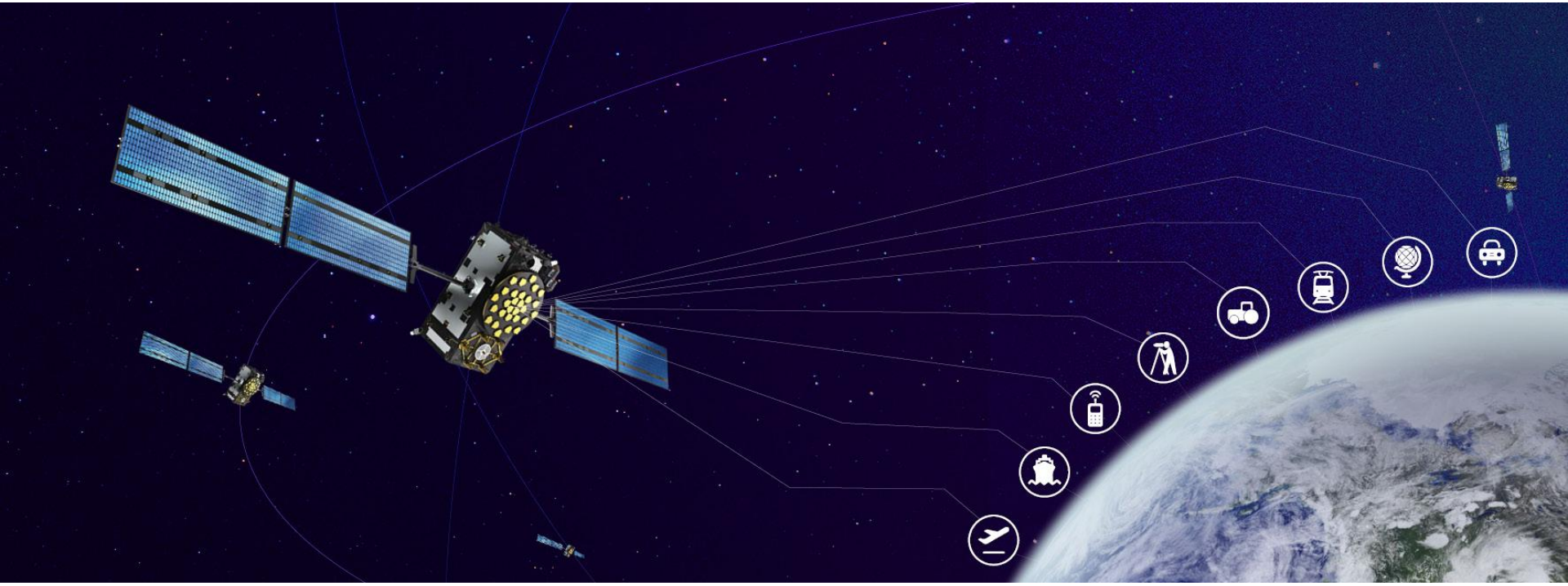

European
Global Navigation
Satellite Systems
Agency

EGNOS and Galileo contributions to agriculture, forest and mapping

GALILEO EGNOS

NAVIGATION SOLUTIONS
POWERED BY EUROPE

Agenda

Agriculture Applications and Trends in Precision Farming

EGNOS and Galileo Contributions to Precision Farming

Applications and Trends in Surveying and Mapping

EGNOS and Galileo Contributions to Surveying and Mapping

GSA Activities and R&D in Agriculture & Surveying and Mapping

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GNSS based precision farming solutions and applications available today

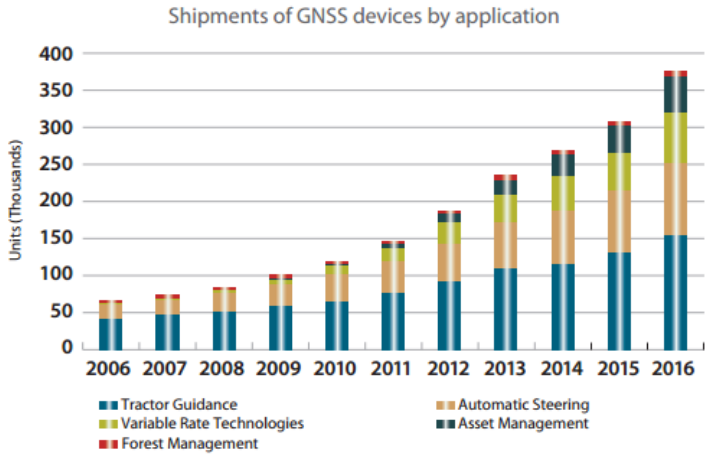
GNSS applications:

Precision agriculture:

- Farm machinery guidance
- Automatic steering
- Variable rate application
- Yield monitoring
- Biomass monitoring
- Soil condition monitoring
- Livestock tracking and virtual fencing
- Forest management

Agri-logistic applications:

- Farm machinery monitoring and asset management
- Geo-traceability
- Field delineation



No 1 application: Tractor guidance

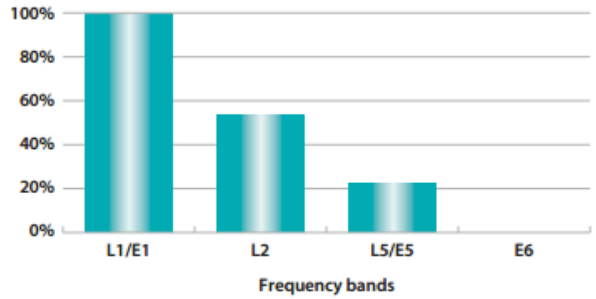
No 2 application: Automatic steering

Key Trends:

- GNSS stimulates integrated farm management's uptake
- The drones uptake is increasing and growing in popularity in commercial applications, with agriculture likely to be one of the largest users of drone technology

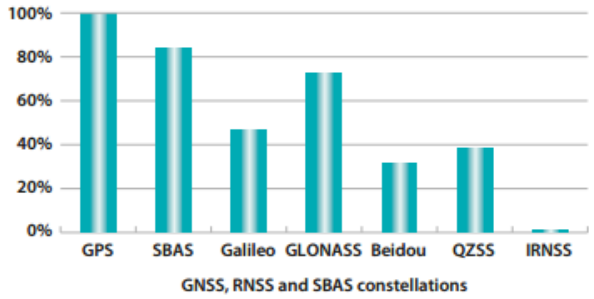
Multi-constellation and multi-frequency are widely adopted to fulfil stringent accuracy requirement

Frequency capability of GNSS receivers[1]



