



European  
Global Navigation  
Satellite Systems  
Agency



**EGNOS**

NAVIGATION SOLUTIONS  
POWERED BY EUROPE

# Webinar “Galileo for Surveying”

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

**10 September 2018**

# Agenda



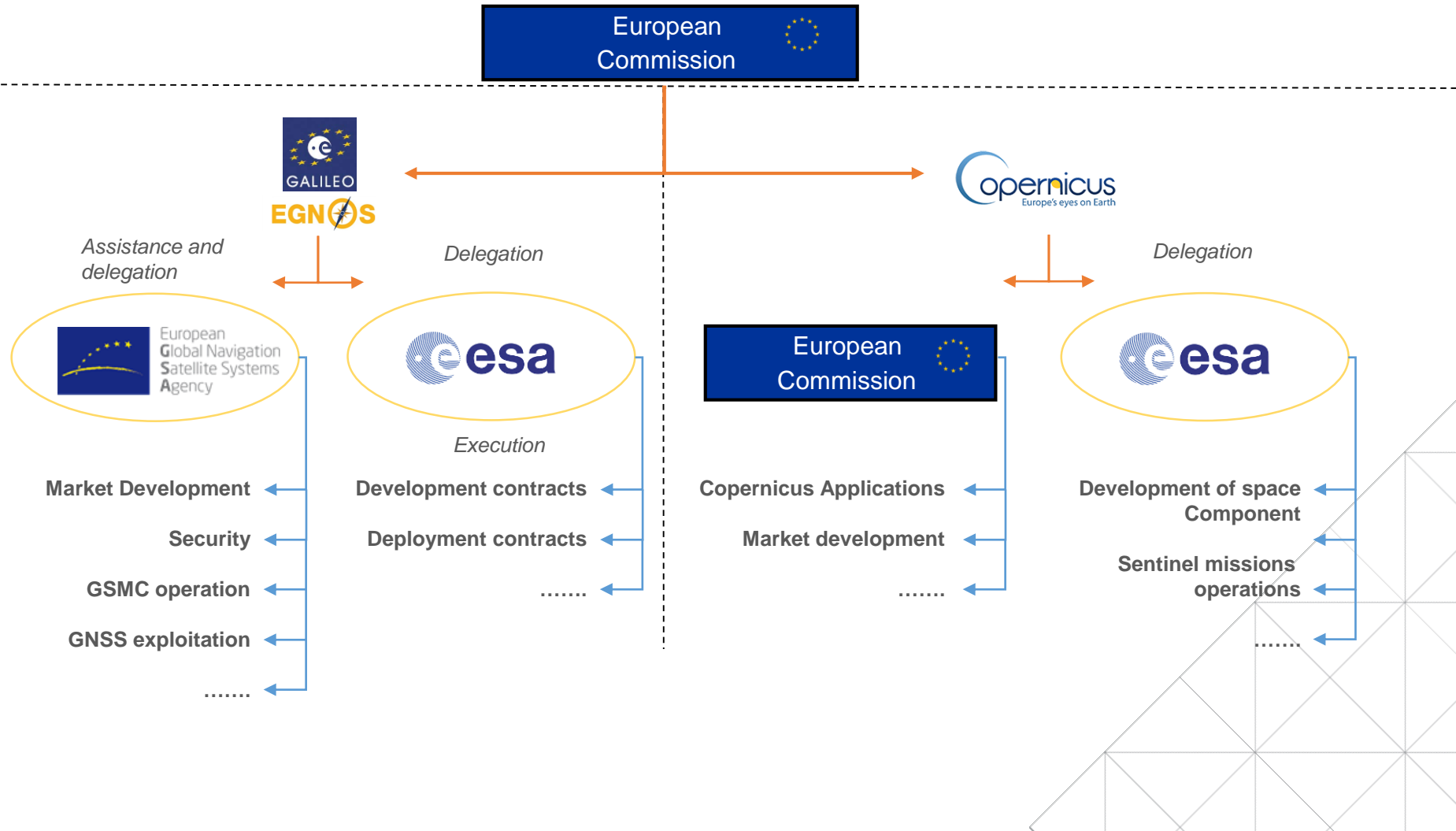
-  **GSA: Who we are and what we do**
-  **European GNSS: State of Play**
-  **Market and Technology Trends**
-  **E-GNSS for Surveying and Mapping**
-  **R&D and Funding Opportunities**

