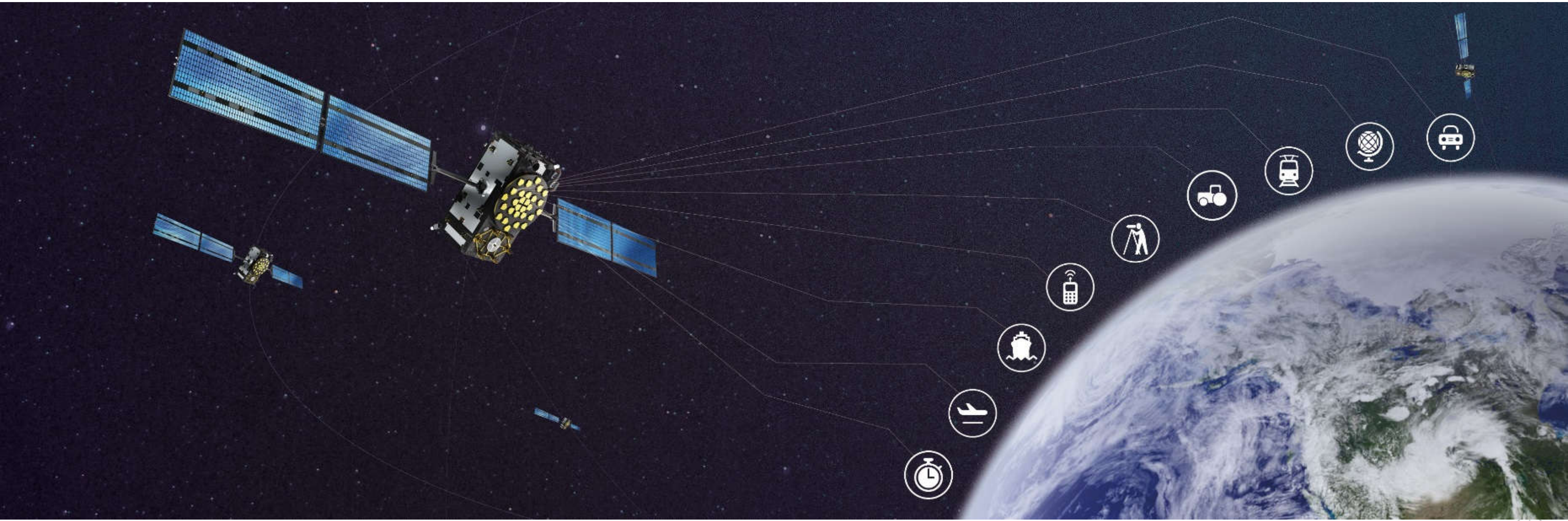


EU Services for Precision Farming

Máster Universitario en Ingeniería Agronómica

European Satellite Services Provider (ESSP), European GNSS Service Center (GSC) and European GNSS Agency (GSA)

September 28th, 2020

15 Years of EU Satellite Navigation

GSA

GALILEO EGNOS

NAVIGATION MADE IN EUROPE

Copernicus

Europe's eyes on Earth

Agenda for today

- Introduction
- Information about Galileo
- Information about Copernicus
- Information about EGNOS
- Synergies between EGNSS and Copernicus
- Q&A Discussion
- How EGNOS is being used in agriculture today?

Would you like to provide feedback?

Who are the speakers today?

María Eva RAMÍREZ
European GNSS Service Center (GSC)

Teresa MARTÍNEZ RECHE
European Satellite Services Provider (ESSP)

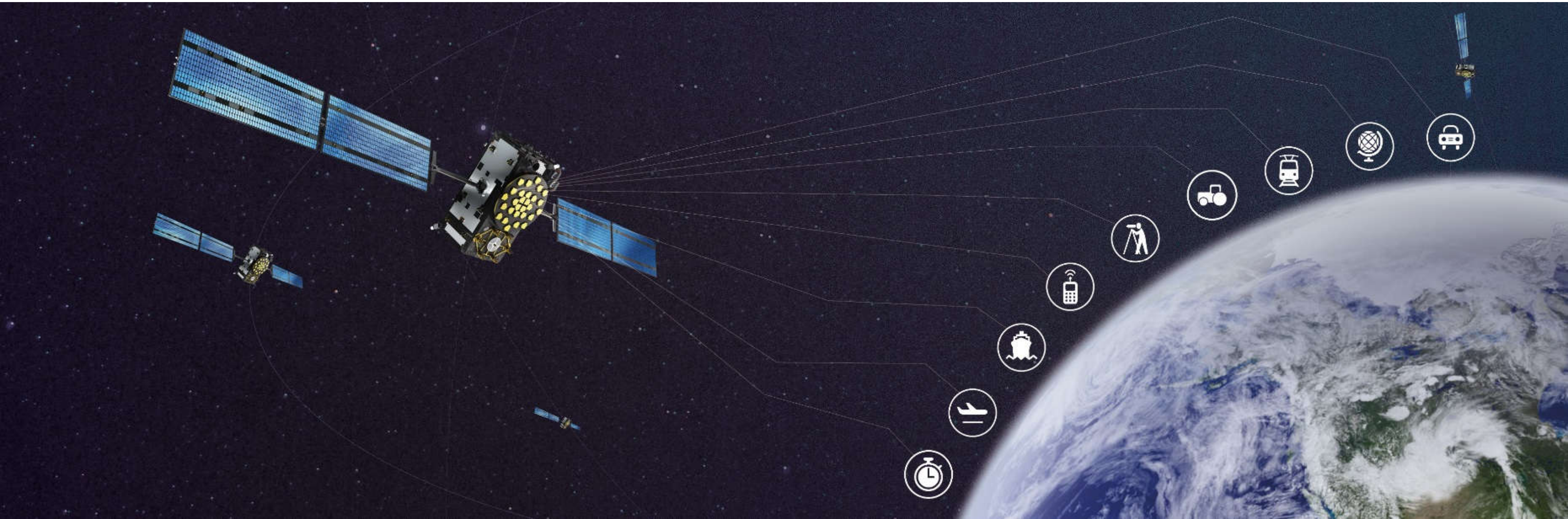
Maria RUIZ MOLINA
European Satellite Services Provider (ESSP)

Joaquin REYES GONZÁLEZ
European GNSS Agency (GSA)

GALILEO

Copernicus
Europe's eyes on Earth

EGNOS



15 Years of EU Satellite Navigation

GSA

Introduction

Máster Universitario en Ingeniería Agronómica

Joaquín REYES GONZÁLEZ

September 28th, 2020

GALILEO EGNOS

NAVIGATION MADE IN EUROPE

Copernicus

Europe's eyes on Earth

Who is who in the EU space?

GSA

European Commission

esa

European Global Navigation Satellite Systems Agency

ESSP

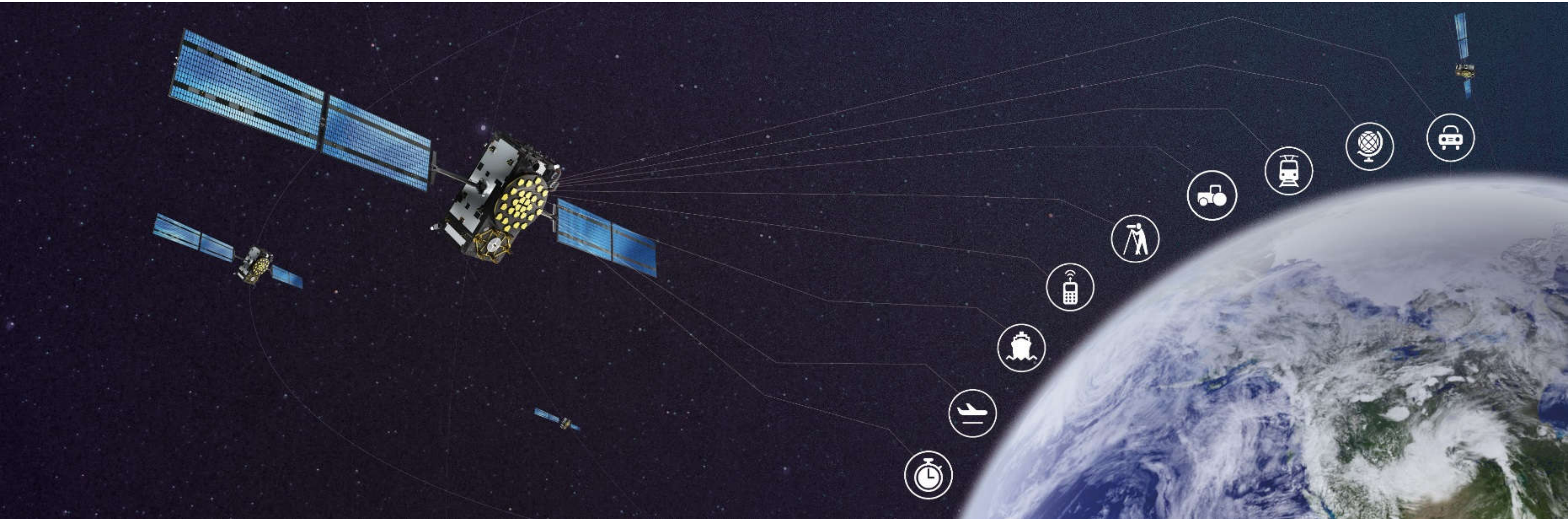
spaceopal

GALILEO

Copernicus
Europe's eyes on Earth

EGNOS

GSA is headquarter in Prague with several premises across Europe



Introduction to Galileo System and Applications in Agriculture Domain

Máster Universitario en Ingeniería Agronómica

María Eva RAMÍREZ

September 28th, 2020

15 Years of EU Satellite Navigation

GSA

GALILEO EGNOS

NAVIGATION MADE IN EUROPE

Copernicus

Europe's eyes on Earth

Goals

1. To know the main Galileo Differentiators
2. To Understand the main elements within Galileo System
3. To know the current and future Galileo Services
4. Applications in Agriculture
5. GNSS Service Center

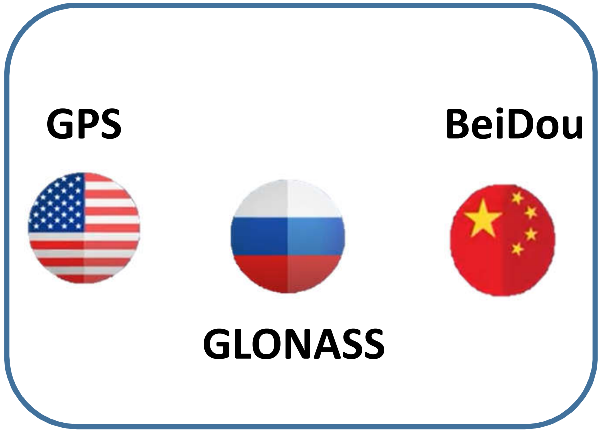
Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

