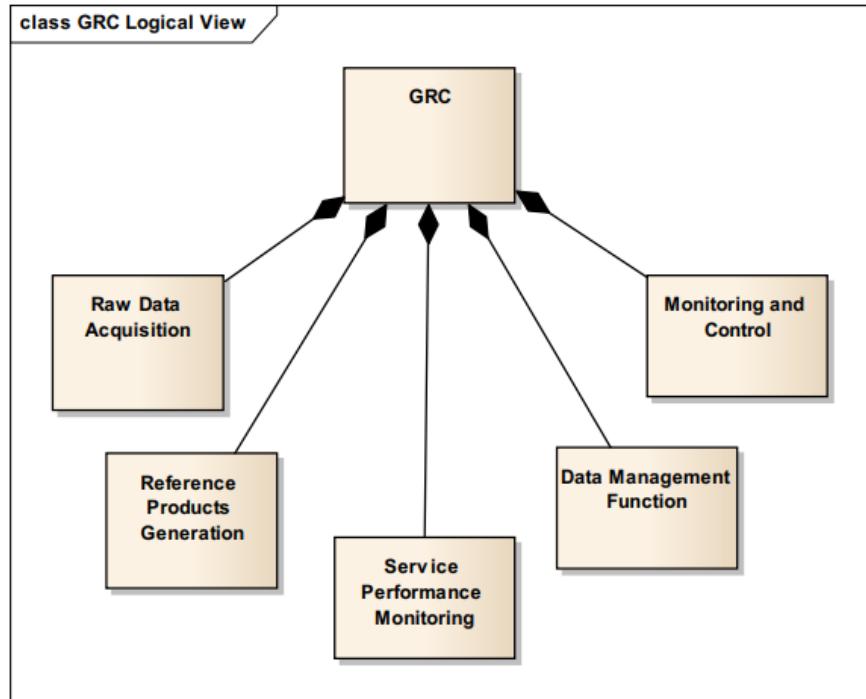
| Definition | Committed Target | March 2018 |
|--|-----------------------|------------|
| Ranging accuracy Dual Frequency (95%) | Worst Satellite month | < 7.0 m |
| | Constellation average | < 2.0 m |
| Ranging accuracy (Single Frequency (95%) | Worst Satellite month | < 7.0 m |
| | Constellation average | < 2.0 m |
| Availability of Dual Frequency Ranging (global average) | > 87% | 100% |
| Per Satellite Availability of Signal in Space (monthly, OS, global average, healthy SF/DF) | > 87% | >98.75% |
| UTC Time dissemination uncertainty (DF, 95% over campaign period) | < 30 ns | 5.5 ns |
| Availability of UTC dissemination | > 87% | 100% |
| GST - GPS time offset uncertainty (95% over campaign period) | < 20 ns | 5.6 ns |
| GST - GPS time offset availability (over campaign period) | > 80% | 98.75% |

The Galileo Reference Centre (GRC) performs independent monitoring and assessment of service provision



- Perform independent monitoring and assessment of service provision
- When feasible, assess the compatibility and interoperability between Galileo and other GNSS
- Provide service performance expertise to Programme
- Support investigations of service performance and service degradations
- Archive service performance data over nominal operational lifetime of system
- Integrate data and products from EU Member States, Norway and Switzerland (MS)