# Agenda



-  **GSA: Who we are and what we do**
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-  **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 – GSMC

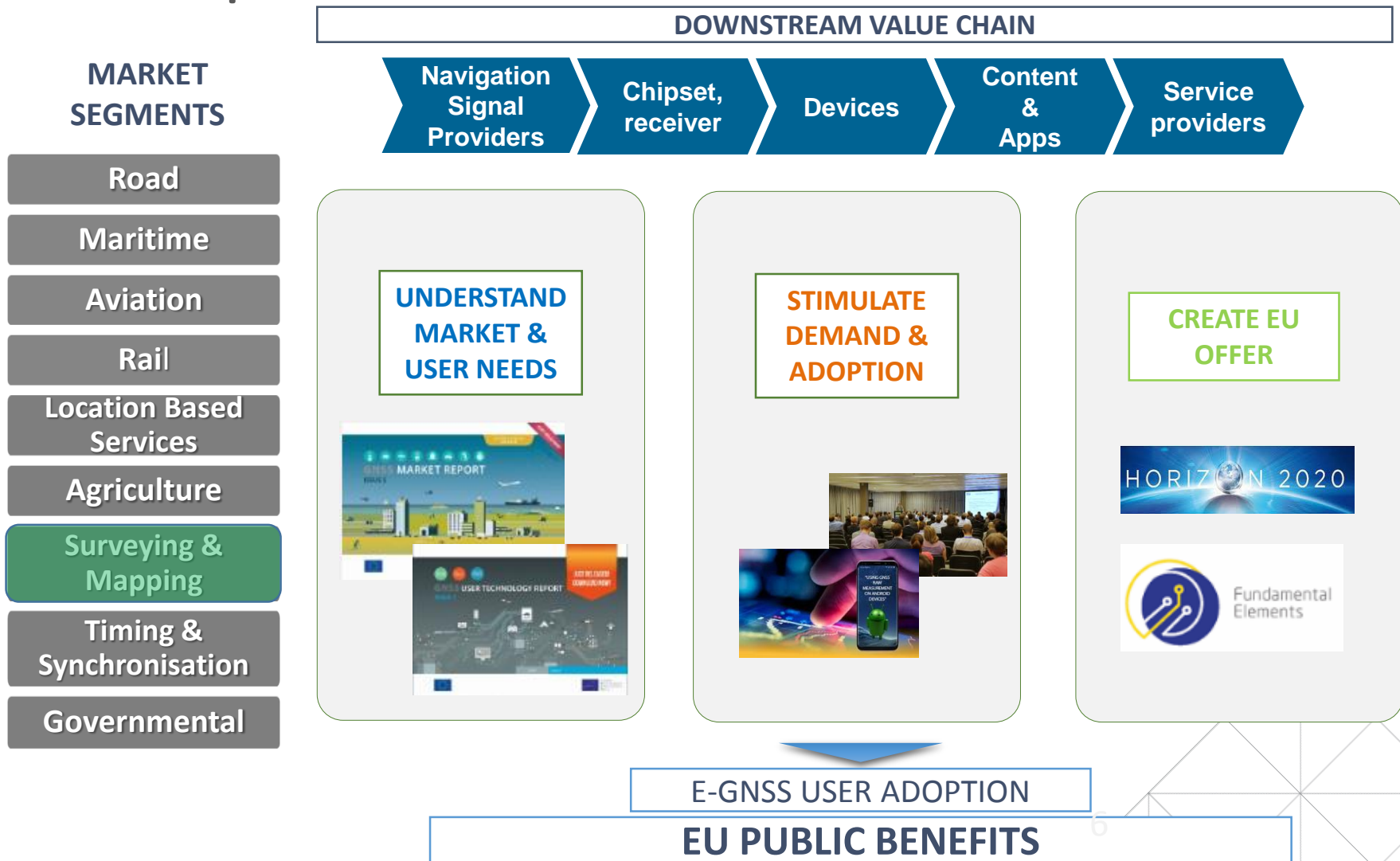
Swanwick, UK – GSMC

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



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# Galileo deployment is progressing

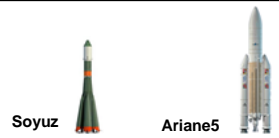


**4 Galileo satellites successfully launched on a customized Ariane 5 on 25/07, 2018**



2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
From Baïkonour					From Kourou				
<p>"GIOVE-A"</p>					<p>"GIOVE-B"</p>				
					<p>1-2</p>				
					<p>3-4</p>				
					<p>5-6</p>				
					<p>7-8</p>				