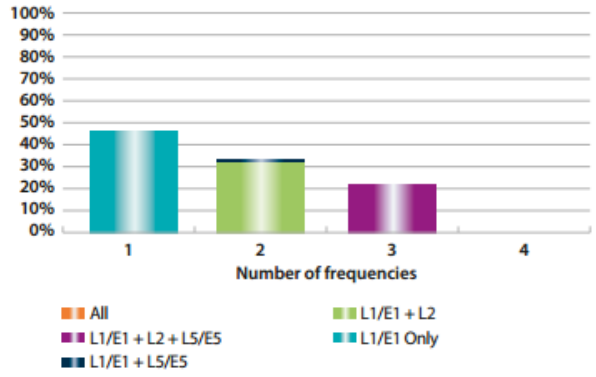
[1] shows percentage of receivers supporting each frequency band

Constellation capability of GNSS receivers[2]



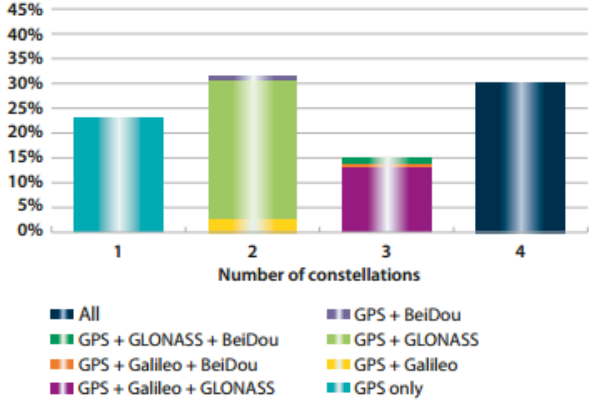
[2] shows percentage of receivers capable of tracking each constellation

Supported frequencies by GNSS receivers[3]



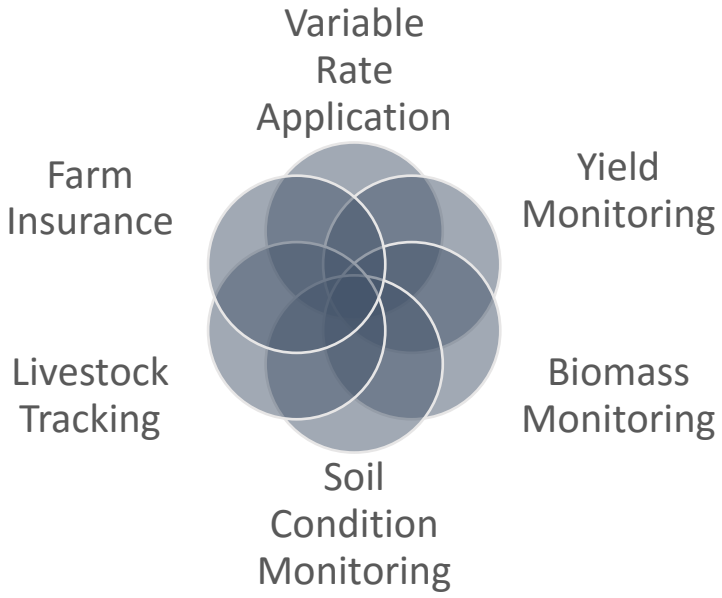
[3] shows percentage of receivers capable of tracking 1, 2, 3 or all the 4 frequencies

Supported constellations by GNSS receivers[4]



[4] shows percentage of receivers capable of tracking 1, 2, 3 or all the 4 GNSS constellations

Uptake of Drones in Precision Farming increases the use of GNSS



GNSS is the backbone of commercial drones and a key enabler ensuring safe navigation and reliability

- Agriculture alone could be a $350 million market in 2025*
  Fragmented **regulation over Europe - barriers to the development** of commercial use drones

* GSA GNSS Market Report, Issue 5

GNSS is a core component in Integrated Farm Management Systems

IoT Connectivity

Robotics

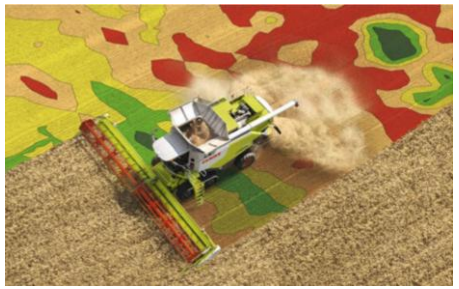
Drones

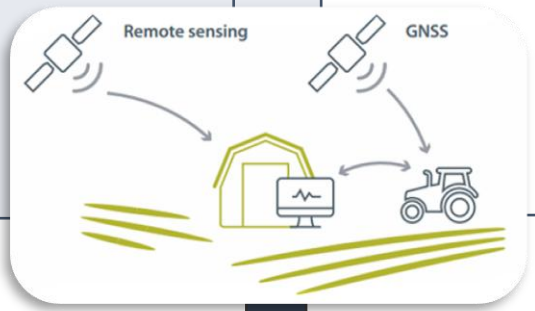
Earth Observation

Meteo

EGNSS as key component or complement

- Linking the data to specific geographical coordinates
- Providing geo-location
- Tracking and positioning





Integrated Farm Management Systems support farmers in their decision-making

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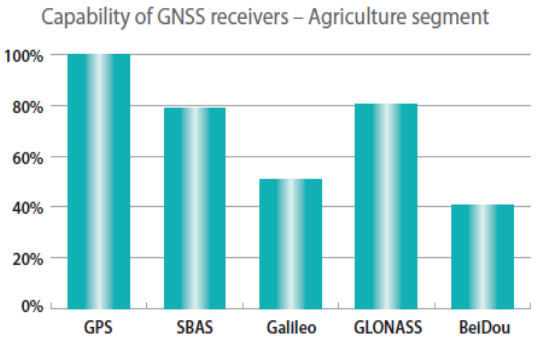
EGNOS provides advantages to both farmers and society

- Offers an **affordable solution** for precision agriculture
- Enables farmers to **optimise yields, increase labour productivity and reduce driver fatigue** – all with minimal investment
- Supports **machinery guidance** solutions with sub-metre level accuracy, which is suitable for basic-value crop cultivation (e.g. cereals)
- Enables more **efficient management** of farming activities such as **spreading, spraying and harvesting**



EGNOS provides advantages to both farmers (higher profits margins) and society (increased food supply and more environmentally friendly agriculture).