1

Galileo Differentiators

Galileo Background - Introduction

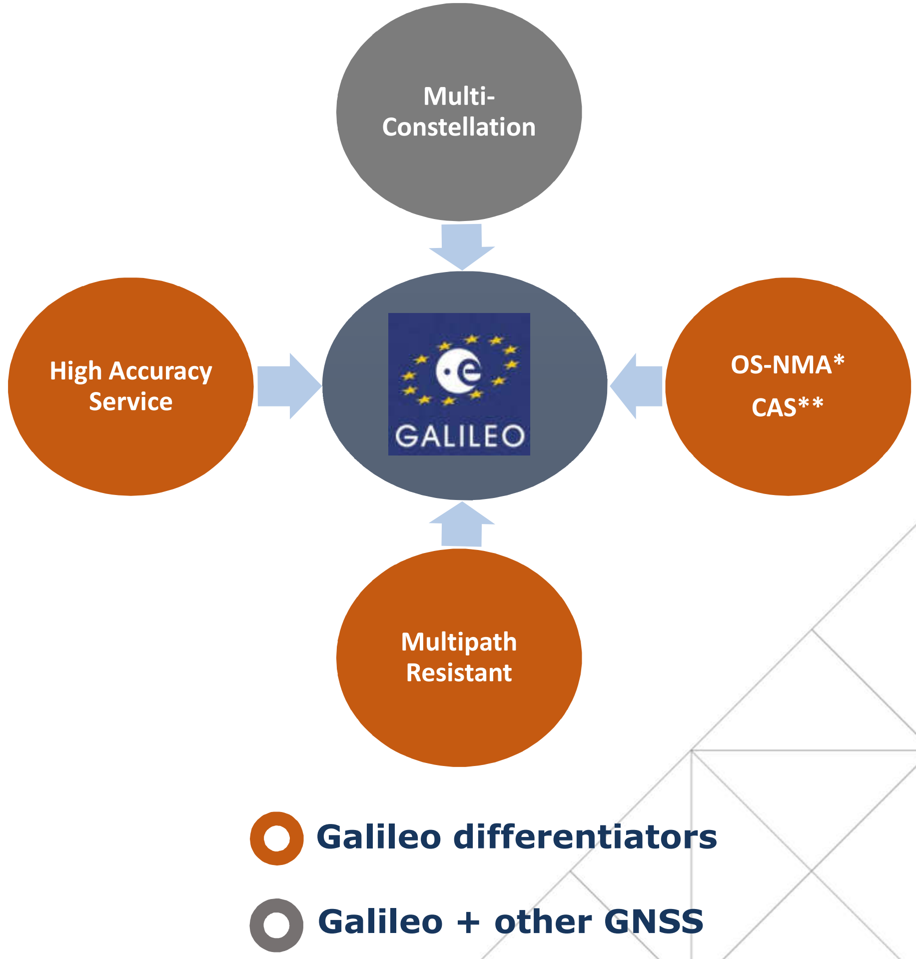
Galileo Galilei



Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo Background – Differentiators

- ✓ Fully **interoperable** with other GNSS constellations
- ✓ **Open service free of charge**, delivering **multiple frequencies**
- ✓ Modern signal is more **resistant to multipath**
- ✓ **Global high-accuracy service** for free delivering down to 20 cm accuracy
- ✓ Only constellation that provides **Signal and data authentication,** offering trustability for civilians



**Open Service Navigation Message Authentication (OS-NMA)*
***Commercial Authentication Service (CAS)*

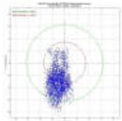
Galileo Background – Important Dates

1999
First appearance of Galileo in the Communication of the European Commission.

2003
Development of two test satellites GIOVE-A and GIOVE-B.

2006
GIOVE-A transmits the first Galileo-like signal towards the Earth.

2011
First two operational satellites (GSAT0101 and GSAT 0102) are launched on October.



2013
First independent Galileo position fix is achieved on 12 March 2013

2016
December 15th

Galileo Initial Services

2018

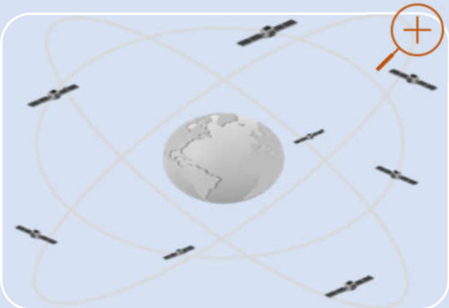
4 Galileo satellites successfully launched on a customized Ariane 5 on 25/07, 2018

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

2

Main Elements of Galileo System

Galileo System



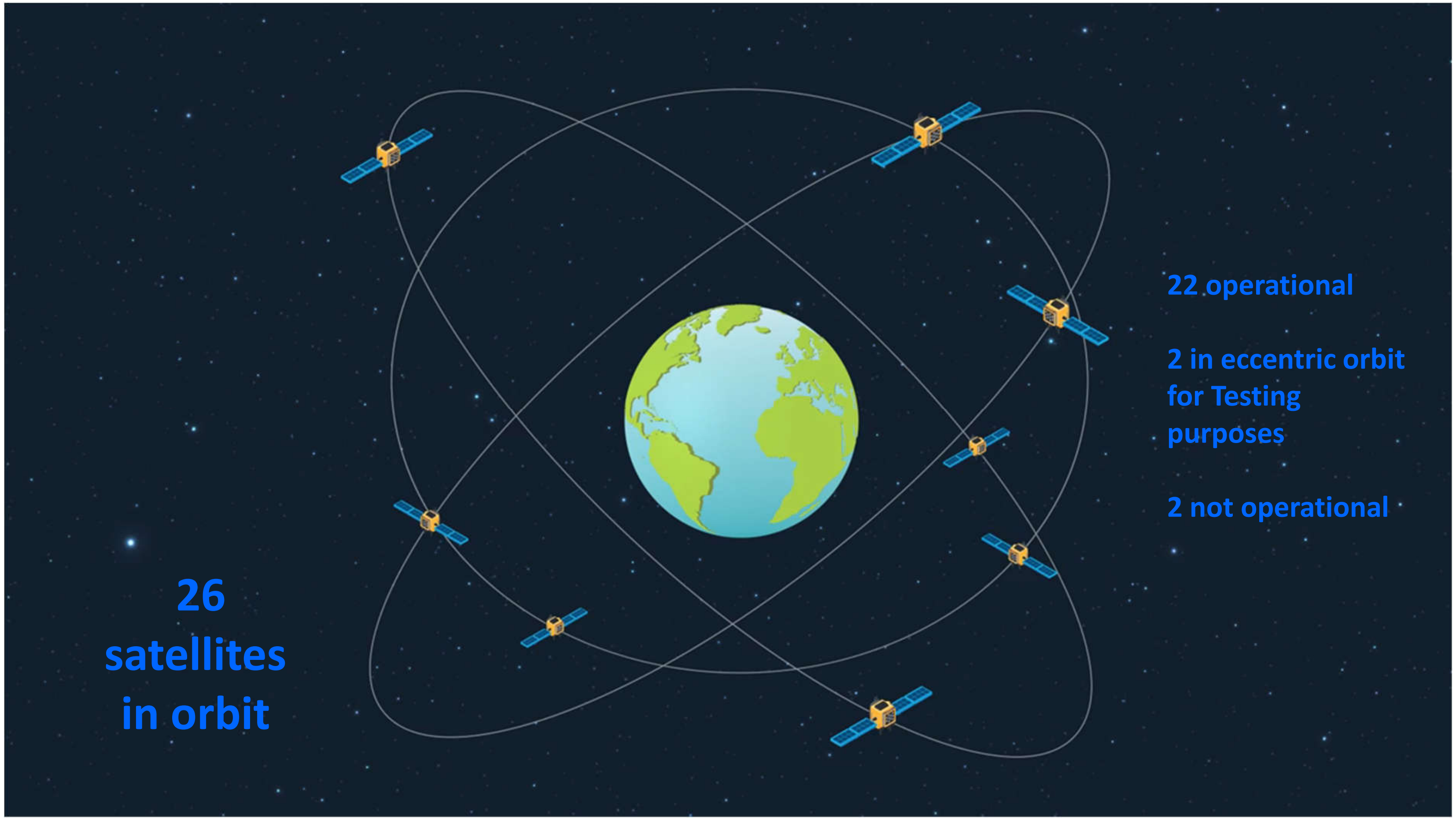
Space Segment

Ground Segment

User Segment

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo System: Space Segment



Once fully deployed:

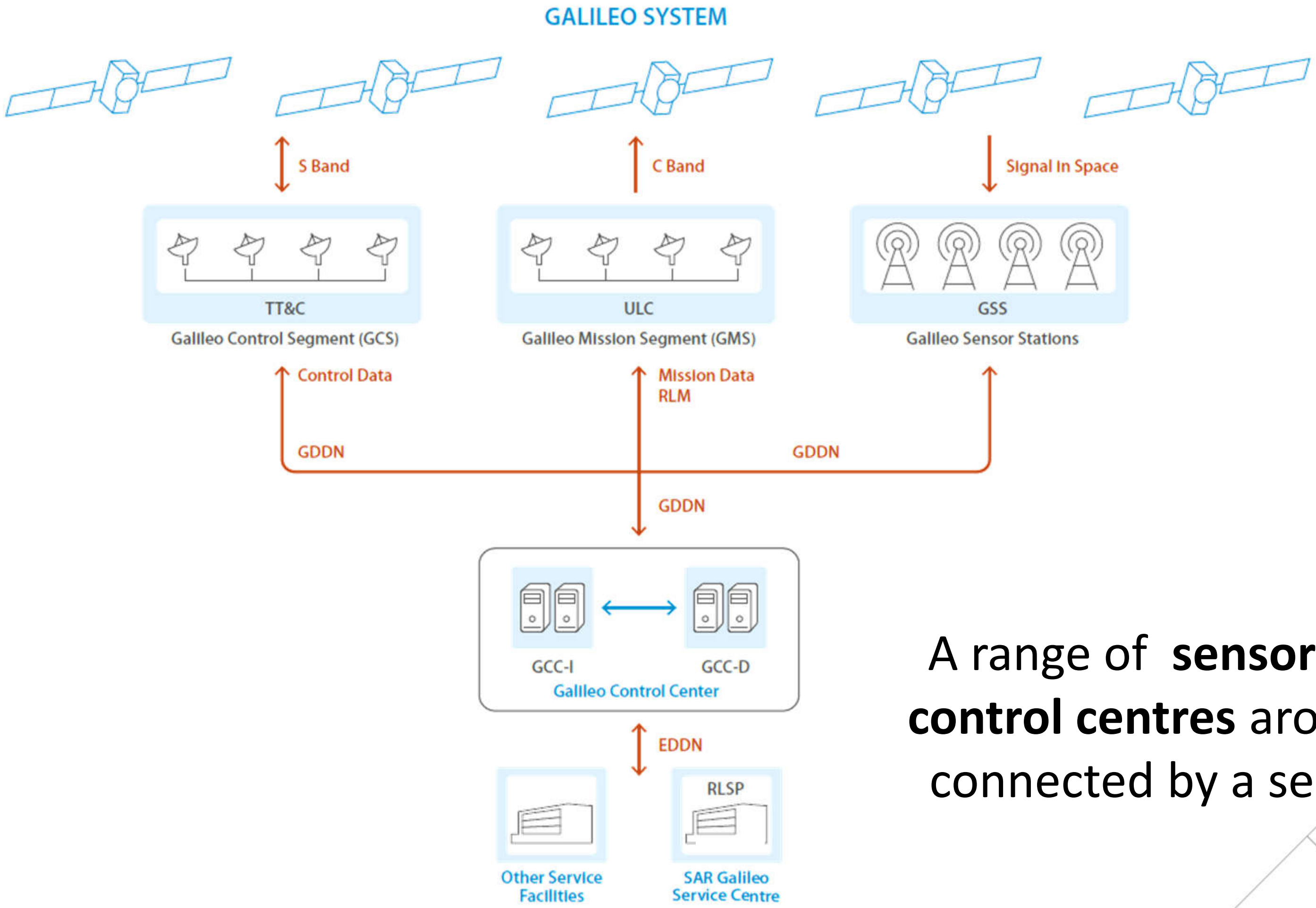
30 satellites

24 operational
+
6 orbit spares in 3 Medium Earth Orbit (MEO) orbital planes: 23.200 km

spaceopal
a DLR GfR and Telespazio company

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo System: Ground Segment



A range of **sensors stations** and **control centres** around the world, connected by a secure network.