2015	2016	2017	2018	2019	2020/21
<p>9-10</p>	<p>11-12</p>	<p>13-14</p>	<p>15-16 17-18</p>	<p>19-20 21-22</p>	<p>23-24 25-26</p>
				<p>27-28</p>	<p>29-30</p>
				<p>31-32</p>	



**Galileo Initial Services**

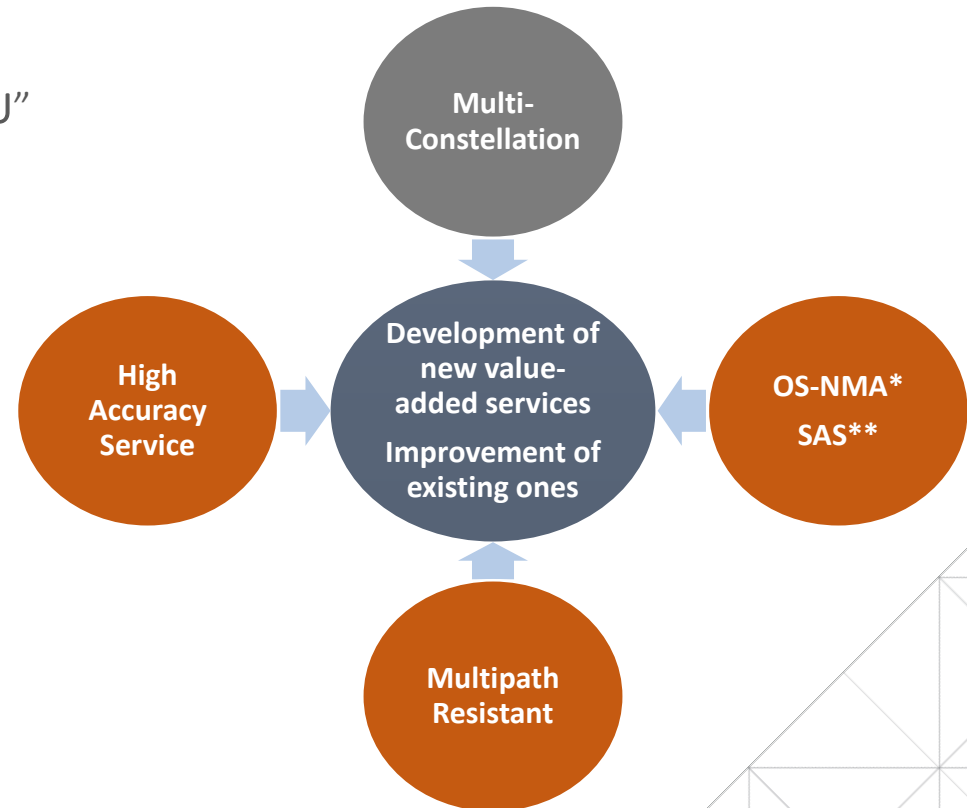
**26 satellites already launched, more satellites already bought and under preparation**



# 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



 Galileo differentiators

 Galileo + other GNSS

\*Open Service Navigation Message Authentication

\*\*Signal Authentication Service

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



USE **GALILEO**.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 the following categories: GALILEO & GSC OVERVIEW, GNSS MARKET & APPLICATIONS, SYSTEM STATUS, ELECTRONIC LIBRARY, SUPPORT TO DEVELOPERS, and MULTIMEDIA & NEWS. Below the navigation bar, there are three main service areas: GALILEO HELP DESK (with a chat icon), GALILEO SYSTEM STATUS (with a globe icon), and GALILEO INCIDENT REPORT (with an envelope icon). The main content area features a large banner for 'How is Galileo performing?' with a satellite image and two report covers. Below this is a 'SUBSCRIPTION' section with 'REGISTER' and 'LOGIN' buttons, and a 'Find Out More on www.usegalileo.eu' section with a computer monitor icon. The bottom section is titled 'Latest news' and includes a 'SEE ALL' link. There are three news items: 'Agriculture a key beneficiary of EU', 'Agriculture and Space Day: Space technology...', and 'EGNOS' with a lightning bolt icon. The website URL 'www.gsc-europa.eu' is displayed at the bottom.