80% of European GNSS enabled tractors are equipped with EGNOS

=> Over 16.000 new EGNOS enabled tractors in 2016

Galileo brings further benefits to Precision Farming

Galileo Open Service

- More satellites, Galileo signal design and dual frequency capability contribute to **better operations in harsh environment** (e.g. edge of the forest, valleys)
- Galileo inclusion to RTK network result in an improved reliability, availability and accuracy **providing better results in guidance, auto-steering systems** (including repeatability)

Galileo Commercial Service

- **Real time corrections across the globe** (Precise Point Positioning) to improve accuracy for your guidance and auto-steering systems
- **The only constellation** offering corrections directly from satellites **without dependency of Internet or additional communication channels**
- **Sub-dm level accuracy and cm-level pass-to-pass accuracy** to improve your trajectory with convenience and flexibility
  - **Does not rely on proximity to** ground network **infrastructure**
  - **Faster convergence time** due to Galileo triple frequency

Galileo will further improve the performance of GNSS-assisted agriculture and bring benefits in every phase of the farming operation

Galileo and EGNOS are supporting the effective implementation of the Common Agricultural Policy (CAP) in Europe

GNSS plays a role in measurements needed to prove eligibility for funding and for the performance of on-the-spot checks performed by the public authorities in charge

Integrated Administration and Control System (IACS)

- GNSS used for Land Parcel Identification System (LPIS) purposes
  - Questionable cases or where the interpretation based on orthophoto does not work
  - Upload of GNSS measurement delivered by farmers
- GNSS used for On-the-Spot Checks purposes of area based subsidies
  - Parcel location (navigation to parcel)
  - Area measurement

Copernicus open data contributes to Precision Farming

- Revolutionary Earth Observation and Monitoring programme
- Delivers openly and freely in a wide range of application areas:
  - operational data
  - information services

COPERNICUS APPLICATIONS in AGRICULTURE

- Yield mapping, input management, farm management recording, etc.
- Seasonal mappings of cultivated areas
- Field scale and crop dynamics mapping
- Irrigation management and drought monitoring
- Food security monitoring and agriculture development in Africa
- Support to subsidy control (CAP)

E-GNSS and Copernicus for forestry

Applications

- Health status/biomass monitoring
- Forest management
- Harvest monitoring
- Insurance

Example: Forest management and operations

- Monitoring of vegetation areas, sample plots, health status

+

- Galileo: More robust signal under tree canopy
- EGNOS for stem localisation

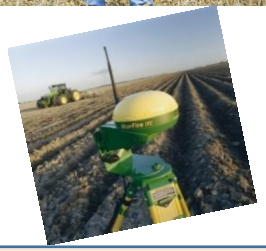
- Identification and mapping of damage areas or under stress
- Location of clear-cut areas, sample plots, roads

Example GSA/EC project: PARADISE

Synergies E-GNSS-Copernicus to support various agriculture applications (1/2)

Applications

- Environmental management
- Variable rate application (VRT)
- Harvest monitoring
- Biomass monitoring
- Soil sampling
- Risk management
- Insurance



Example 1: VRT (Variable Rate Applications)

- Differentiated maps of the crops: soil moisture, health of crops, vegetation index (NDVI), etc.

+

- Highly accurate positioning of machinery

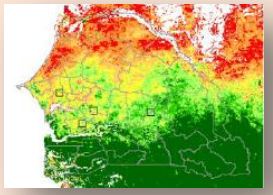
- Precise application of the fertilisers and pesticides where and when they are most necessary
- Lower environmental footprint
- More efficient use of manpower

Synergies E-GNSS-Copernicus to support various agriculture applications (2/2)

Example 2: Farmers' aid control within CAP

- EO used for control with Remote Sensing within Integrated Administration and Control System (IACS)
- Sentinel is very promising to support IACS processes

- Land Parcel Identification System (LPIS) purposes
- On-the-Spot Checks purposes of area based subsidies



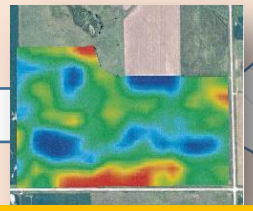
Control and verify farmers' aid applications in CAP

Example 3: Soil monitoring (humidity, sampling, etc.)

- Agricultural field's soil conditions

+

- In-situ measurements of soil parameters (e.g., moisture by GNSS reflectometry)
- Location-tagging of soil samples



- Metre and centimetre level maps of soil parameters
- Targeted irrigations and treatments

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Surveying GNSS based applications available today

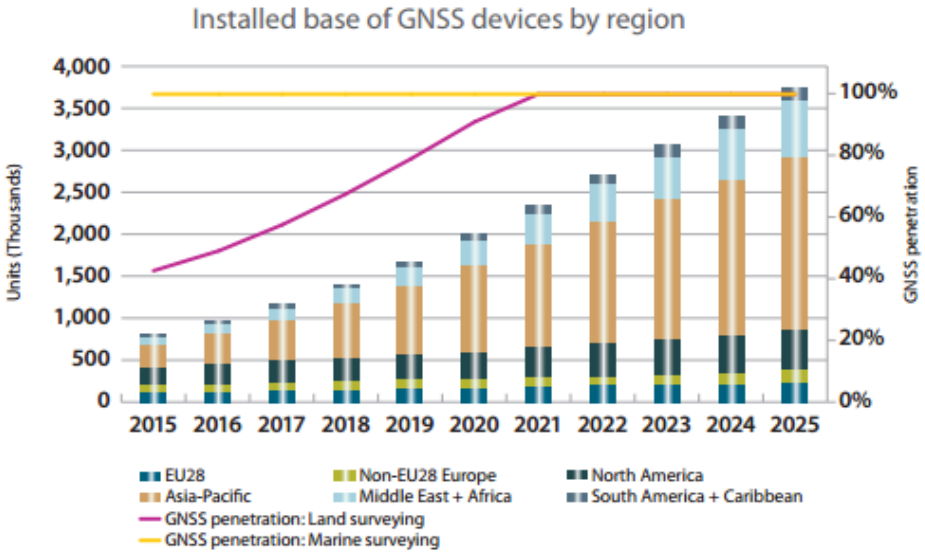
GNSS applications:

Applications in Land Surveying:

- Cadastral surveying
- Construction surveying
  - ✓ Machine control
  - ✓ Person-based
- Mapping
- Mine Surveying
- Infrastructure Monitoring

Applications in Marine Surveying:

- Marine surveying

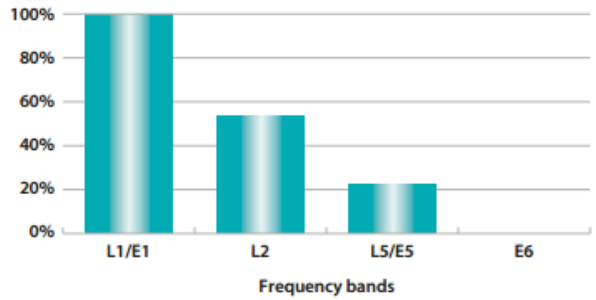


Key Trends:

- Construction activities in Asia-Pacific and North America will drive GNSS growth
- Precise Point Positioning (PPP) is gaining more surveying users
- Uptake of drones in the surveying domain

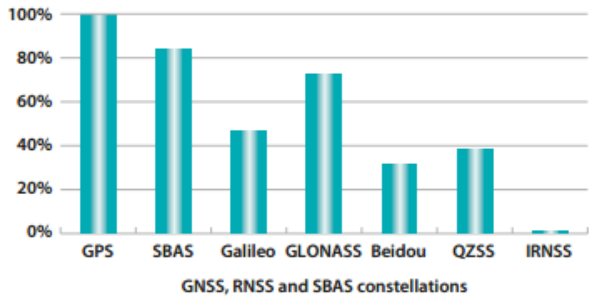
Multi-constellation and multi-frequency are widely adopted to fulfil stringent accuracy requirement