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo System: Ground Segment

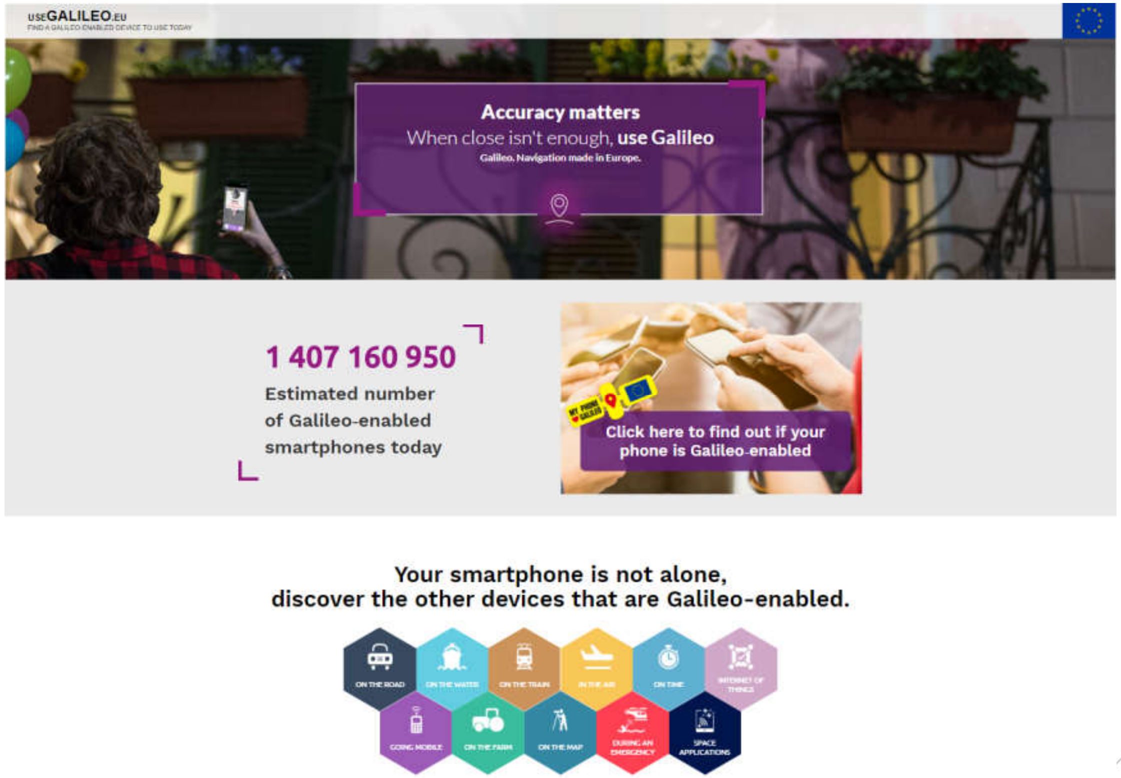
Source: [esa.int]

spaceopal
a DLR GfR and Telespazio company

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo System: User Segment

www.usegalileo.eu



The set of **receivers and devices** provided with the set of signals and making use of the Galileo services

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

3

Galileo Services

Galileo Services: Current and Future

- ✓ **Freely accessible service for** positioning, timing and navigation message authentication
- ✓ Encrypted service for **governmental authorised** use, designed for greater robustness and higher availability
- ✓ **Assists locating people** in distress and confirms that help is on the way

New services on the horizon

- ✓ Freely accessible global **high accuracy positioning service**
- ✓ **OS-NMA Navigation Message Authentication (free), and Commercial Authentication service,** based on the E6 signal code encryption, 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)

Commercial Authentication Service (CAS)

4

Agriculture Applications

From its beginning, agriculture has not stopped evolving

Agriculture 1.0

From Ancients to 1920

Manual labor, intensive labor, relative small and diverse

Agriculture 2.0

From 1920 to 2010

Agribusiness appears

machines, fertilizers, better seeds, agronomic management practice

Agriculture 3.0

From 2010

Precision Farming

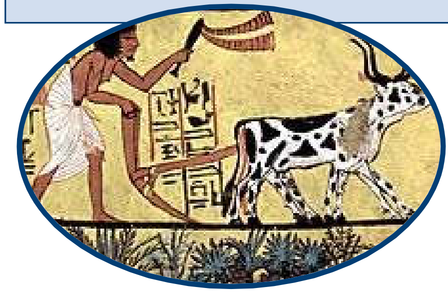
Guidance systems, yield monitoring, sensors, data management, etc.

Agriculture 4.0

From now on!