GRC Architecture and Operational Concept



Member States contribute to GRC



Core Facility

- Situated in the Netherlands
- Stand-alone capabilities

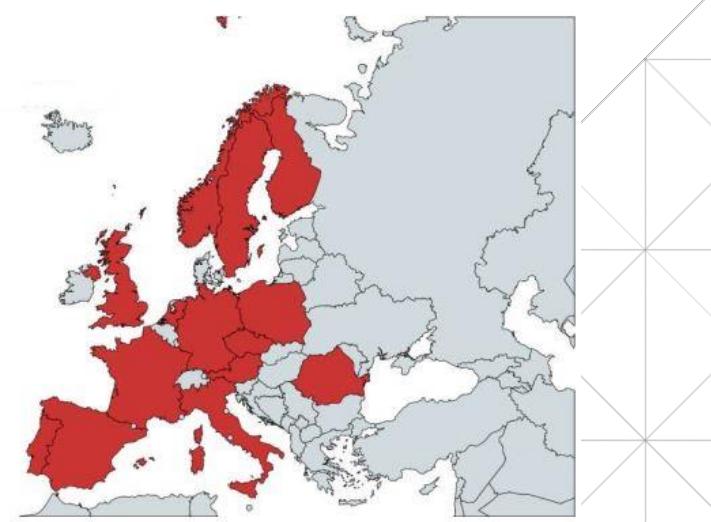


MS Contributions

- Data
- Products
- Expertise

23 organisations from 14 countries

- Worldwide network of reference stations
- Reference products
- Timing labs
- Radio telescopes
- Laser ranging
- Vehicles, vessels and airplanes



User Requirements discussed with industry leaders, users and experts to shape the future of Galileo Services



User driven E-GNSS

- The interaction with users is essential for the success of E-GNSS
- User needs drive E-GNSS
- During the UCP all available knowledge on user needs shared

User Requirement Document to be published for public in 2018



Next UCP:
Marseille,
December
2018

<https://www.euspaceweek.eu/>



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GSA: Who we are and what we do



European GNSS: State of Play



Market and Technology Trends

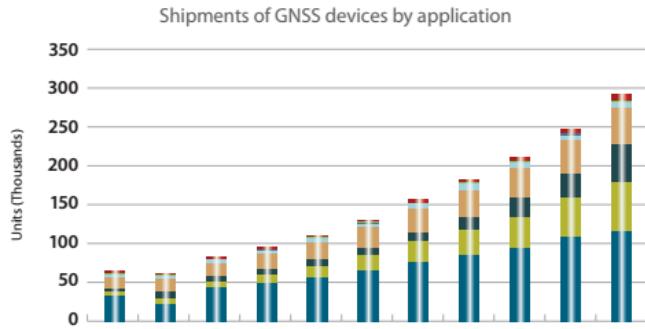


E-GNSS for Surveying and Mapping

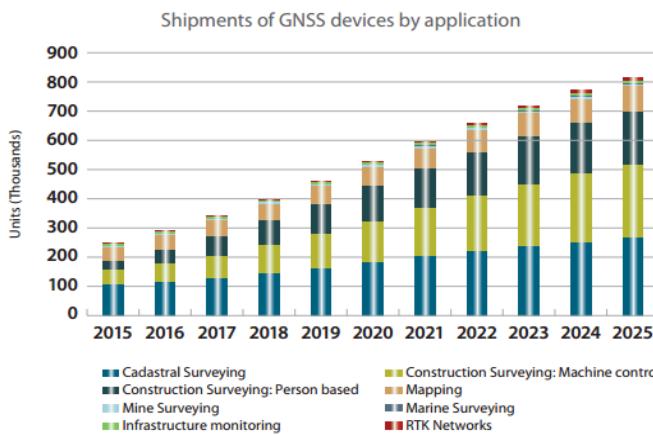


R&D and Funding Opportunities

Construction, mapping and cadastral industries stimulated growth in shipments of GNSS surveying equipment



Surveying, Mapping and Construction (both person-based and machine control), accounted for **95% of the shipments of GNSS devices in high precision market in 2016**



In the coming decade, the total **amount of shipments** is expected to reach 815,000 units worldwide, representing **almost a 4-fold increase over 2015**

The surveying segment benefits largely from the modernisation of the GNSS Signal Structure and Chipset Design



- Evolution of GNSS methods and services utilising multi-constellations and multi-frequency capability
- Benefits from optimised receiver features
- Enhanced multi-sensor integration
- Synergies between GNSS and EO (Copernicus)
- Prices go down
- UAV penetration into mapping



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- Embedding the full GNSS frequency spectrum
- This trend significantly benefits, e.g., TCAR* and extra-wide laneing algorithms for faster TTFF (RTK), faster convergence (PPP), and better elimination of ionosphere refraction.