Frequency capability of GNSS receivers[1]



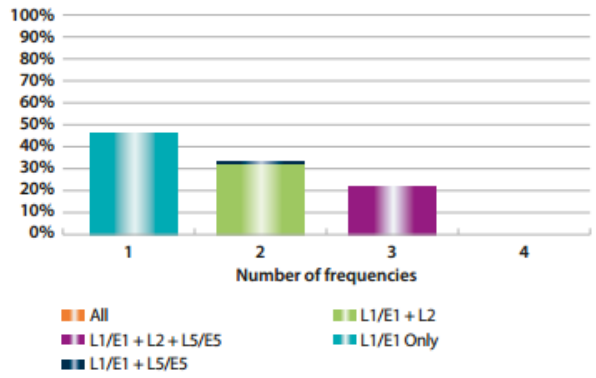
[1] shows percentage of receivers supporting each frequency band

Constellation capability of GNSS receivers[2]



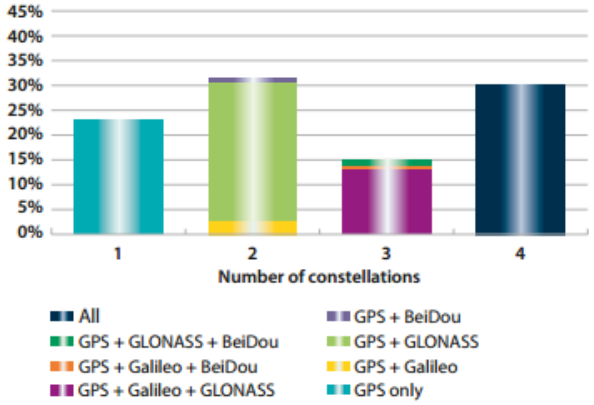
[2] shows percentage of receivers capable of tracking each constellation

Supported frequencies by GNSS receivers[3]



[3] shows percentage of receivers capable of tracking 1, 2, 3 or all the 4 frequencies

Supported constellations by GNSS receivers[4]



[4] shows percentage of receivers capable of tracking 1, 2, 3 or all the 4 GNSS constellations

Technology developments will soon enable low-cost receivers capable of cm-level precision

Key Performance Parameter (KPP)	EGNOS contribution*	Galileo contribution*
Availability		••
Accuracy	••	•••
Integrity	•••	
Robustness		•••

Main drivers and trends:

- Increased availability of low-cost equipment capable of down to cm-level precision (with multi-frequency and multi-constellation support)
- Uptake of PPP
- Integration of GNSS with other complementary technologies (LIDAR, robotics, mobile mapping, etc.)
- Synergies between GNSS and Earth Observation
- UAV penetration into mapping

Augmentation service providers are accelerating the adoption of Galileo

RTK

- **HW: Majority of RTK providers upgraded or have started to upgrade**
  - SWEPOS (SE), GeoSoft (ET), SAPOS (DE), SOGEI (IT), GEONET (JP), etc.
- **SW: RTK Network:** Galileo functionality **under implementation** and **challenge with interoperability** of different brands within one network
- First **field tests prove benefits** of adding Galileo to RTK
  - **Better reliability, continuity and availability,** resulting in **better operation in difficult environment**

Regular GSA workshops and industry consultations

"Based on our test results, we clearly recommend Galileo corrections to our customers needing reliable high precision"
SWEPOS RTK

PPP

President and CEO of NovAtel, Michael Ritter stated
"Our OEM customers are already benefiting from t**he enhanced reliability, availability and accuracy the Galileo constellation adds to the GNSS**."

Anders Haneborg, Fugro commercial manager said
"Galileo's Initial Services operations […] a key consideration for our customers during critical positioning operations"

Graham Purves, President and CEO of Veripos stated

"As an European company, we are **particularly proud and excited about the opportunities the Galileo services create** for our customers. The **reliability and safety enhancements** made possible through these new services allow Veripos to continue to expand the capabilities of our cutting edge safety critical positioning solutions."

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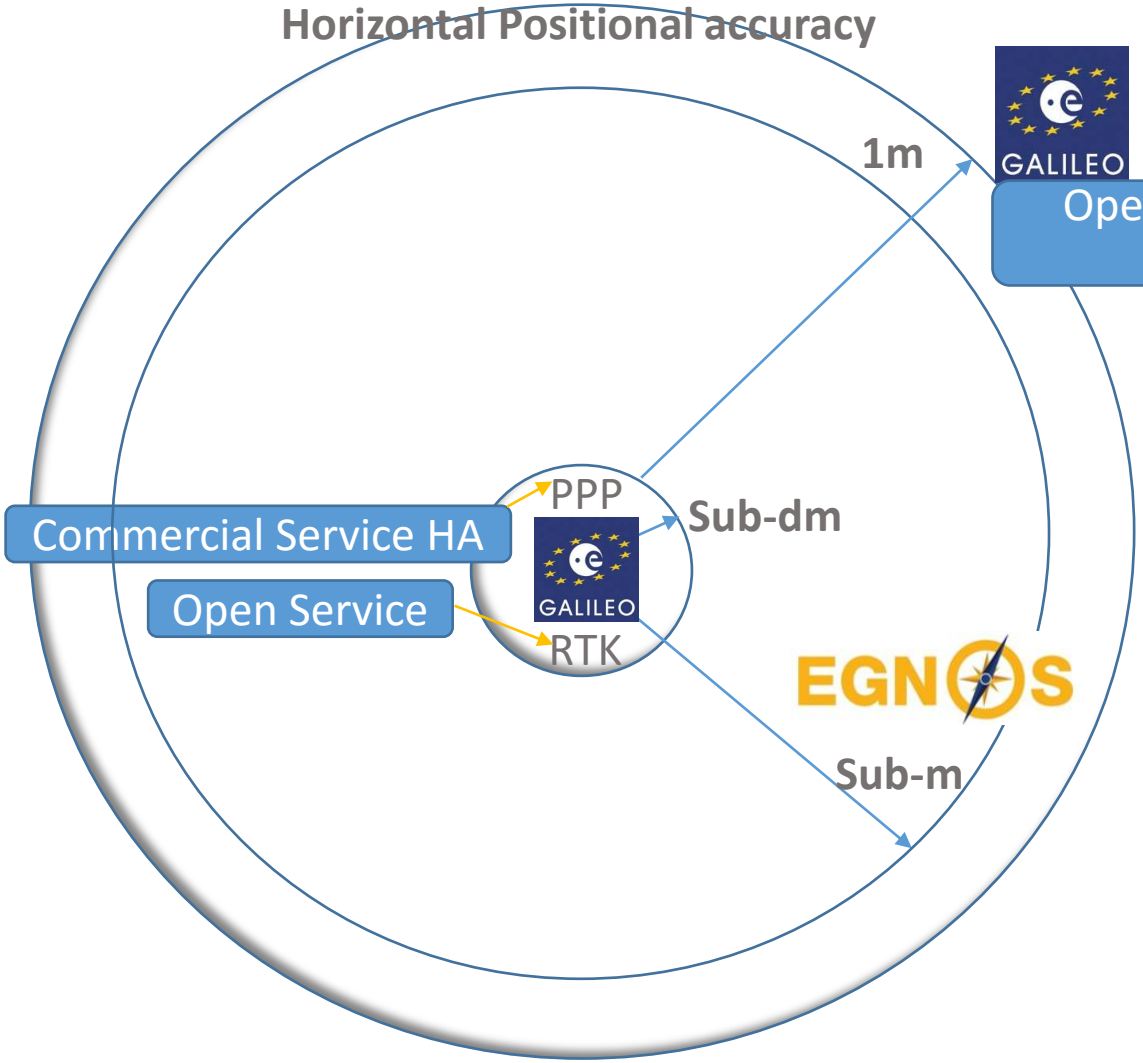
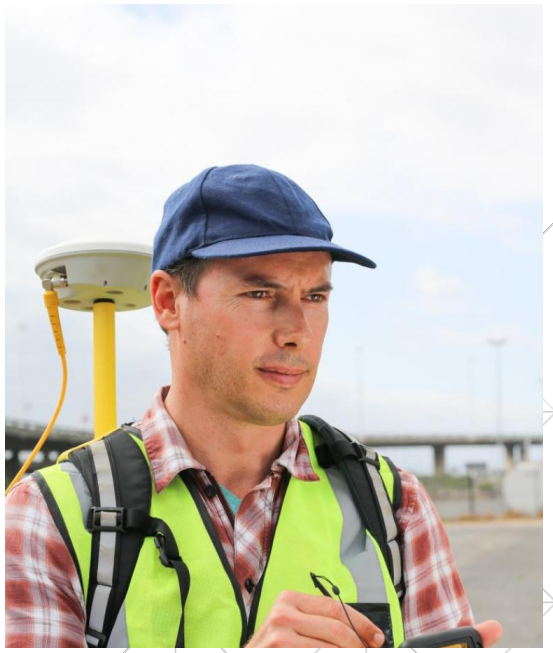
Surveyors may benefit from various E-GNSS services