# Galileo Open Service outperforming Minimum Performance Level (MPL) targets



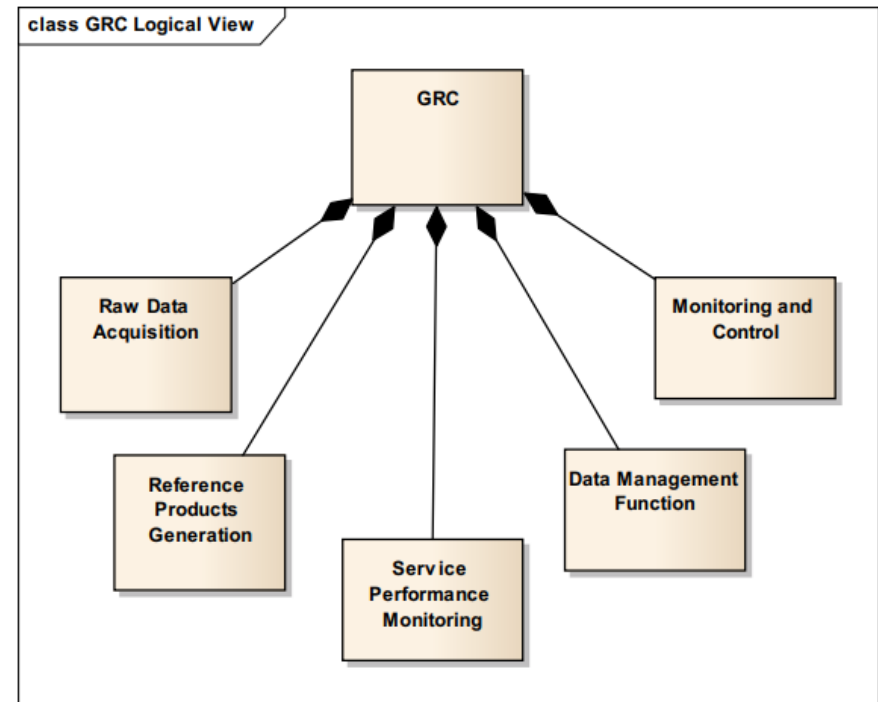
Definition		Committed Target	March 2018
<b>Ranging accuracy Dual Frequency (95%)</b>	Worst Satellite month	< 7.0 m	0.78 m
	Constellation average	< 2.0 m	0.50 m
<b>Ranging accuracy (Single Frequency (95%))</b>	Worst Satellite month	< 7.0 m	0.73 m
	Constellation average	< 2.0 m	0.51 m
<b>Availability of Dual Frequency Ranging (global average)</b>		> 87%	100%
<b>Per Satellite Availability of Signal in Space (monthly, OS, global average, healthy SF/DF)</b>		> 87%	>98.75%
<b>UTC Time dissemination uncertainty (DF, 95% over campaign period)</b>		< 30 ns	5.5 ns
<b>Availability of UTC dissemination</b>		> 87%	100%
<b>GST - GPS time offset uncertainty (95% over campaign period)</b>		< 20 ns	5.6 ns
<b>GST - GPS time offset availability (over campaign period)</b>		> 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