* TCAR (Three-Carrier Ambiguity Resolution)

** Precise Point Positioning

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- 400-500 channels for a single chipset
- Provide connection to a single antenna, dual antennas for heading, or dual antennas + INS for full 3D positioning in dynamic or constrained environments
- • Copernicus: provides frequent and global images of land and its evolution (e.g., land fill and usage, urban areas, change detection)
- • EGNSS: precise guidance to specific areas, location geo-tagging
- User-friendly web interface with cloud connectivity



* TCAR (Three-Carrier Ambiguity Resolution)

** Precise Point Positioning

The surveying segment benefits largely from the modernisation of the GNSS Signal Structure and Chipset Design



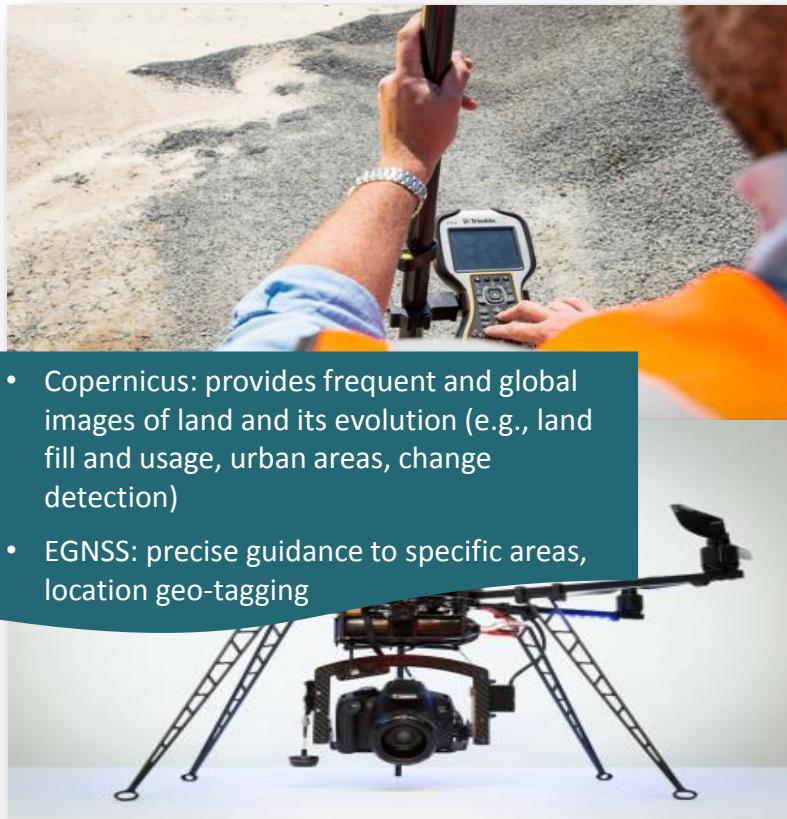
- Evolution of GNSS methods and services utilising multi-constellations and multi-frequency capability
- Benefits from optimised receiver features
- Enhanced multi-sensor integration →
 - LIDAR, robotics, mobile mapping, INS, etc.
- Synergies between GNSS and EO (Copernicus)
- Prices go down
- UAV penetration into mapping



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- Evolution of GNSS methods and services utilising multi-constellations and multi-frequency capability
- Benefits from optimised receiver features
- Enhanced multi-sensor integration
- Synergies between GNSS and EO (Copernicus)
- Prices go down 
 - The quality/price ratio of the receivers is continuously improving.
 - Also, RTK/PPP services prices go down, sometimes for NO or very low fee
- UAV penetration into



* TCAR (Three-Carrier Ambiguity Resolution)

** Precise Point Positioning

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- Evolution of GNSS methods and services utilising multi-constellations and multi-frequency capability
- Benefits from optimised receiver features
- Enhanced multi-sensor integration
- Synergies between GNSS and EO (Copernicus)
- Prices go down
- UAV penetration into mapping →