New technologies

IoT, Real Time analysis, satellite imagery, prediction, resources optimization



What we look for in Agriculture

Accuracy

Availability

Continuity

Authentication

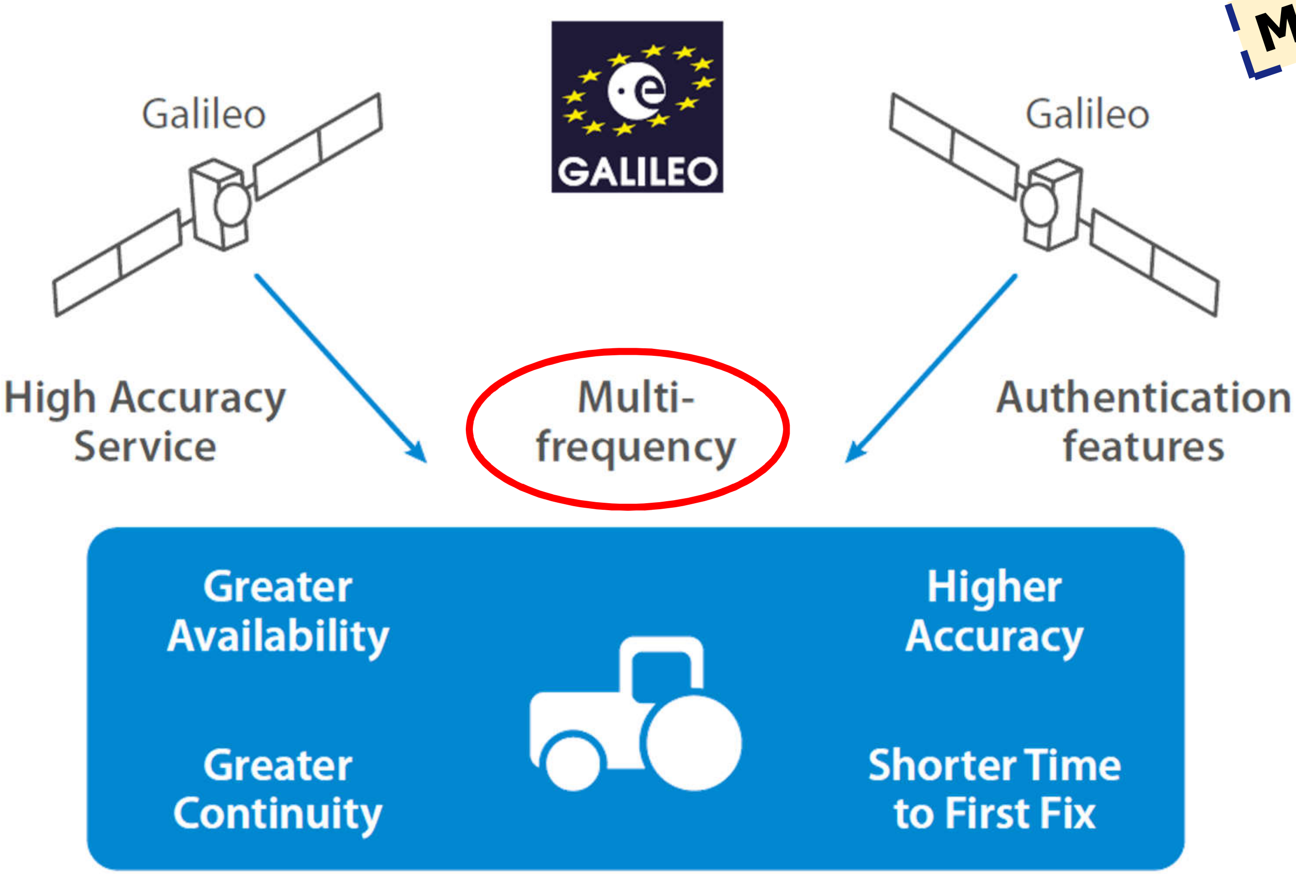
Connectivity

Interoperability

Traceability

Galileo for Agriculture Applications

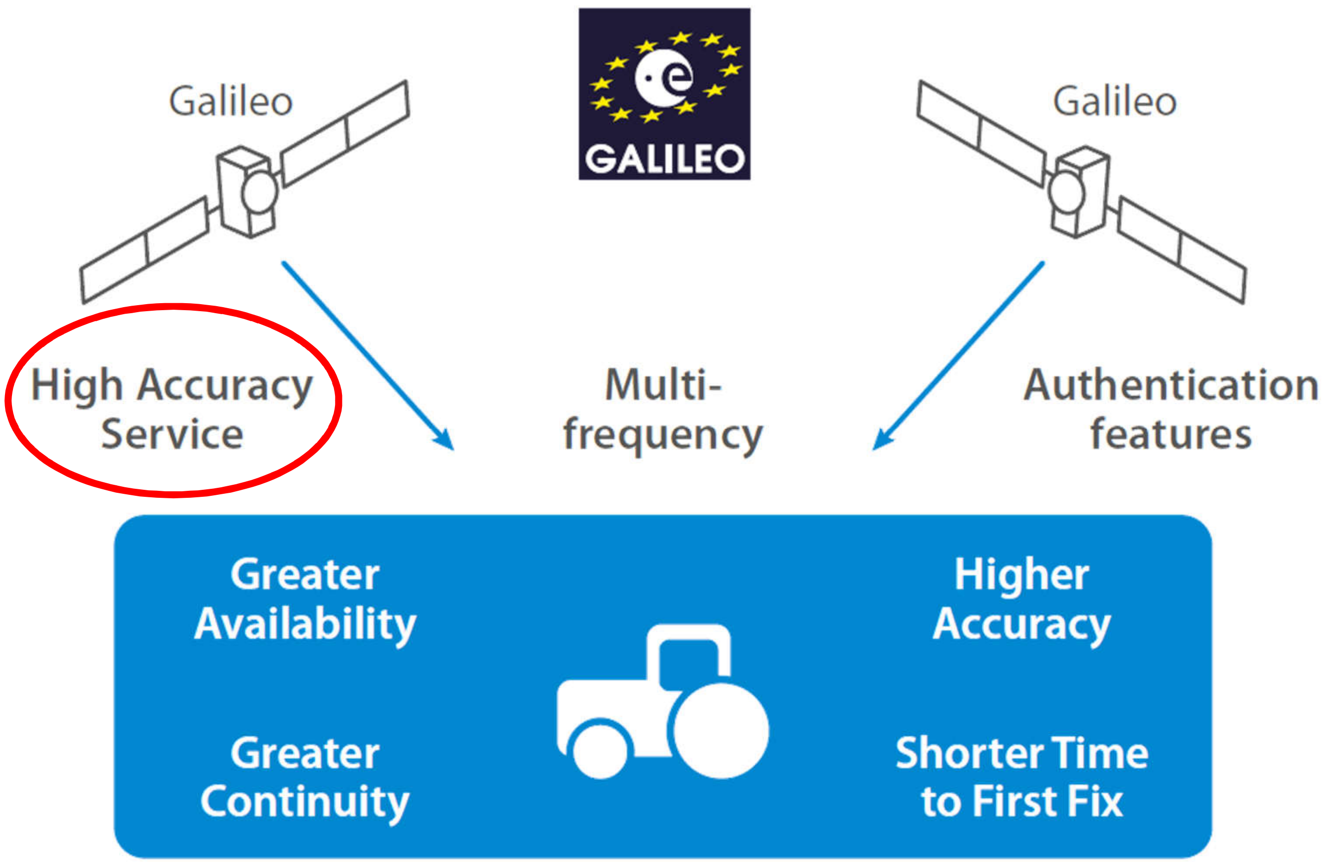
MULTI-FREQUENCY



- ✓ Better **coverage** and **improved performance in harsh environment**
- ✓ Better **Resilience to Multipath Effects**
- ✓ Significantly benefits for faster **TTFF**, **convergence** and elimination of **ionosphere** effect

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo for Agriculture Applications



HAS

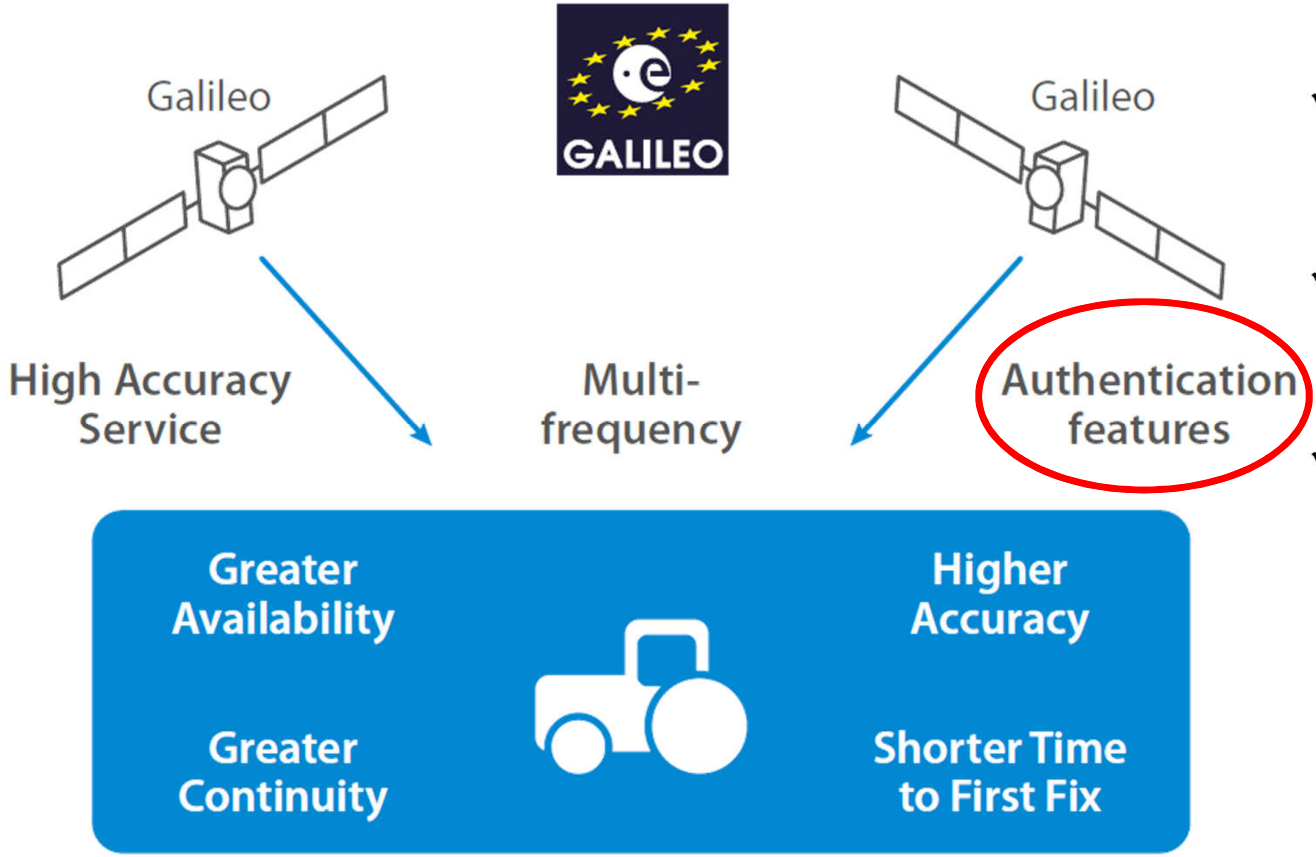
- ✓ High Accuracy corrections **across the globe and for free**
- ✓ Around **20 cm target accuracy**
- ✓ **Nor require proximity** to base stations for corrections
- ✓ Useful for **guidance, monitoring, VRA, field delineation**

spaceopal
a DLR GfR and Telespazio company

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

Galileo for Agriculture Applications

OS-NMA & CAS



- ✓ **OS-NMA** through E1 frequency, **cost-free** service
- ✓ Additional **encrypted spreading codes** in the E6 signal through CAS to protect against sophisticated attacks
- ✓ Assure that the positioning is based on **authentic measurements and data transmitted by Galileo satellites**, to **prevent spoofing**
- ✓ Useful for **geo-traceability, geo-tagging photo within CAP, autonomous/automatic steering**

Current Applications: agriculture solutions registered growth across different applications

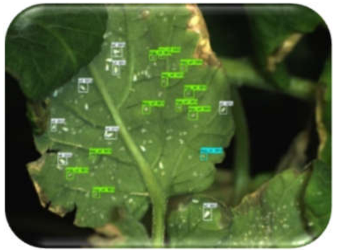
Precision Agriculture

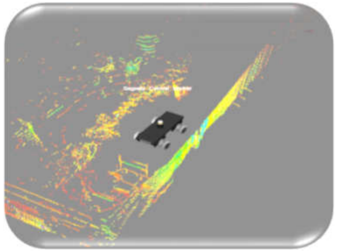
- Farm machinery guidance: GNSS positioning for drivers **assistance.**
- Automatic steering allows he operator to engage in core agricultural tasks.
- Variable rate application uses GNSS positioning with information from other sensors.
- Yield monitoring for site-specific monitoring of harvest, combining the output of a yield sensor with GNSS positioning
- Biomass monitoring enables site-specific monitoring of biomass in an agricultural field.
- Soil condition monitoring for updates of soil moisture levels, fertility or diseases to optimize their management. GNSS used for soil samples positioning.
- Livestock tracking and virtual fencing to track animals.
- Precision Viticulture relies on GNSS for the geo-location of sensors.
- Precision Forestry uses GNSS for site-specific forest management.

Agri-logistic Applications

- Farm machinery monitoring and asset management use real-time GNSS information for monitoring the location and mechanical status of equipment.
- Geo-traceability enhances the effectiveness of food, animal and product traceability.
- Field definition is the activity of measuring precisely the boundaries and the size of agricultural fields.
- Geo-tagged photos EGNSS4CAP– enabled by GNSS – will be used under the CAP in support of subsidies control (validation process) and updates on the Land Parcel Identification System (LPIS).

GREENPATROL: robotic solution for Integrated Pest Management





The GreenPatrol project makes direct use of the added value provided by European GNSS to develop an **innovative robotic solution for Integrated Pest Management in greenhouses**

Project relies on increasing accuracy provided by Galileo, thanks to its signal strength inside the greenhouse and to the availability of multiple frequencies

http://www.greenpatrol-robot.eu/

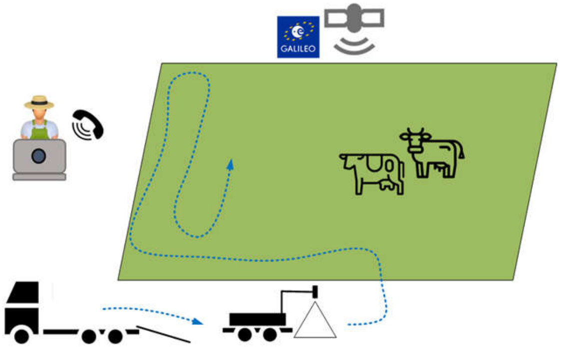
Galileo Servi … ope … under European Union
funded conti … h the GSA, which is the Galileo Service Provider

GALIRUMI: Galileo-assisted robot to tackle the weed of dairy farming

Two new techniques to control broad-leaved dock

Electric weeding

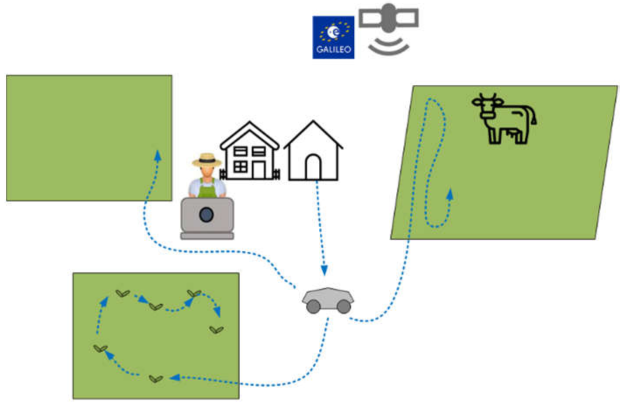
- Medium size robot.
- Operation through farm contractor.



1) Farmer notifies contractor that needs to clean pasture.
2) Contractor brings a robot, set it in motion and leaves.
3) Using Galileo, robot traverses the entire pasture systematically and autonomously.
4) Weed killed with a high-voltage electric shock.
5) Once finished, robot notifies the contractor to come and pick it up.

Laser weeding

- Small and less expensive robot.
- Farmer operates its own robot.



1) Farmer owns a small robot and deploys on each pasture when needed (several times during a growing season).
2) The first time, robot traverses the entire pasture to search for weeds. Robot degrades the weed by removing its leaves using laser.
3) Galileo is used to record the location of the weeds.
4) In ongoing robot deployments, stored locations of weeds are used to move from weed to weed.