Galileo Open Service: Key points

Advantages of Galileo OS E1/E5 bands
(some of them starting with Initial Services)

Easier **mitigation of multipath errors**

Higher SNR (signal-to-noise ratio)

Multi GNSS : provides additional advantages

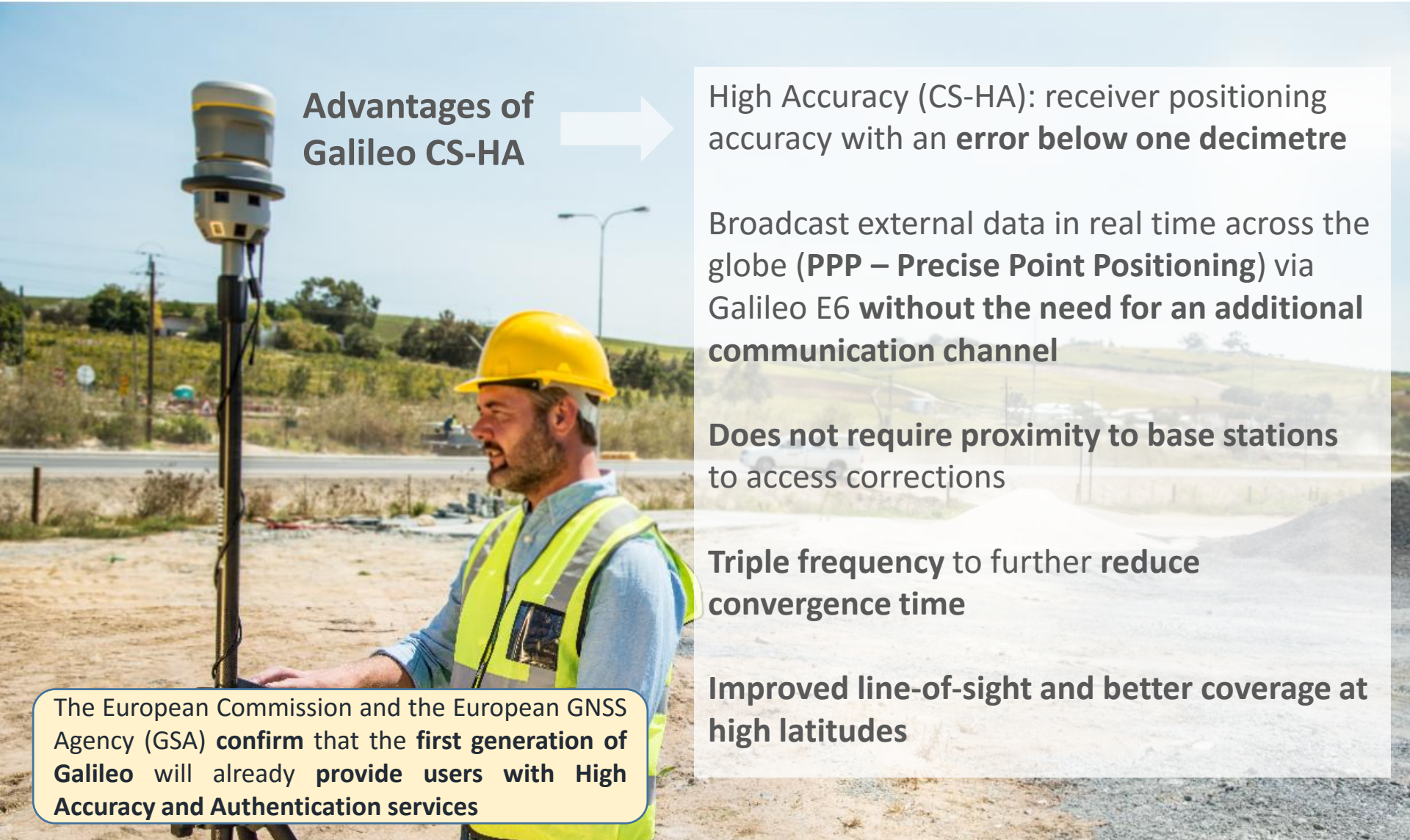
- **Increase availability, continuity and reliability**
- **Improved geometry**

Better results **in harsh environement** (urban canyons, tree canopy, etc.)