- Drones provide aerial imagery/LIDAR data used for precise mapping, serve as a replacement for 2D/3D measurement tools

* TCAR (Three-Carrier Ambiguity Resolution)

** Precise Point Positioning

GNSS-Copernicus synergies (1/3)



Environmental management

Environmental management

- Land use, soil moisture, vegetation state including forests, water quality and quantity for both rivers and lakes, snow cover, land carbon



- Precise guidance to specific areas of interest, geo-location tagging
- Additional Galileo-enabled applications (in-situ measurements, e.g., by UAVs)



Support the preservation of environment by facilitating the interventions in areas of interest



GNSS-Copernicus synergies (2/3)



Disaster prevention

Monitoring of land slides

- Frequent, worldwide measurements of land masses displacements
- Detection of vertical displacements

+

E-GNSS antennas and receivers to register temporal interpolation and horizontal displacements

- Monitoring of subsidence, tectonic changes or other environmental hazards
- Supporting early intervention



GNSS-Copernicus synergies (3/3)



Smart Cities

Urban planning & Mobility



- Monitor urban growth
- Urban green areas
- Land use and its evolution
- Detect illegal landfills
- Change detection



- Determine parcels and items such as utilities, infrastructures, etc.
- Understand the mobility habits of citizens (e.g. Traffic Flow Management)



Public authorities and spatial planners enabled to design **smart cities**

- Urban planning
- Define new urban corridors
- Infrastructure & utilities monitoring
- Reinforce the law



A growing potential for high precision solutions delivered through mass market devices



Android 7+ access to raw GNSS measurements



GSA GNSS Raw Measurements Task Force

GSA hosted GNSS Raw Measurements Taskforce Workshop in GSA in Prague on May 30

Dual frequency mass market receivers



- Industry is moving towards dual frequency
 - Increase of accuracy in open environment
 - More robust to multipath in urban scenarios
- Number of SVs broadcasting in the E5/L5 band are growing every year

Democratisation of mapping and affordable augmentation services

- Receiving **orbital & clock corrections** from ground stations, for getting **dm-level precision** and **faster convergence time**



High-precision positioning entering the mass market

Interested to know more? Download GSA GNSS Market and GNSS User Technology reports



GNSS market trends & applications



<https://www.gsa.europa.eu/market/market-report>

GNSS receiver trends & technology



Issue 2 in Q3/2018



<https://www.gsa.europa.eu/european-gnss/gnss-market/2016-gnss-user-technology-report>

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GSA: Who we are and what we do



European GNSS: State of Play



Market and Technology Trends



E-GNSS for Surveying and Mapping



R&D and Funding Opportunities

EGNOS already available serving EU citizens and industry



- Accuracy ~1m, free
- Accuracy ~1m, **compliant to aviation standards** by providing correction data and **integrity**
- Accuracy <1m, **corrections provided via internet**



Open Service (OS)



EGNOS Data Access (EDAS)



Galileo is the European GNSS offering a wide range of services



- Freely accessible service for positioning, timing and navigation message authentication
- Encrypted service designed for greater robustness and higher availability
- Assists locating people in distress and confirms that help is on the way
- Freely accessible high accuracy positioning service
- Authentication service based on the E6 signal code encryption and OS-NMA, allowing for increased robustness of professional applications



Open Service (OS)
OS-Navigation Message Authentication (OS-NMA)

Public Regulated Service (PRS)



Search and Rescue Service (SAR)