Enabling the digitisation of agriculture government controls through EGNSS

Open Source Android application using GNSS raw measurements and **EGNSS differentiators (Galileo dual-frequency and Galileo authentication service OS-NMA)**

- Increasing accuracy
- Increasing robustness against data manipulation (position and time)
- Can be integrated and customised for end-user solutions
- Generating input for the Integrated Administrative Control System (IACS) of the Common Agricultural Policy (CAP)

Get the app: www.EGNSS4CAP.eu

What future brings

Market and Technology Trends: GNSS is key to exploiting the full potential of future evolution in agriculture

5G: a key to unlock the benefits of digital farming

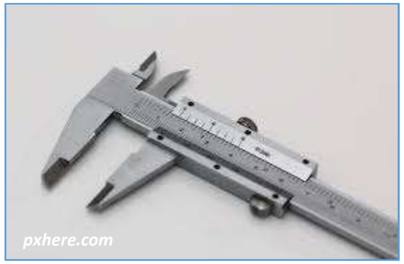
Big Data from Space

Apps

rise of autonomous tractors and robots

Interoperability

Increased Accuracy



Sustainability

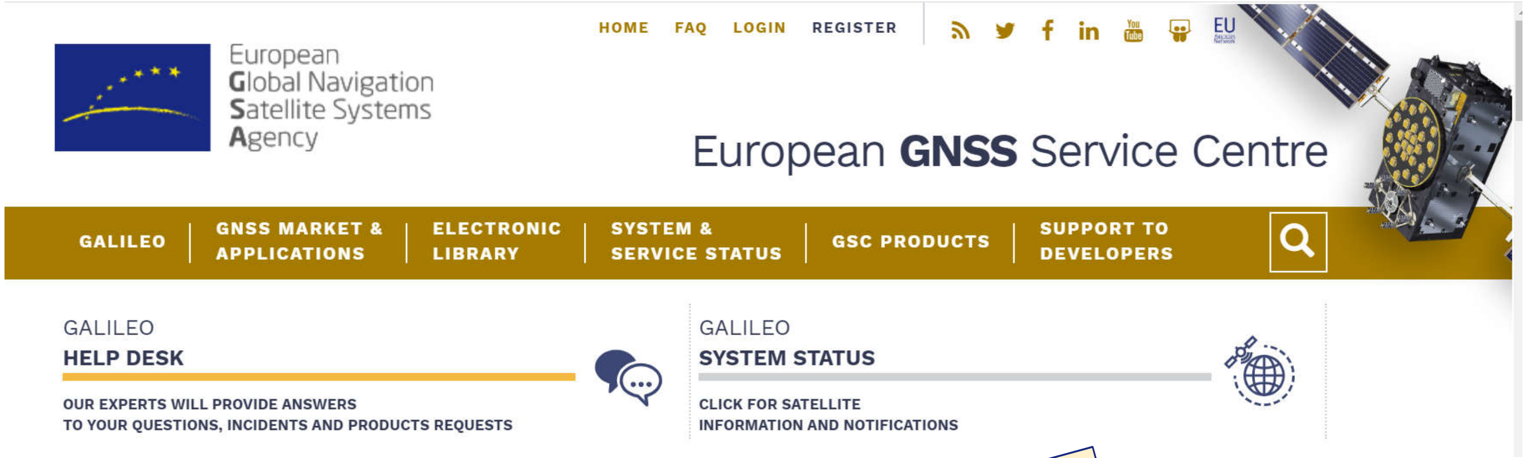
5

GSC: European GNSS Service Center

GSC – European GNSS Service Centre

https://www.gsc-europa.eu/

DON'T FORGET TO VISIT OUR WEB AND REGITER!



Almanacs

Satellite metadata

Source code

Galileo main features

Reference Documentation

Market and Technical Reports

Performance Reports

Service Status

Galileo Service Operator (GSOp) is operating at GSC, under European Union funded contract and concluded with the GSA, which is the Galileo Service Provider

EGNOS

Copernicus in Agriculture

TERESA MARTINEZ– ESSP
(Teresa.Martinez@external.essp-sas.eu)

ESSP-MOM-27104

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Table of contents

- Introduction
- Space component
- Services component: Land
- In situ Component (LUCAS)
- Applications in Agriculture

European Global Navigation Satellite Systems Agency

NAVIGATION MADE IN EUROPE

Table of contents

- Introduction
- Space component
- Services component: Land
- In situ Component (LUCAS)
- Applications in Agriculture

EGNOS
European Global Navigation Satellite Systems Agency
ESSP
NAVIGATION MADE IN EUROPE

Introduction of Copernicus

What is Copernicus?

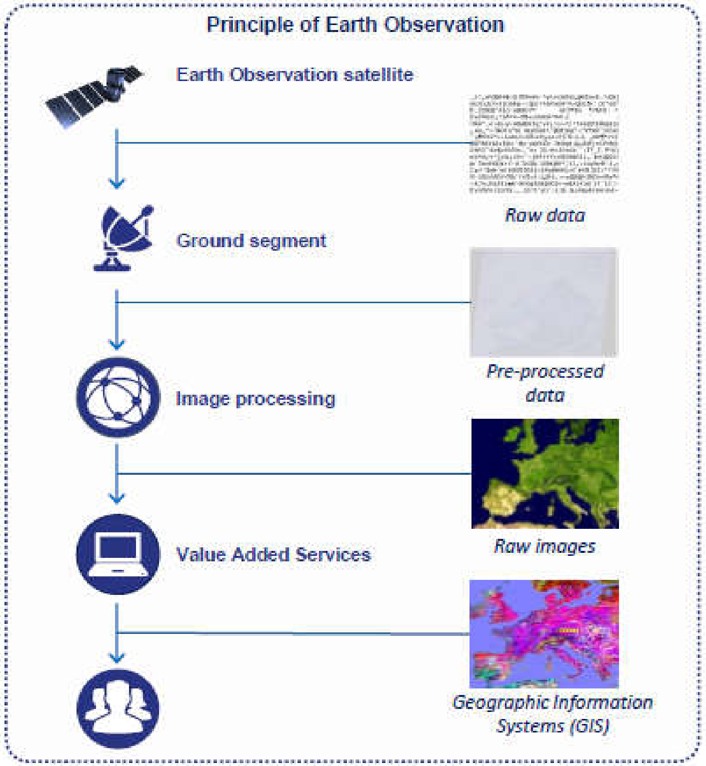
Copernicus, formerly GMES, is Europe´s Earth Observation and Monitoring Programme coordinated and managed by European Commission in cooperation with partners as ESA and EUMETSAT.

Copernicus provides innovative and effective tools to monitor our planet, facilitating and improving the exploitation and management of its multiple resources for the benefit of all European citizens.

Copernicus delivers operational data and information services freely and openly accessible in a wide range of application areas, based on satellite EO data and in situ (non-space) data.

Earth Observation (EO)

How the information in transformed to Value Added Services?



Copernicus supports precision farming for an Apulian vineyard.

Source: User stories ESA

EGNOS

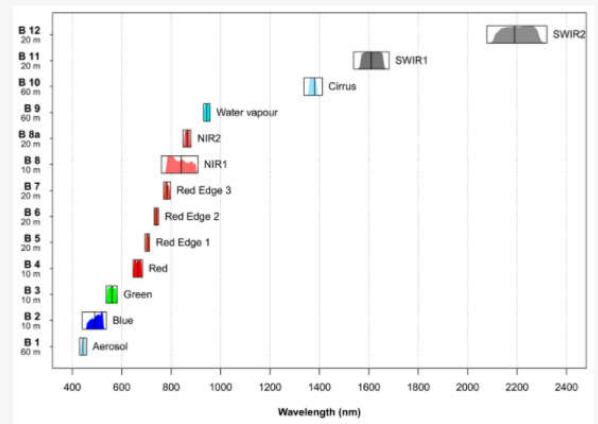
European Global Navigation Satellite Systems Agency

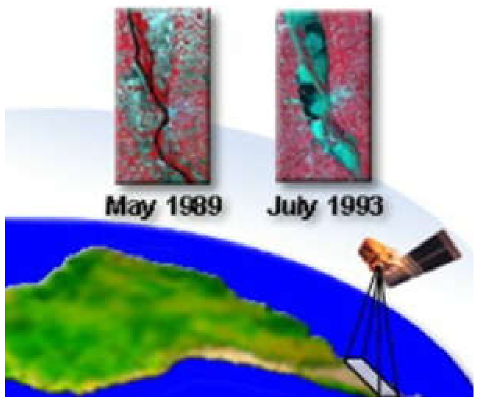
ESSP

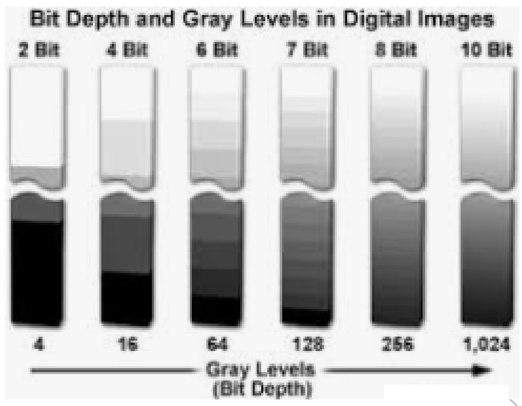
NAVIGATION MADE IN EUROPE

Resolution of images (EO)

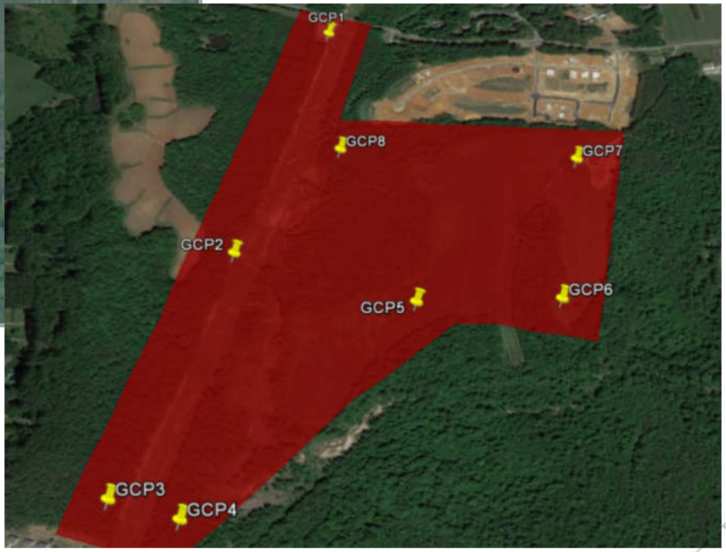
- Spatial
- Radiometric
- Spectral
- Temporal







Georreferencing (EO)