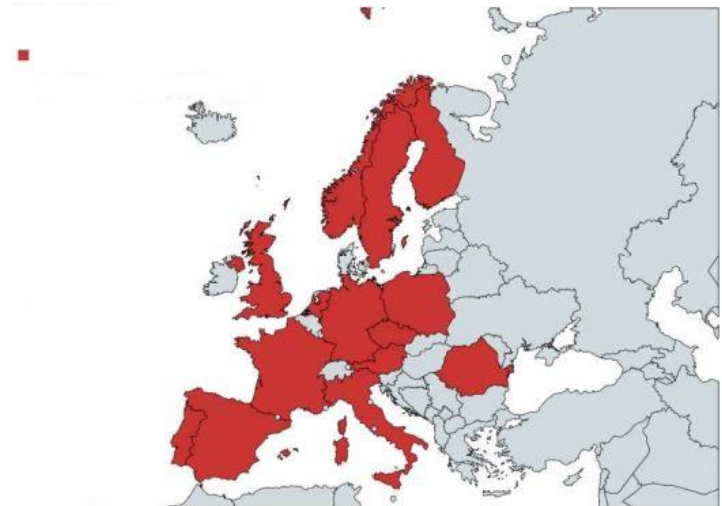


## MS Contributions

- 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/>



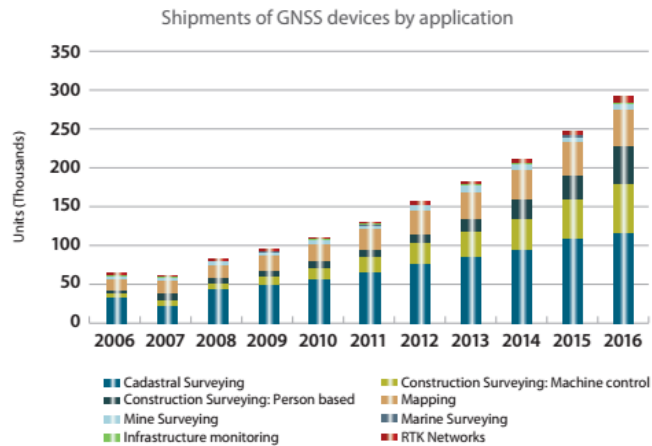
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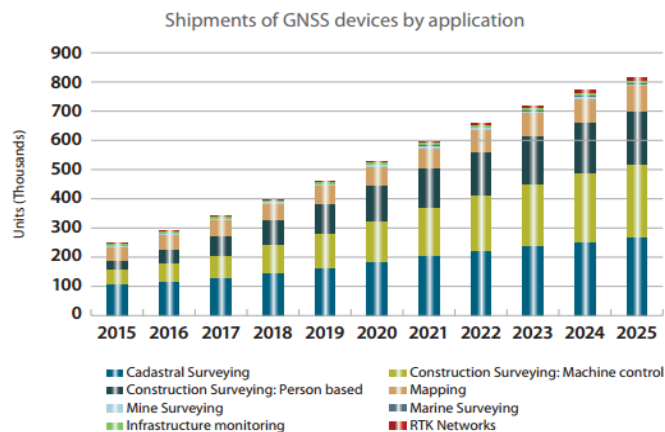
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# Construction, mapping and cadastral industries stimulated growth in shipments of GNSS surveying equipment



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



\* TCAR (Three-Carrier Ambiguity Resolution)

\*\* Precise Point Positioning

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



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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) or RTK via
- EGNSS: precise guidance to specific areas, location geo-tagging
- User-friendly web interface with cloud connectivity

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- LIDAR, robotics, mobile mapping, INS, etc.



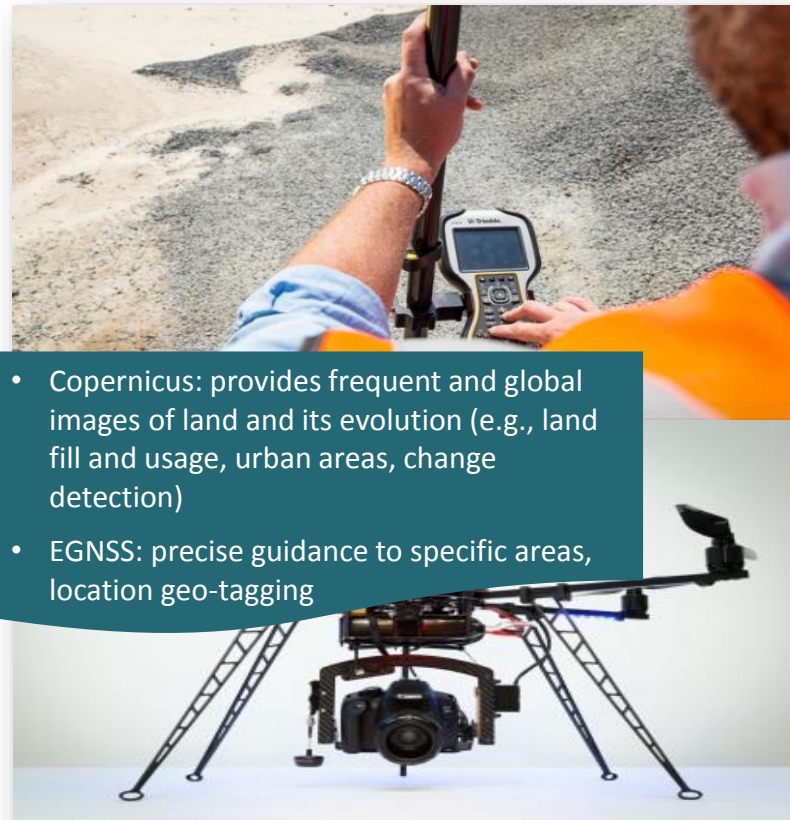
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- UAV penetration into