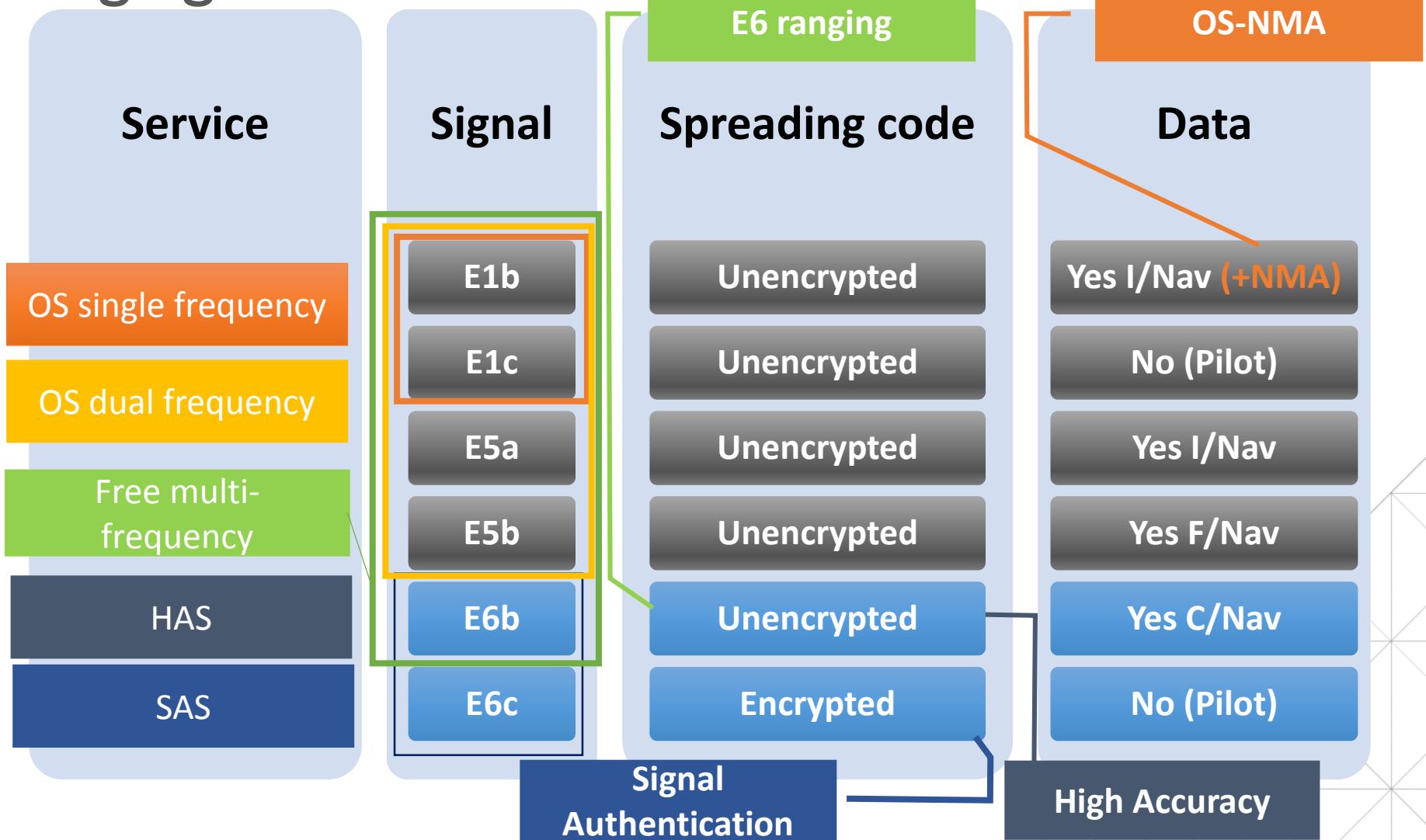
High Accuracy Service (HAS)



Signal Authentication Service (SAS)

Overview of signals

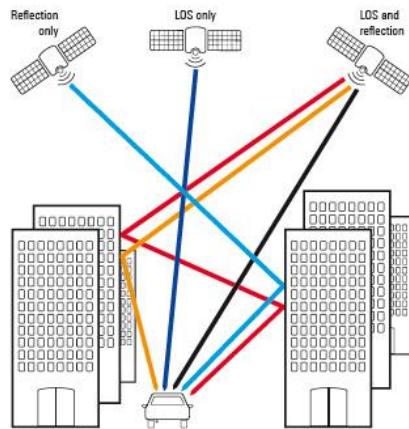
Open service / High Accuracy Service / E6 ranging