OS-NMA: **spoofing detection**

Galileo Commercial Service

Key Points



Advantages of Galileo CS-HA

High Accuracy (CS-HA): receiver positioning accuracy with an **error below one decimetre**

Broadcast external data in real time across the globe (**PPP – Precise Point Positioning**) via Galileo E6 **without the need for an additional communication channel**

Does not require proximity to base stations to access corrections

Triple frequency to further **reduce convergence time**

Improved line-of-sight and better coverage at high latitudes

The European Commission and the European GNSS Agency (GSA) **confirm** that the **first generation of Galileo** will already **provide users with High Accuracy and Authentication services**

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Three main pillars towards E-GNSS adoption – the bigger picture

DOWNSTREAM VALUE CHAIN

MARKET SEGMENTS

- Road
- LBS
- Aviation
- Rail
- Maritime
- Agriculture
- Surveying & Mapping
- Timing & Synchronization
- Governmental

Bodies influencing the market → **Navigation Signal Providers** → **Chipset, receiver** → **Devices** → **Content & Apps** → **Service providers**

Understand **market and user needs and satisfaction**

User Satisfaction

Stimulate

DEMAND & ADOPTION

- EGNSS added Value
- Cooperate with receivers and aps
- Roadmaps with stakeholders
- Support EC policies

Fundamental Elements

Fundamental Elements

Support EU

COMPETITIVE OFFER

of Services and applications applications

HORIZON 2020

E-GNSS USER ADOPTION

EU PUBLIC BENEFITS

A full analysis of GNSS receiver capabilities is available in the GSA's Technology Report

Available for download

HTTP://BIT.LY/2CGARXF

2016 GNSS USER TECHNOLOGY REPORT

Available for download

An in-depth analysis of 3 GNSS Macrosegments :

- MASS MARKET SOLUTIONS
- TRANSPORT SAFETY AND LIABILITY-CRITICAL SOLUTIONS
- HIGH PRECISION, TIMING AND ASSET MANAGEMENT SOLUTIONS

Leveraging R&D

AGRICULTURE VALUE CHAIN

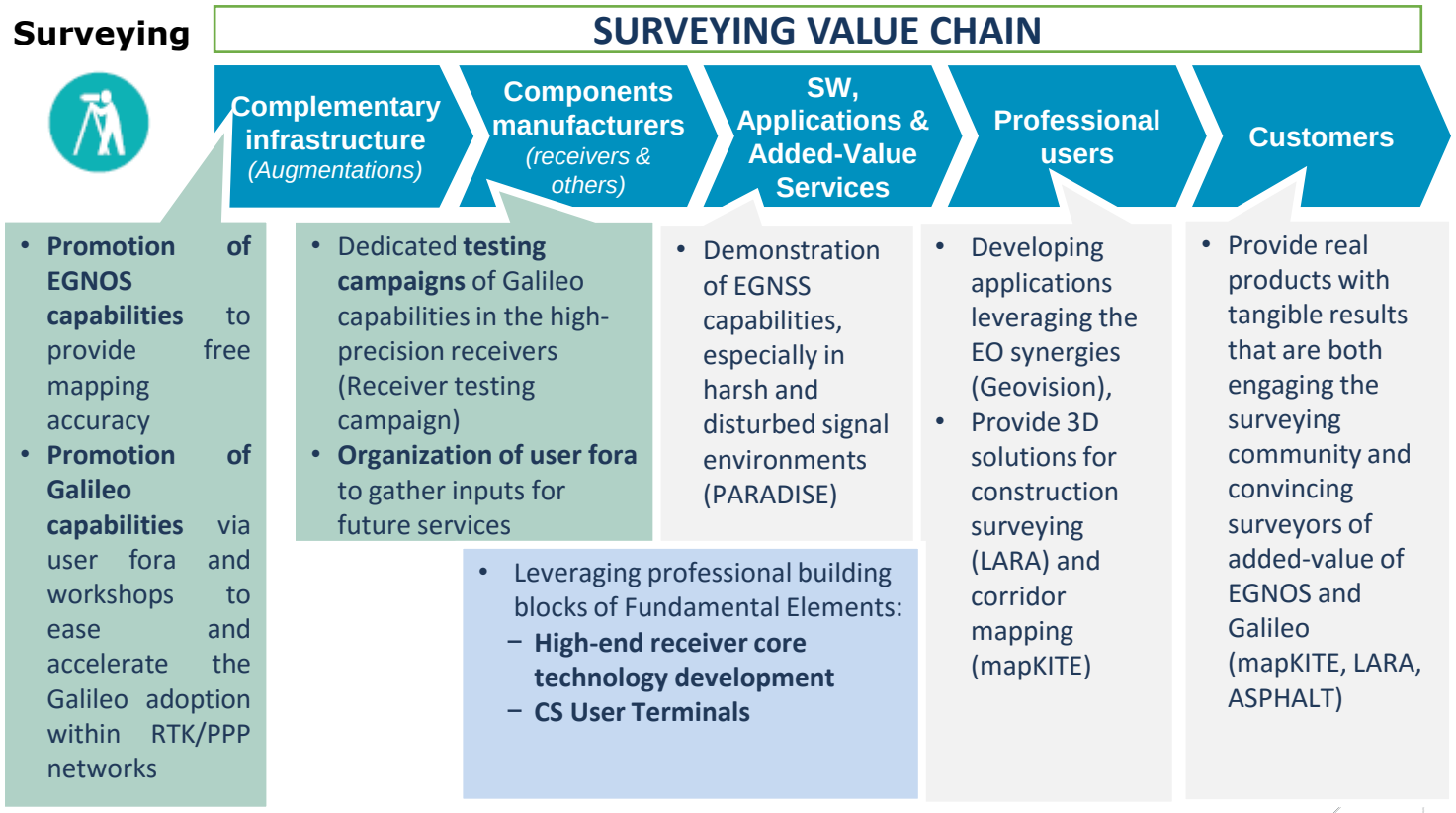
Augmentation service providers	Components manufacturers *(receivers & others)*	Device Vendors	Tractor manufacturers	Farm Mgmt Solutions & applications providers
• **Promotion of EGNOS capabilities** • **Promotion of Galileo capabilities** via user fora and workshops	• **Testing campaign** of Galileo capabilities • Organization of **user fora** (JRC MARS CAP, CAPIGI, CEMA)	• **New technologies** (UAS) for precision agriculture applications (FieldCopter, MISTRALE)	• **dedicated user fora** • (CAPIGI, CEMA, Agritechnica)	• Supported the development of a end-to-end solution for machinery inventory, optimisation of machine operations (GEOPAL; MISTRALE, etc.)