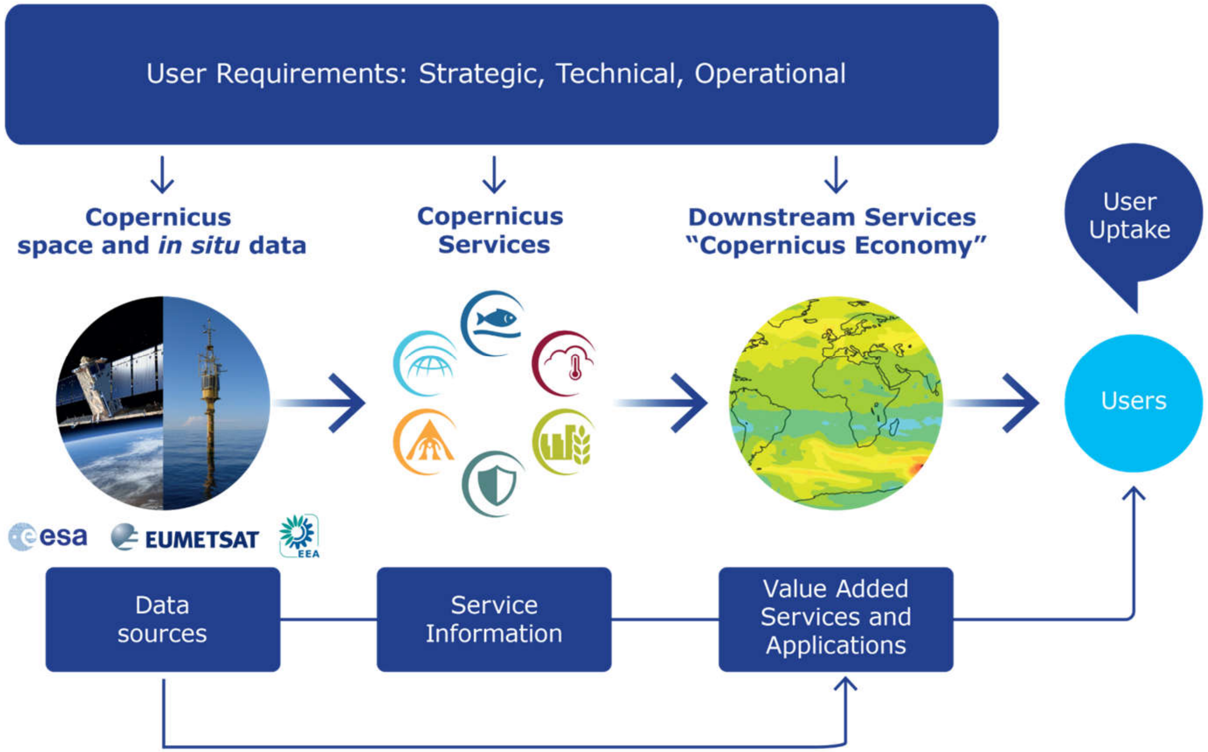
EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Value added services



EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Copernicus Components

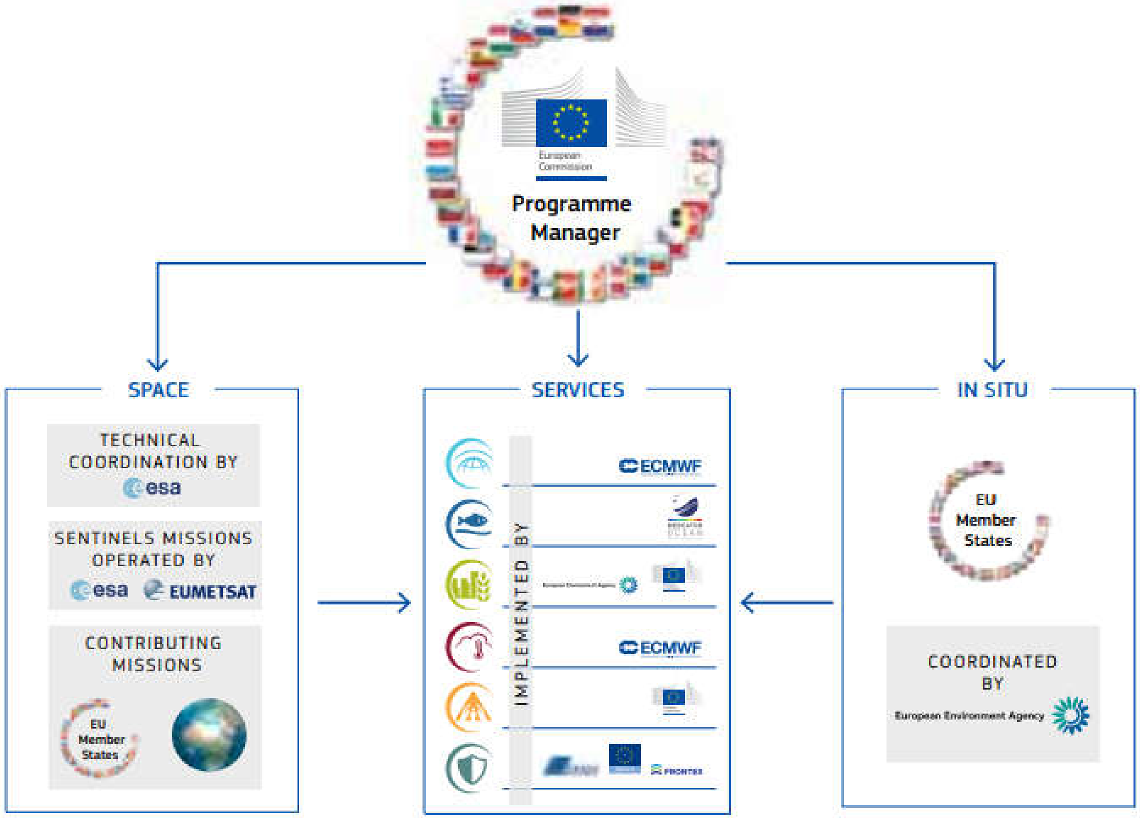
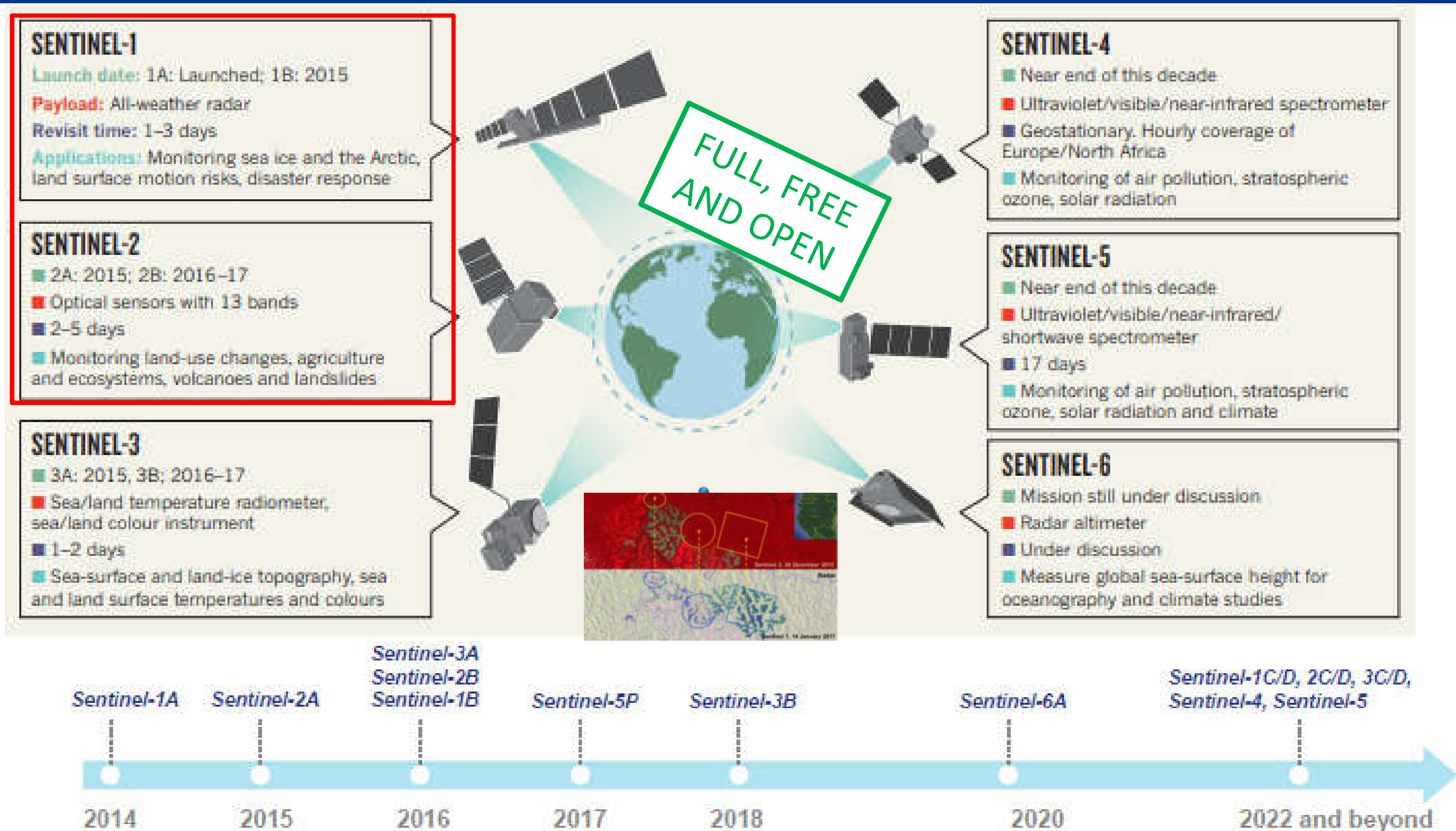


Table of contents

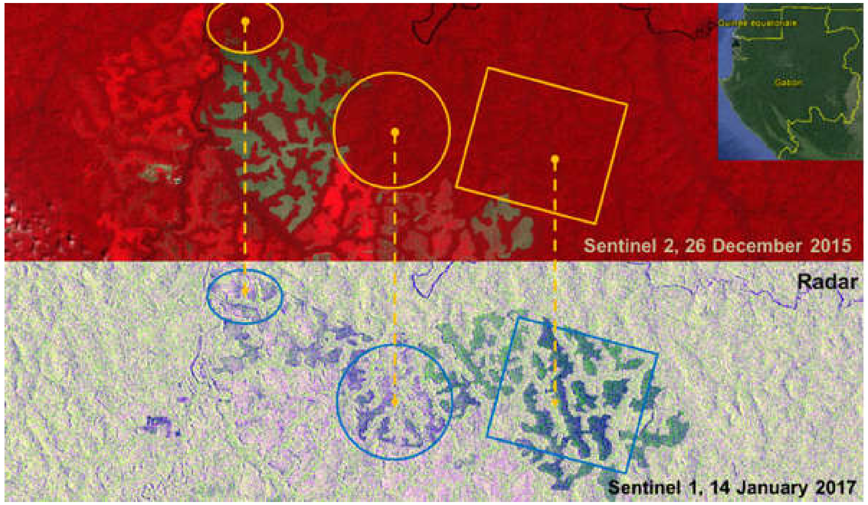
- Introduction
- **Space component**
- Services component : Land
- In situ Component (LUCAS)
- Applications in Agriculture

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

Sentinel constellation



Sentinel in agriculture



Sentinel 2 and 1 complementarity (water content): Source: ESA

Sensagri — HORIZON 2020

Example of project: H2020 SENSAGRI is developing and validating three prototypes for Copernicus Pan-European Land core services, for agricultural applications

Surface soil moisture (SSM), green and brown LAI and seasonal crop type mapping prototypes are based in the combined use of **Sentinel-1 and Sentinel-2**

Four proof-of-concept for agricultural monitoring services are also being developed and validated: regional-national detailed crop maps, tillage change detection, actual irrigation and yield estimation