Galileo Open Service improves positioning performance for surveyors



Advantages of Galileo Open Service E1/E5/E6 multi-frequency



- **Better results in harsh environment** (urban canyons, tree canopy, etc.) enabled by:
 - ✓ **Easier mitigation of multipath errors** by E5 AltBOC modulation
 - ✓ **Higher SNR** (signal-to-noise ratio)
 - ✓ **Additional satellites** (Galileo + existing constellations)
- **Increased availability, continuity and reliability** of measurements enabled by:
 - ✓ **Additional satellites** (Galileo + existing constellations)
 - ✓ **Improved geometry**
- **Improved convergence time** when integrated in PPP solutions

Choice for 2nd and 3rd GNSS frequency



E5/L5: 2nd Frequency

- E5/L5, a protected frequency
- Shared by all GNSS and SBAS
- More widely separated from L1, thus minimising the iono-free linear combination errors

E6: 3rd Frequency

- E6 High quality open signal (modulation, chipping rate)
- Best frequency for tri-laning
- Multiple signals bring greater reliability and accuracy

Commercial Service goes for FREE



Galileo High Accuracy Service (HAS)

- Around 20cm target accuracy without additional communication channel
- Does not require proximity to base stations to access corrections
- Improved line-of-sight and better coverage at high latitudes
 - All the three due to broadcasting external data in real time across the globe (PPP – Precise Point Positioning) via Galileo E6
- Further reduced convergence time
 - Due to triple frequency
- Full operational capability in 2020+

| | Signal and Data features |
|---------------------------|--|
| Frequency | 1278.75 MHz |
| Signal | E6B |
| Min. Power | -158 dBW |
| Modulation | BPSK(5) |
| Chip Rate | 5.115 Mcps |
| Code Length | 1 ms |
| Symbol Rate | 1000 sps |
| Data Rate | 492 bps |
| HA Data Rate | 448 bps (TBC) |
| Data Coding | FEC, as per Galileo OS SIS ICD, + interleaving 123 x 8 |
| Spreading Code Encryption | No |
| Data Format | TBD, but based on an open ICD. |
| Data (TBC) | Orbit and clock corrections, code and phase biases, SQM, flags, ionospheric information. |

Current status of Galileo in Surveying



Augmentation service providers

- Majority of RTK providers upgraded or have started to upgrade to Galileo Capabilities
- First providers started to transmit full Galileo solution: Galileo enabled network-RTK corrections
 - Pioneers: SWEPOS (SE), GeoSoft (ET), ORPHEON (FR)), Trimble and Leica (HXGN) RTK networks
- The main PPP providers support Galileo corrections



TERRASTAR

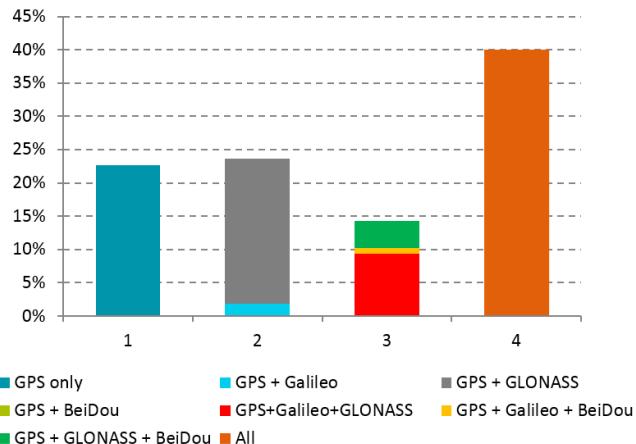


RTX + VRS NOW

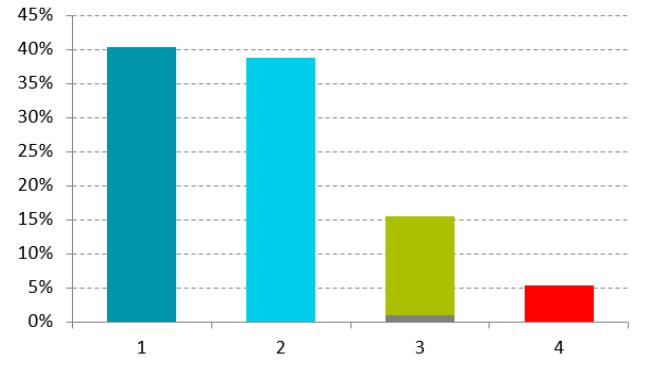


Receiver Capabilities*

Supported constellations by GNSS receivers



Supported frequencies by GNSS receivers



*professional receivers (surveying+agri+timimg)