Leveraging professional building blocks of Fundamental Elements:

- **High-end receiver core technology development**
- **CS User Terminals**

FP/ H2020 | Fundamental Elements | MKD uptake

Leveraging R&D



The GSA's funding mechanisms promote the development of Galileo compatible solutions

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

8 €mln budget dedicated **to high precision market in the 3rd H2020 call – under evaluation**

Fundamental Elements

Fundamental Elements projects focus on fostering the development of innovative Galileo- and EGNOS-enabled receivers, antennas and chipsets technologies. The objective is to achieve products that address user needs in priority market segments

€75.5 M for non-PRS projects

http://www.gsa.europa.eu/r-d/gnss-r-d-programmes

Success story: GEOPAL FP7 project
Improve logistics for European farmers

GEOPAL is a (GNSS) based system useful to plan logistics in agriculture for European farmers

- **Improves the efficiency of in-field and inter-field logistic activities:**
  - Fleet management and logistics (operations management tools and the required ICT systems)
  - Coordination, mission and route planning functionalities for field machinery
  - Closed loop integrated optimal planning, execution of automated field operations and monitoring

SEVENTH FRAMEWORK PROGRAMME

GNSS and big data

- GEOPAL product provides high accuracy
  - -> by using of the EGNOS system and GNSS signal

- Won the prestigious medal **AgriTechnica 2015**: to be awarded in November 2015 (via CLAAS route-optimizing software)

H2020 projects are on the way to deliver mapping products: mapKITE

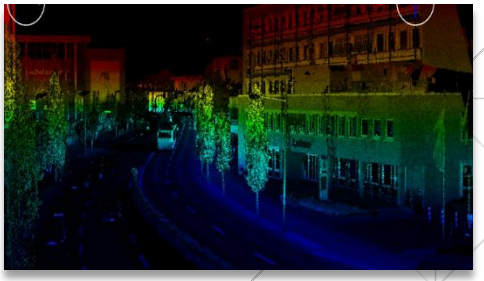
mapKITE

Core components

- **Galileo+ EGNOS**
- "follow-me" UAS-car
- Remote sensors and data from air and ground

Developed an innovative mapping system that takes advantage of the Galileo and EGNOS:

- Design, develop and exploit a practical **mobile tandem terrestrial-aerial mobile mapping system**
- Geodata acquisition and post-mission processing of corridors (roadways, railways and/or waterways)
- Calibrated aerial and/or terrestrial imagery and 3D models
- Easy to understand and use during field work
- Improve on site interaction and navigation application
- Commercialize the final product and related services and address relevant markets



Farming by Satellite contest: Fostering innovation that trigger new apps and business ideas

http://www.farmingbysatellite.eu/

2016 winners have been announced in Green Week in Berlin in January 2017

1st place: ISA Lille, France
2nd place: TTT Solutions, Czech R.
3rd: Glorify (Ambrogio Zanzi), Italy
Special Africa Prize: Shamballite, Kenya

GSA supports Young Surveyors

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

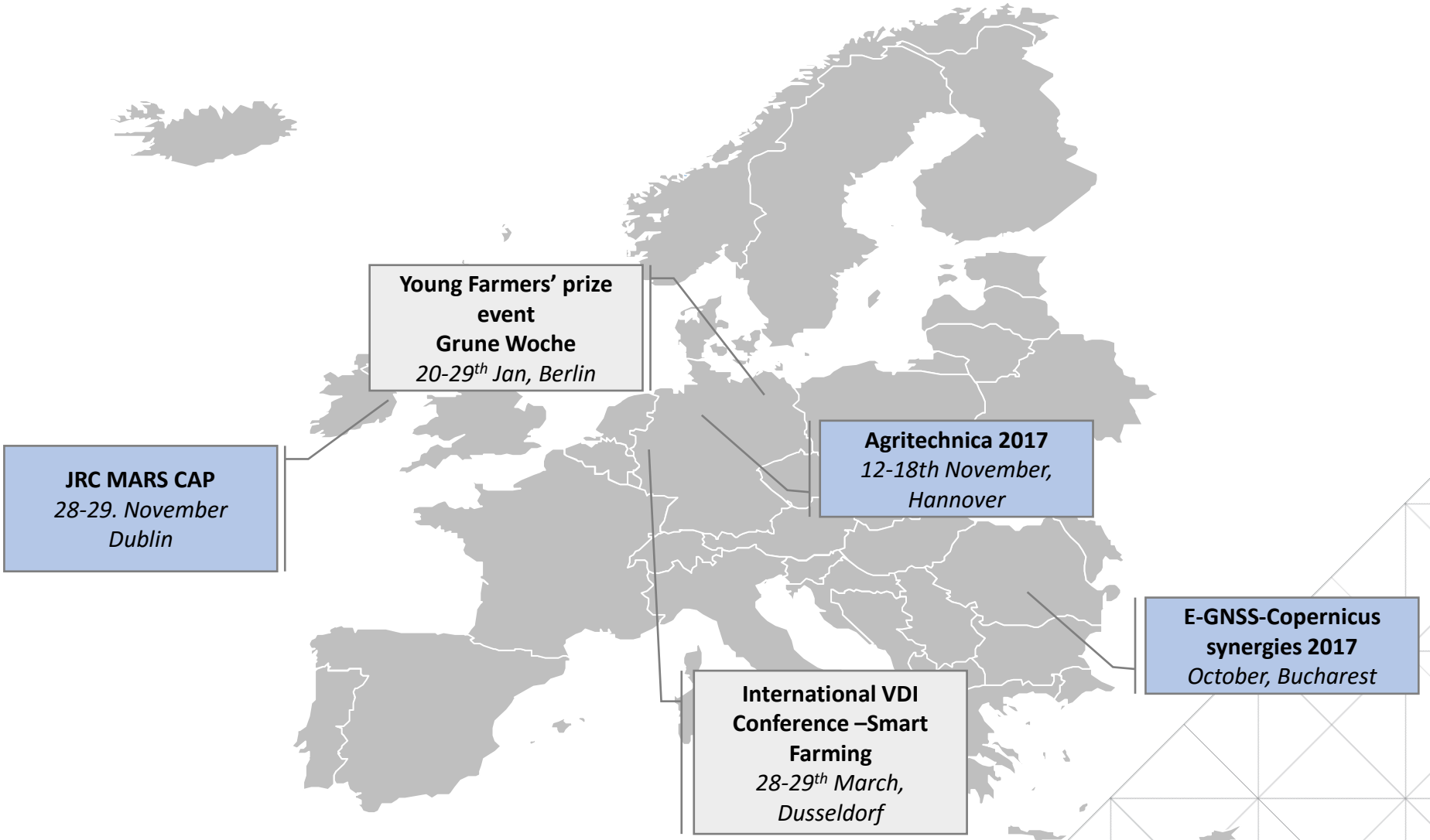
GSA is sponsoring a **special prize dedicated to Galileo, EGNOS and Copernicus** as part of the annual Council of Geodetic Surveyors' Young Surveyors prize