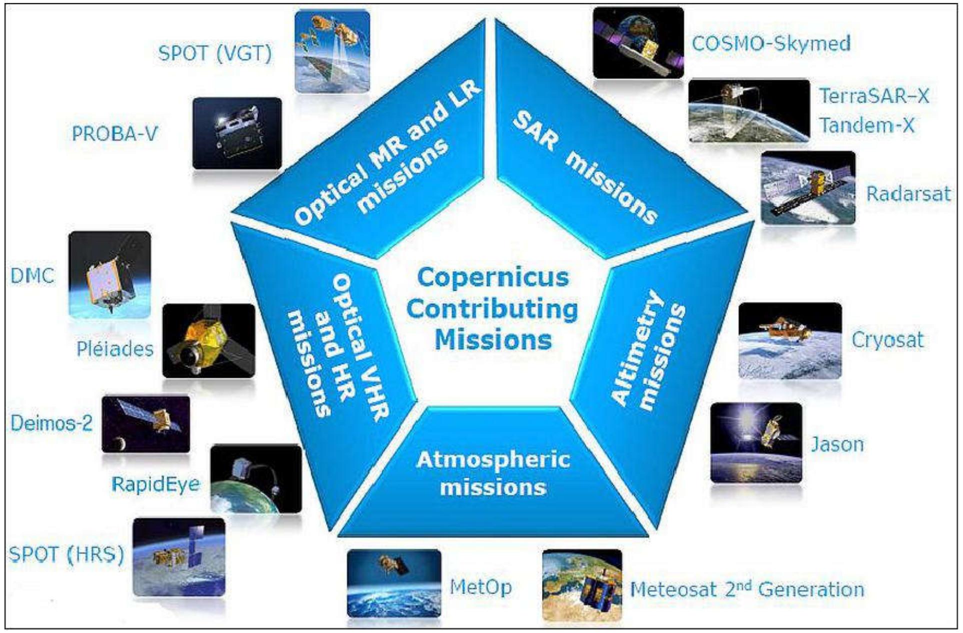
Contributing Missions

Contributing Missions:

Subject to Data Owner's Data Policy

Distributed by:

- ESA
- EUMETSAT
- National Space Agencies



NOTE: To obtain products with high accuracy, very high resolution data (VHR) from Contributing Missions tend to be required, which resolution is in the order of **EGNOS** and can contribute to improve the accuracy of the products derivate form these data.

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

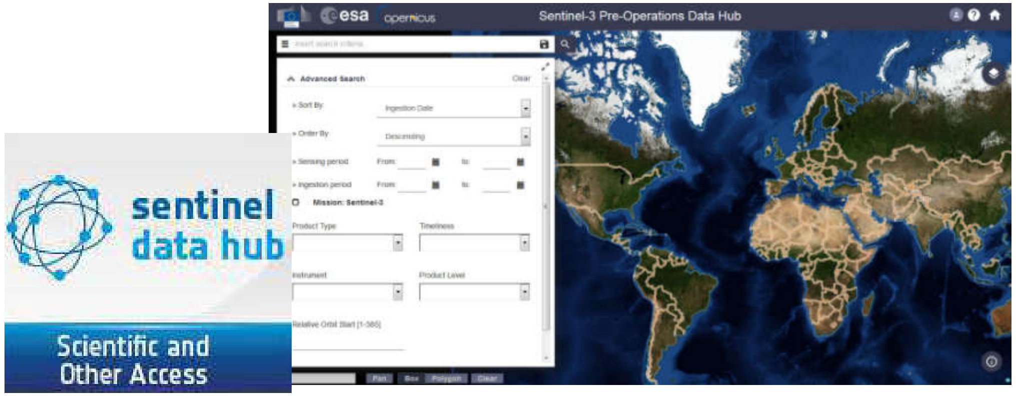
Access to satellite data

Managed by EUMETSAT:

- **EUMETCast**
- **CODA**

Managed by ESA:

- **Sentinels Scientific Data Hub**
- **CSDA**



How to access the data?

Registration and License signature:
https://spacedata.copernicus.eu/web/cscda/data-access/registration

↓

Select one or more datasets and Subscribe for data access
https://spacedata.copernicus.eu/web/cscda/data-access/subscription-to-datasets

↓

Download Data via FTP or the dedicated Catalogue and Download Tool
https://spacedata.copernicus.eu/web/cscda/data-access/discovery-and-download

DIAS: online platforms

Table of contents

- Introduction
- Space component
- Services component : Land
- In situ Component (LUCAS)
- Applications in Agriculture

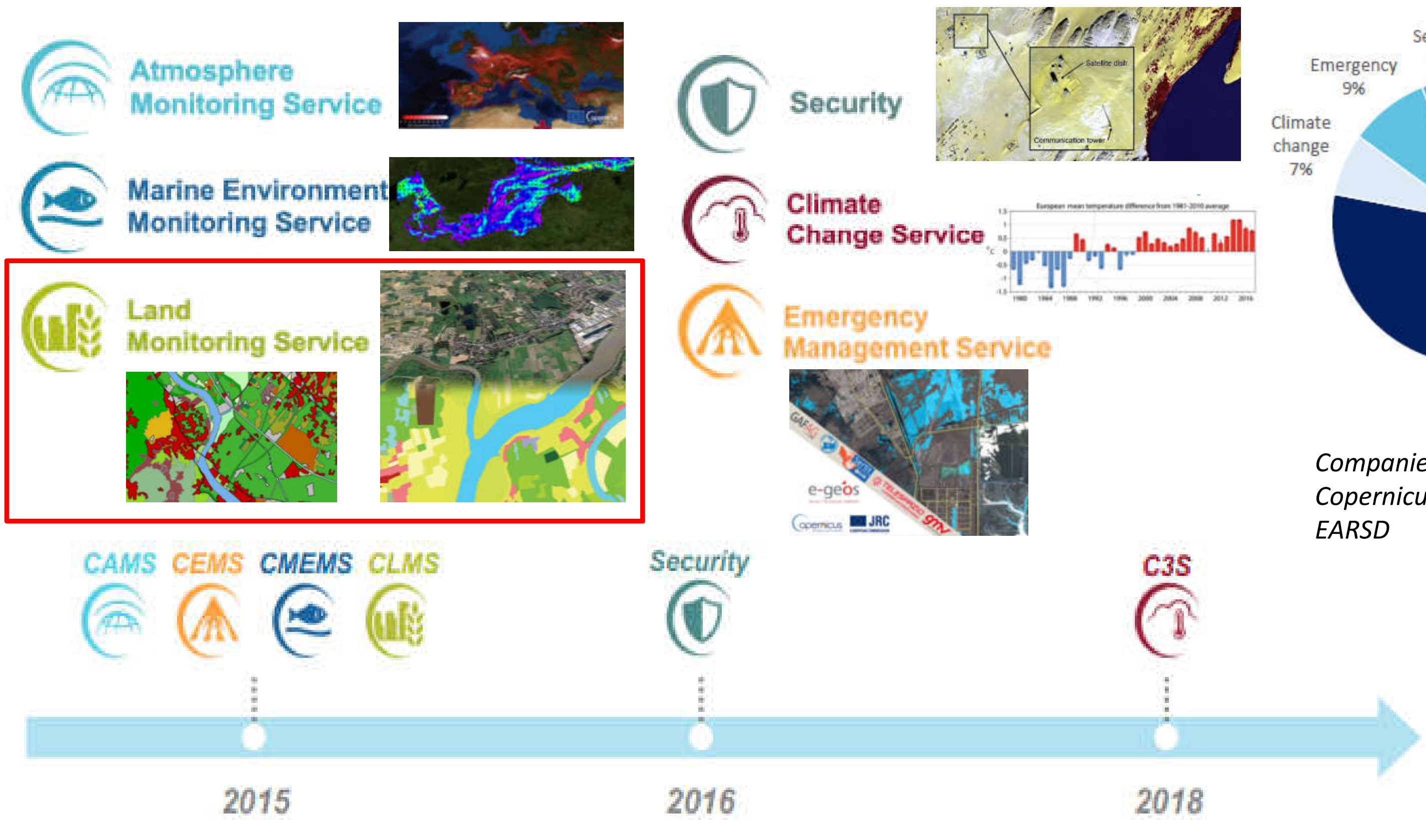
EGNOS

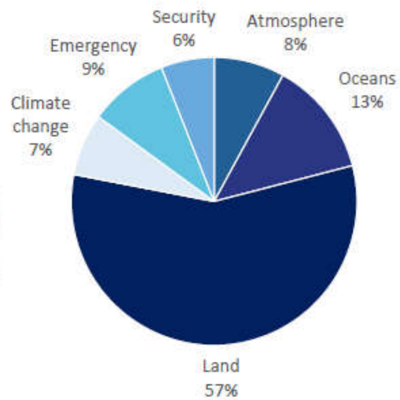
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Service component





Companies' interest in Copernicus services. Source: EARSD

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

Service component: Land

Land Monitoring Service

- Ecosystems
- Biodiversity
- Agriculture
- Forestry
- Energy
- Natural Resources
- Water
- Urban planning

Global

Pan-European

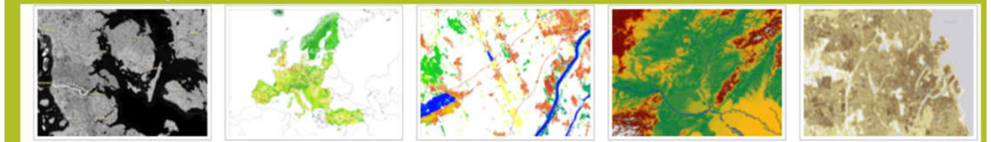
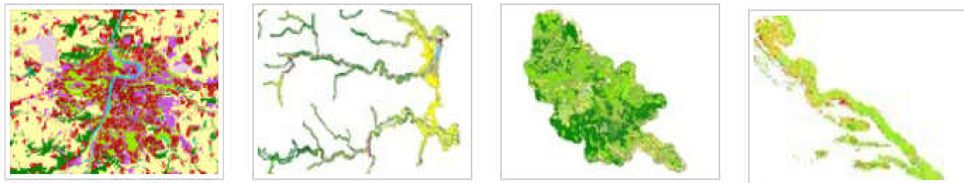


Image Mosaics | CORINE Land Cover | High Resolution Layers | Reference Data | Related Pan-European products

Local



Urban Atlas | Riparian Zones | Natura 2000 (N2K) | Coastal Zones

EGNOS | European Global Navigation Satellite Systems Agency | ESSP | NAVIGATION MADE IN EUROPE