**<http://gpsworld.com/innovation-instantaneous-centimeter-level-multi-frequency-precise-point-positioning/>

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European GNSS: State of Play



Market and Technology Trends



E-GNSS for Surveying and Mapping



R&D and Funding Opportunities

GSA has been leveraging two main R&D programmes as tools to stimulate the offer and increase E-GNSS adoption



Aims to foster adoption of EGNSS via content and application development and supports the integration of services provided by these programmes into devices and their commercialisation

20 €mln is the budget dedicated to EGNSS applications and products in the 4th H2020 call

The call is divided into four topics :

- ✓ Green, safe and smart mobility
- ✓ Digitisation
- ✓ Societal resilience and environment
- ✓ Awareness raising and capacity building

Opening:
16 October
2018

Deadline:
05 March 2019



Fundamental
Elements

Fundamental Elements projects focus on fostering the development of innovative Galileo- and EGNOS-enabled receivers, antennas and chipsets technologies

FE upcoming opportunities

The call is divided into four topics :

- ✓ Multipurpose Galileo Antenna
- ✓ Advanced Interference detection
- ✓ Filling the gaps in Rx Technologies
- ✓ HAS and SAS user terminal (ex- CS user terminal)
- ✓ Enhanced receiver for autonomous driving/navigation
- ✓ Enhanced GNSS user terminal (including OS-NMA and I-NAV improvements)
- ✓ SoL in rail signalling

GSA has been leveraging two main R&D programmes as tools to stimulate the offer and increase E-GNSS adoption



The banner features a dark blue background with a starry galaxy image. At the top left, the 'HORIZON 2020' logo is visible. On the right, there is a blue circular icon with a yellow keyhole symbol and the word 'Fundamental' next to it. The main title 'Horizon 2020 Space Information Day & Brokerage Event' is centered in large white font. Below the title, the date '11-12 October 2018, European GNSS Agency - Prague' is displayed. At the bottom left, a yellow box lists 'Societal resilience and environment' and 'Awareness raising and capacity building'. At the bottom right, another yellow box lists '(including OS-NMA and I-NAV improvements)' and 'SoL in rail signalling'.

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11-12 October 2018, European GNSS Agency - Prague

- ✓ Societal resilience and environment
- ✓ Awareness raising and capacity building

- (including OS-NMA and I-NAV improvements)
- ✓ SoL in rail signalling

Mapping & Surveying: project examples and success stories



GSA

mapKITE – EGNOS-GPS/GALILEO-based high-resolution terrestrial-aerial sensing system

- Tandem system composed by **UAV** and **Vehicle** equipped with cameras and LiDAR and operating as a virtual kite (the UAV follows the Vehicle by receiving its navigation information), also introducing novel element for images georeferencing - Kinematic Ground Control Points
- Potential game-changer for **operational simplicity and cost savings**

mapKITE is protected by the
Spanish patent, no.
ES239454



GIMS - Geodetic Integrated Monitoring System

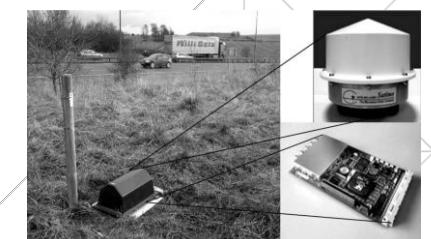
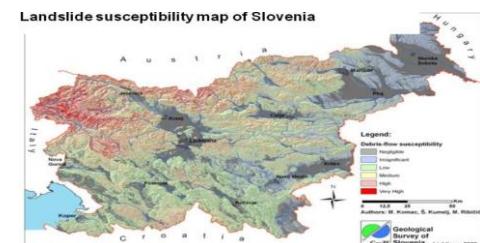
Low-cost system based on EGNSS, Copernicus SAR and other in-situ sensors, for monitoring ground deformations with a focus on landslides and subsidence.