2016 winner has been announced in Intergeo in Hamburg in October 2016

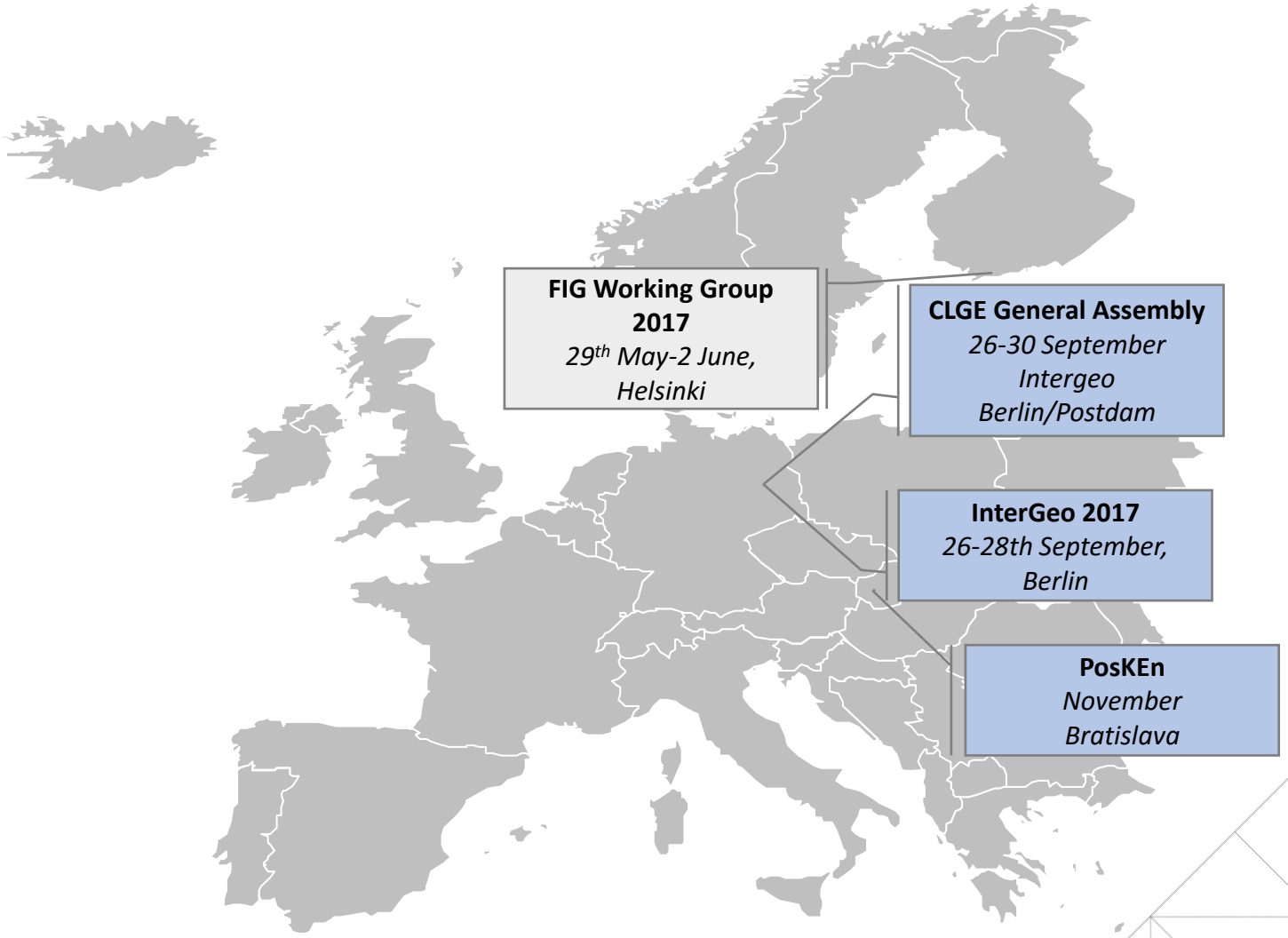
Cecile Deprez, a PhD student at the University of Liege in Belgium, proposed an idea potentially bringing considerably higher precision to mass-market applications, relying on Google's provision of access to GNSS raw measurements for Android users by using of Galileo E5.

Awarding of CLGE Students 2017, *27th September 2017 Intergeo, stand A4.032*

GSA is leveraging the biggest agriculture events



GSA is leveraging the biggest surveying events



Linking space to user needs

How to get in touch:

GSA Newsletter

GNSS YouTube Channel

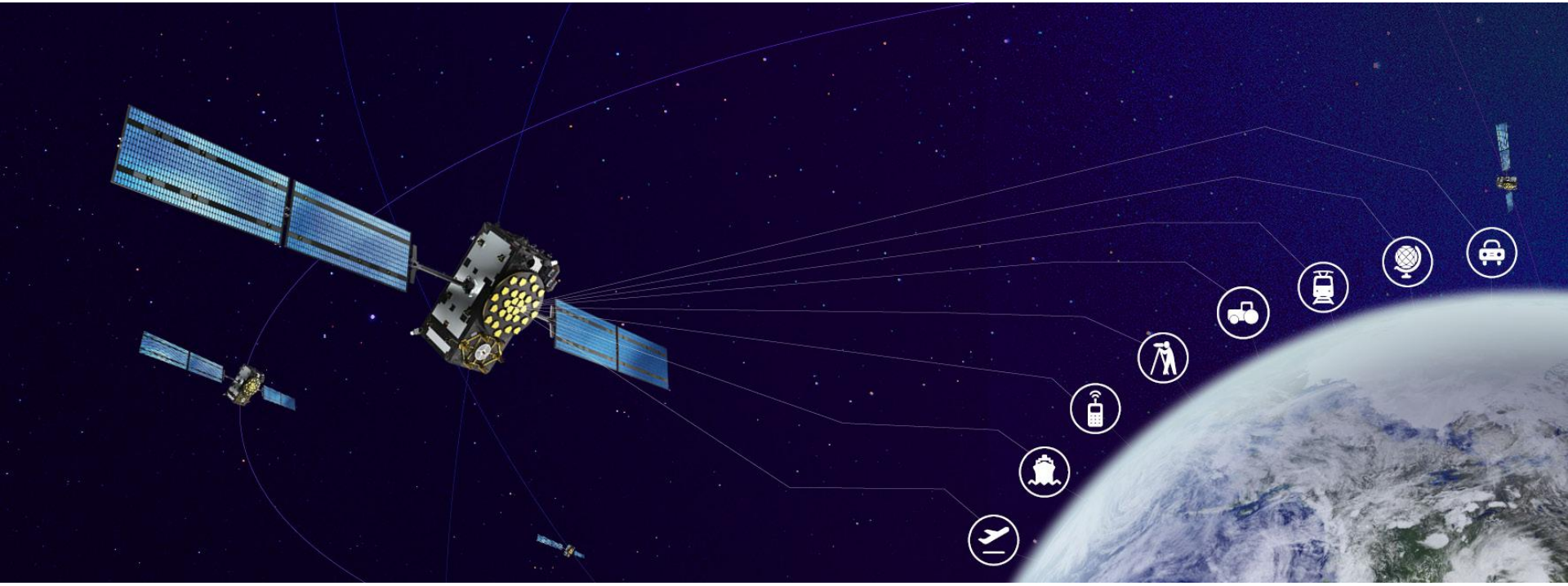
GSA Twitter - @EU_GNSS
EGNOS Twitter - @EGNOSPortal

European GNSS Agency LinkedIn Page
GNSS Market, Research & Development

GNSS Facebook page

GNSS Slideshare Page (presentations)

www.GSA.europa.eu



European
Global Navigation
Satellite Systems
Agency

GALILEO EGNOS

NAVIGATION SOLUTIONS
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Thank you!

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