- The quality/price ratio of the receivers is continuously improving.
- Also, RTK/PPP services prices go down, sometimes for NO or very low fee



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- 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

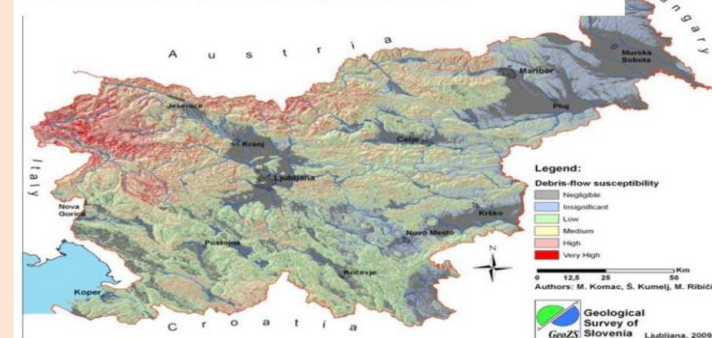
- Frequent, worldwide measurements of land masses displacements
- Detection of vertical displacements



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

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

Landslide susceptibility map of Slovenia



# 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

70 smartphones models Galileo enabled



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

World's first dual-frequency GNSS smartphone hits the market



- 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>

# Agenda

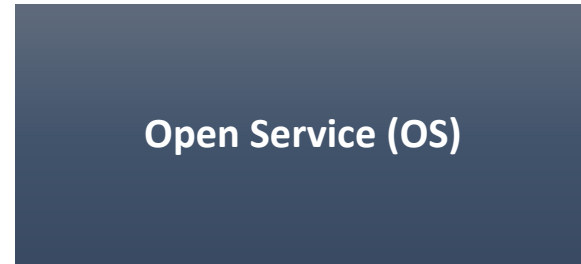


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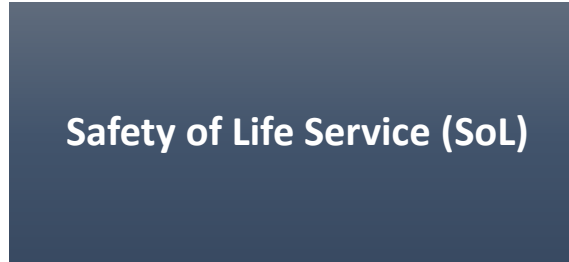
# EGNOS already available serving EU citizens and industry



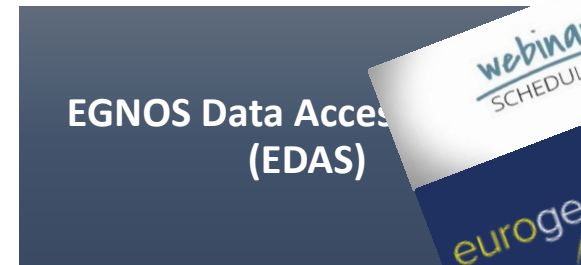
- Accuracy **~1m, free**



- Accuracy **~1m, compliant to aviation standards** by providing correction data and **integrity**



- Accuracy **<1m, corrections provided via internet**



# Galileo is the European GNSS offering a wide range of services



G  
S  
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- 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)

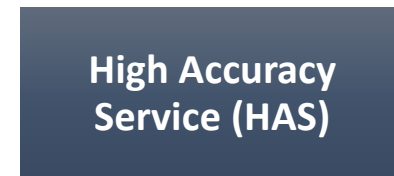
OS-Navigation Message Authentication (OS-NMA)



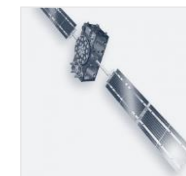
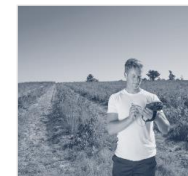
## Public Regulated Service (PRS)