- Vertical displacements (via synthetic aperture radar interferometry InSAR)
- Horizontal displacements
- Temporal interpolation
- Geo-localisation of the in-situ sensors

Features of upcoming products:

- Register deformations with **millimetric level accuracies** and daily acquisition rate
- Real-time alerts in case of sudden movements



GSA supports Young Surveyors



**CLGE Annual Young Surveyors' Prize:
fresh ideas to feed the surveying industry evolution**

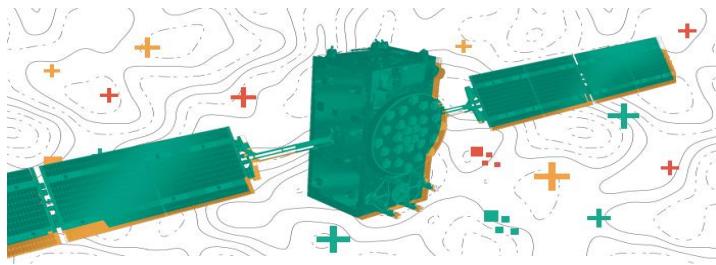


GSA is sponsoring a special prize dedicated to Galileo, EGNOS and Copernicus as part of the annual Council of Geodetic Surveyors' Young Surveyors prize



2017

GSA supports Young Surveyors



YOUNG SURVEYOR'S PRIZE 2018

GSA is sponsoring a special prize dedicated to Galileo, EGNOS and Copernicus as part of the annual Council of Geodetic Surveyors' Young Surveyors prize

CLGE Annual Young Surveyors' Prize:
fresh ideas to feed the surveying industry evolution



2018 edition winners to be awarded at Intergeo 2018 in Frankfurt

Linking space to user needs



How to get in touch:



[GSA Newsletter](#)



[GNSS YouTube Channel](#)



[GSA Twitter - @EU_GNSS](#)
[EGNOS Twitter - @EGNOSPortal](#)



[European GNSS Agency LinkedIn Page](#)
[GNSS Market, Research & Development](#)



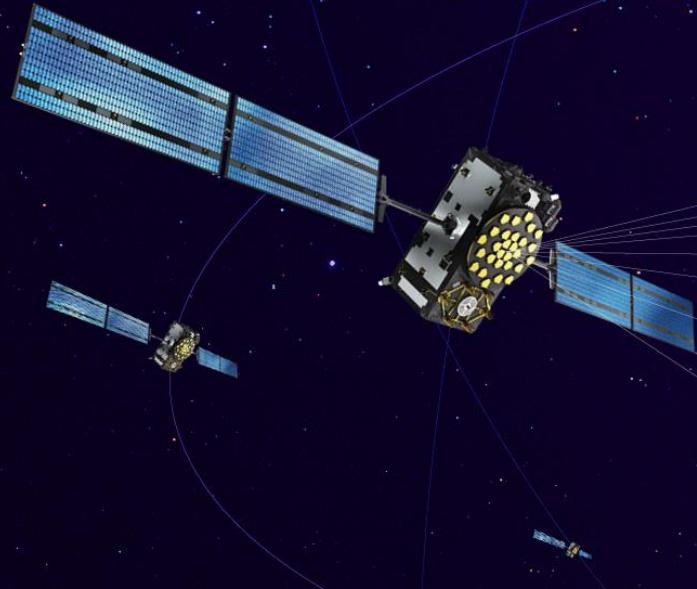
[GNSS Facebook page](#)



[GNSS Slideshare Page \(presentations\)](#)



www.GSA.europa.eu



European
Global Navigation
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Agency

Thank you!

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