## Search and Rescue Service (SAR)



## High Accuracy Service (HAS)

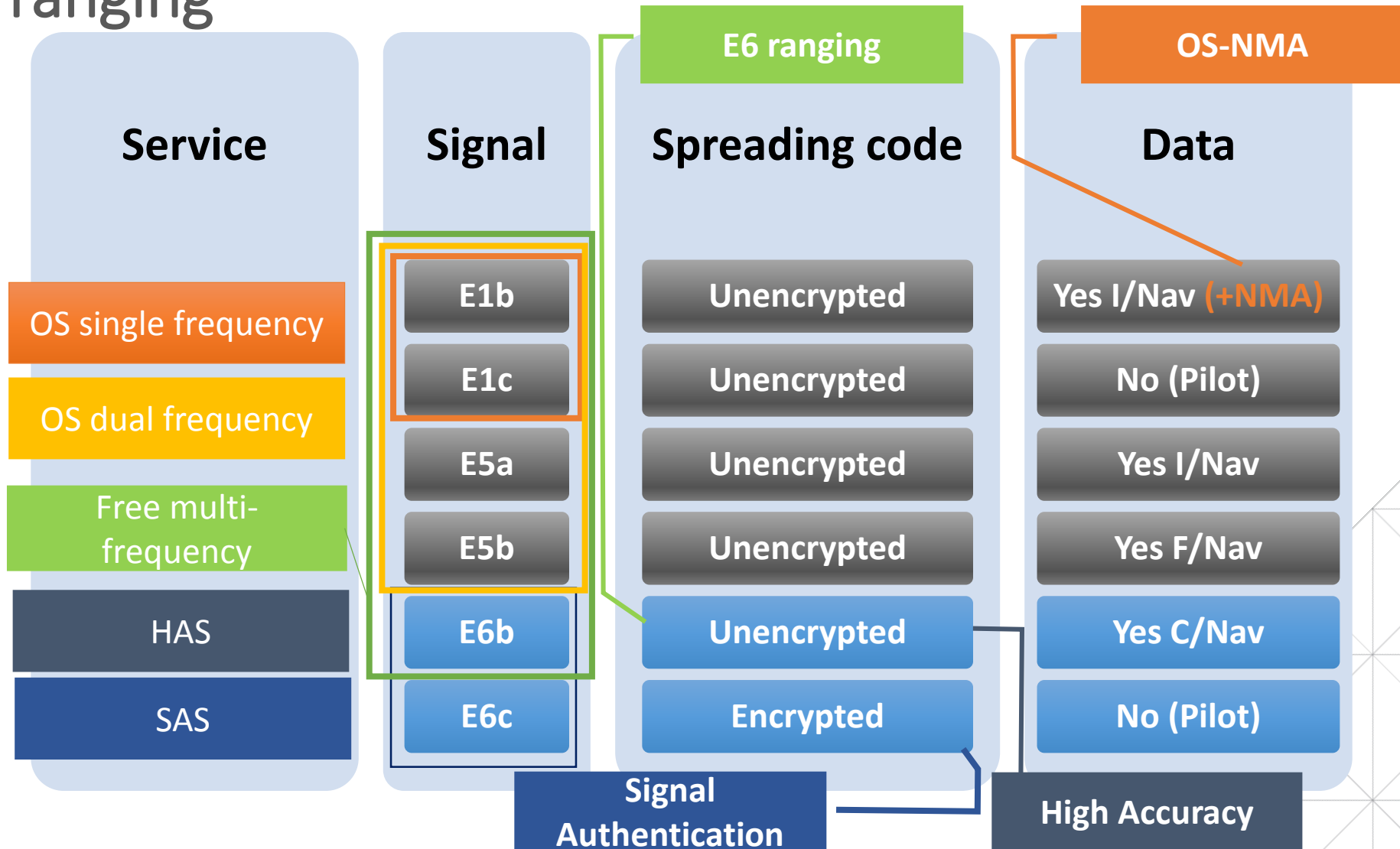


## Signal Authentication Service (SAS)



# Overview of signals

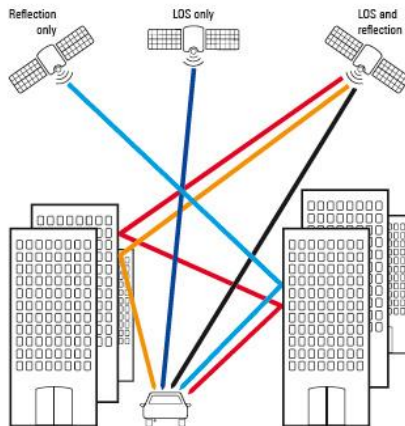
## Open service / High Accuracy Service / E6 ranging



# 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 2<sup>nd</sup> and 3<sup>rd</sup> GNSS frequency



## E5/L5: 2<sup>nd</sup> 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: 3<sup>rd</sup> 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
<b>Frequency</b>	1278.75 MHz
<b>Signal</b>	E6B
<b>Min. Power</b>	-158 dBW
<b>Modulation</b>	BPSK(5)
<b>Chip Rate</b>	5.115 Mcps
<b>Code Length</b>	1 ms
<b>Symbol Rate</b>	1000 sps
<b>Data Rate</b>	492 bps
<b>HA Data Rate</b>	448 bps (TBC)
<b>Data Coding</b>	FEC, as per Galileo OS SIS ICD, + interleaving 123 x 8
<b>Spreading Code</b>	
<b>Encryption</b>	No
<b>Data Format</b>	TBD, but based on an open ICD.
<b>Data (TBC)</b>	Orbit and clock corrections, code and phase biases, SQM, flags, ionospheric information.

# Current status of Galileo in Surveying



## Augmentation service providers



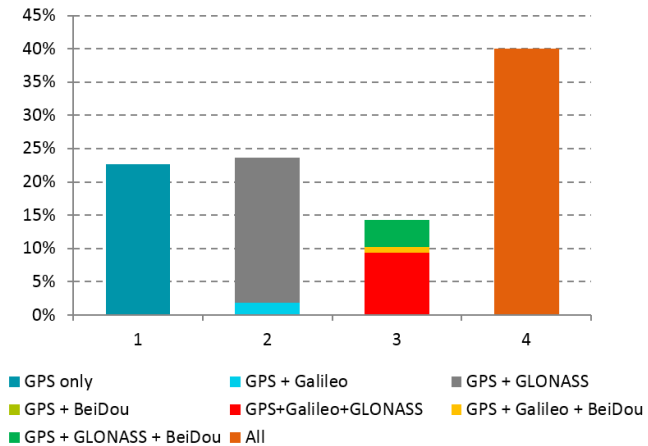
INSIDE



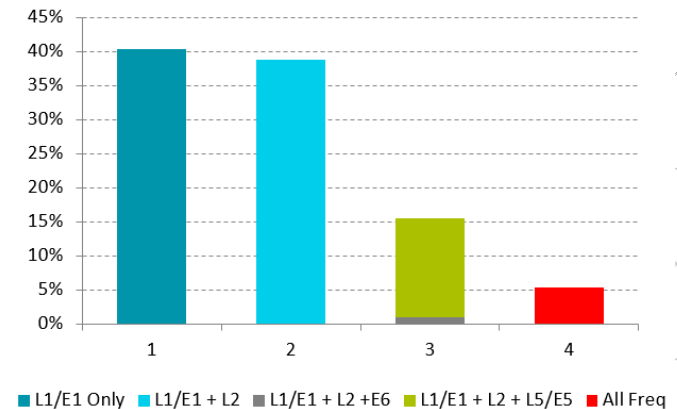
High Precision and Timing Solutions

## Receiver Capabilities\*

Supported constellations by GNSS receivers



Supported frequencies by GNSS receivers



- 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  
Trimble



New PPP computing techniques utilising Multi-Constellation and Multi-Frequency will bring almost instantaneous centimetre level positioning within a few years\*\*

\*professional receivers (surveying+agri+timimng)

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

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# 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 €mIn is the budget dedicated to EGNSS applications and products in the 4<sup>th</sup> 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



Fundamental

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# Horizon 2020 Space Information Day & Brokerage Event

**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



## mapKITE – EGNOS-GPS/GALILEO-based high-resolutionterrestrial-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.

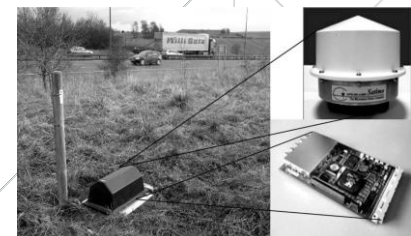
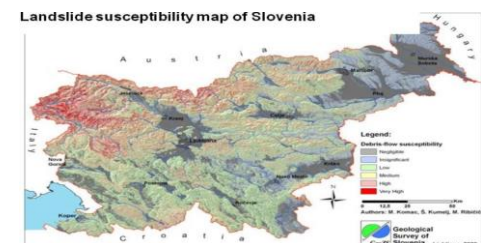


- Vertical displacements ( via synthetic aperture radar interferometry InSAR)
- Horizontal displacements
- Temporal interpolation a
- Geo-localisation of the in-situ sensors



### 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

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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](http://www.GSA.europa.eu)



European  
Global Navigation  
Satellite Systems  
Agency



**EGNOS**

NAVIGATION SOLUTIONS  
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Thank you!

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