Service component: Land

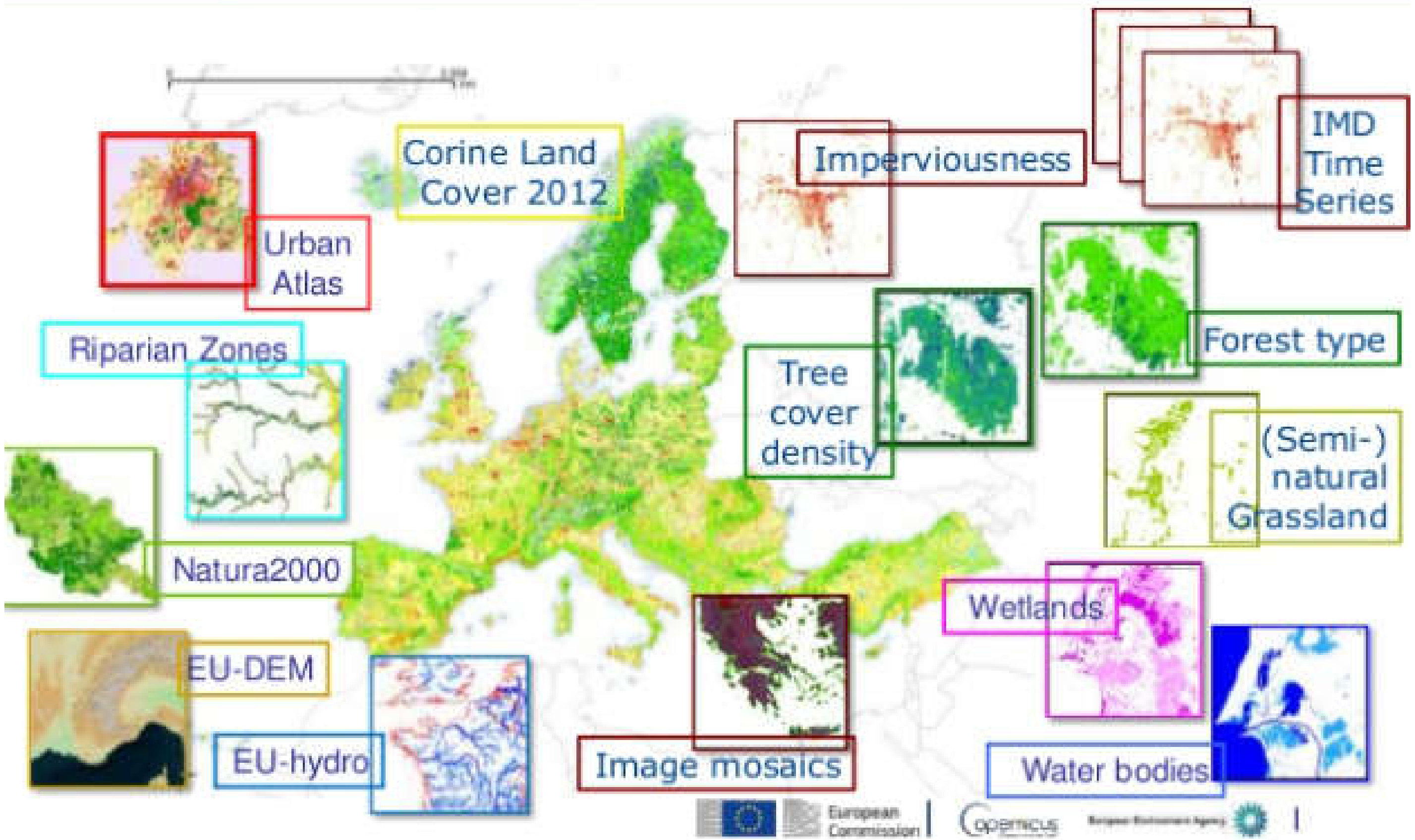


Table of contents

- Introduction
- Space component
- Services component : Land
- **In situ Component (LUCAS)**
- Applications in Agriculture

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

In situ Component

- *In situ* data = observation data from ground-, sea-, or air-borne sensors, reference and ancillary data licensed for use in Copernicus
- Use of *In situ* data:
  - Validate & calibrate Copernicus products
  - Reliable information services
- Implementation in two tiers:
  - Tailored *in situ* data for each Copernicus service level
  - Cross-cutting coordination across services by the EEA
- Spatial data: reference data (land cover, digital elevation models, and aerial imagery).
  - Copernicus Reference Data Access (CORDA)
  - INSPIRE

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

In situ Component (LUCAS)

Europe's **Land** Use-**Land** Cover Area Frame Survey (**LUCAS)** consists on the collection of points in situ and is used for verification and validation of several information services in the Copernicus Land Monitoring Services. The LUCAS Survey, carried out by EUROSTAT on a three-yearly basis since 2006 focuses on the state and changes in the type and use of land

NOTE: **EGNOS** could support the location of the points of **LUCAS** in-situ surveys, especially in homogeneous areas where the location it is difficult, saving time and improving the location accuracy of the measurements of the GPS used

LUCAS (EGNOS success story)

Anaptixi benefits from EGNOS to carry out geomatics projects such as the LUCAS Survey

Anaptixi, a growing research and engineering Greek company, uses EGNOS for field inspection tasks related to area-based subsidies, such as those required by the Common Agricultural Policy (CAP), as well as any other reconnaissance surveys, such as the LUCAS Survey, enhancing the accuracy of their GNSS handheld equipment in real time at no cost

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Table of contents

- Introduction
- Space component
- Services component : Land
- In situ Component (LUCAS)
- **Applications in Agriculture**

Examples of applications and benefits

More affordable applications based on Free Sentinels 1 and 2 Data and the Land Service Products

- Precision farming applications such as 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
- Agriculture development in Africa

Sources: PwC-Strategy& analysis & European Commission

More efficient use of agricultural inputs

Better quality food production

More efficient and appropriate use of fertilizers

€ Expected Copernicus enabled revenues

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

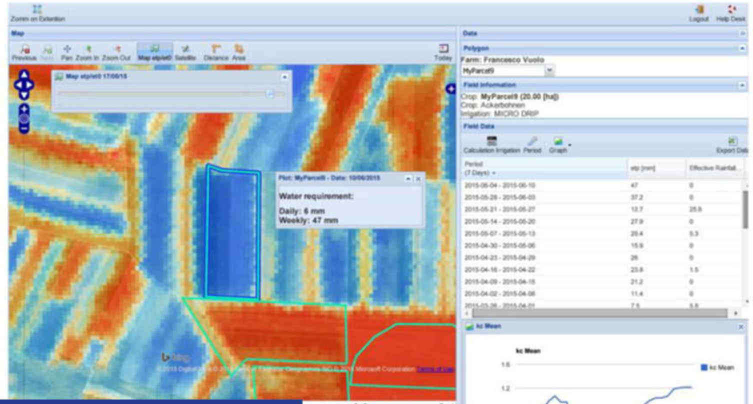
Applications in Agriculture

Improving irrigation management in Austria with Copernicus

Irrigation cost for one year: **8 M€ to 20 M€**

Improvements through optimisation of the **amount of water requirements** + optimisation of the **distribution of individual irrigation events**.

Products delivered:
- **crop development maps**
- **evapotranspiration maps**
- **weather data and forecast**



Extract of the webGIS information used to deliver the information to farmers
(Source: Institute of Surveying, Remote Sensing and Land Information)

NOTE: modern both linear and pivot irrigation equipment relies on GNSS instead of mechanical encoders for automatic irrigation. **EGNOS** submetric accuracy allows irrigation systems to apply water to crops precisely in space and time.

European Global Navigation Satellite Systems Agency

NAVIGATION MADE IN EUROPE

Applications in Agriculture

AgriSat

agriSat app

agriSat Iberia, S.L.

fertimaps
Agricultura eficiente

irrimaps
Riego eficiente

Copernicus is stimulating the creation of new companies within the agriculture sector.

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Sources: PwC-Strategy& analysis & European Commission

Applications in Agriculture

EO4AGRI

- Main Objective: EO4AGRI is a Coordination and Support Action that aims to prepare a European capacity for improving agriculture monitoring.

- EO4AGRI enlarges and further systematizes the knowledge about Copernicus for agriculture and identifies gaps related to the utilisation of EO in AgriFood, related public services and needs of the financial sector, including international policy and coordination programmes

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

EGNOS and Copernicus use case

Dynamic measurement in ground using EGNOS to verify Copernicus images

Copernicus images provides global variables of the soils, for instance, humidity, clay content, etc that can be correlated with observations of sensor in situ that allow improve models based on satellite measurements.

Using EGNOS (and IoT) in the equipment FIELDSCOUT TDR-350, is possible to measure in certain points (survey) soil parameters (humidity, conductivity, temperature ...), allowing to generate conductivity maps with precision. Those maps have been used to verify the images provided by Sentinel -2 for a specific area in Extremadura.

Further details in project **http://www.innoace.eu/**

Conclusions

- **Copernicus** Programme provides free and valuable data available (images, derived products: vegetation indices, layers of forest masses, land use maps, in situ measurements, etc.) to any users, that can be optimally used in applications that benefit decision makers processes and farming practices, contributing to sustainable development.

- The combination of the use of Copernicus with **EGNSS** (i.e. EGNOS) enhances the ability to use satellite technologies and contributes to the benefits obtained.

- The knowledge and contribution of different actors is essential for a good development of applications, including the expertise of agronomists, farmers, etc.

EGNOS

THANK YOU FOR YOUR ATTENTION

http://egnos-user-support.essp-sas.eu

egnos-helpdesk@essp-sas.eu

+34 911 236 555 (H24/7)

www.essp-sas.eu

Corporate Video

EGNOS
in precision farming

Maria Ruiz
(maria.ruiz@external.essp-sas.eu)

European
Global Navigation
Satellite Systems
Agency

NAVIGATION
MADE IN
EUROPE

Table of contents

- EGNOS overview
- EGNOS performance
- EGNOS benefits in agriculture
- EGNOS configuration in farming equipment
- EGNOS user support

Table of contents

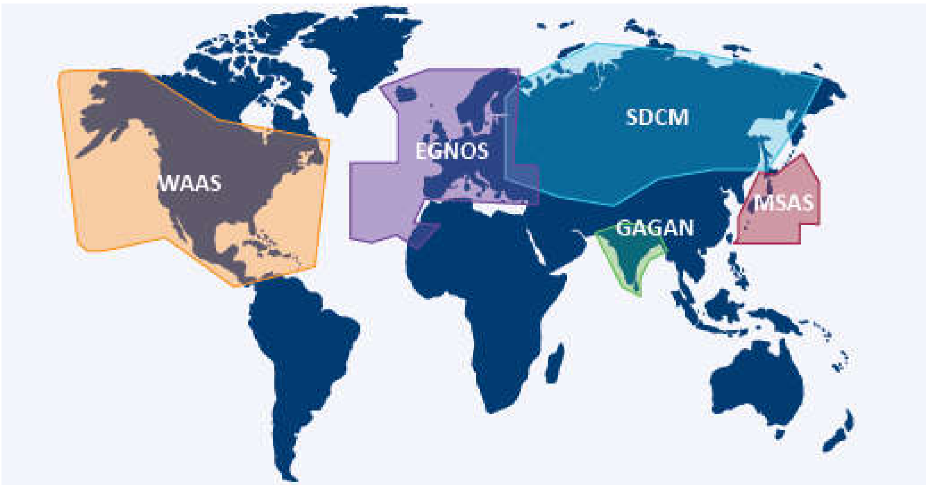
- **EGNOS overview**
- **EGNOS performance**
- **EGNOS benefits in agriculture**
- **EGNOS configuration in farming equipment**
- **EGNOS user support**

EGNOS background

EGNOS (European Geostationary Navigation Overlay Service) is the **free** European satellite-based augmentation system (SBAS) over the L1 signal of GPS

EGNOS was designed for aviation purposes, but it is also suitable for usage on a multitude of other ground applications, including agriculture

EGNOS is interoperable with other SBAS systems (see map below)



In the future (>2024):

- **EGNOS** will augment also **Galileo**
- **EGNOS** will broadcast dual-frequency corrections

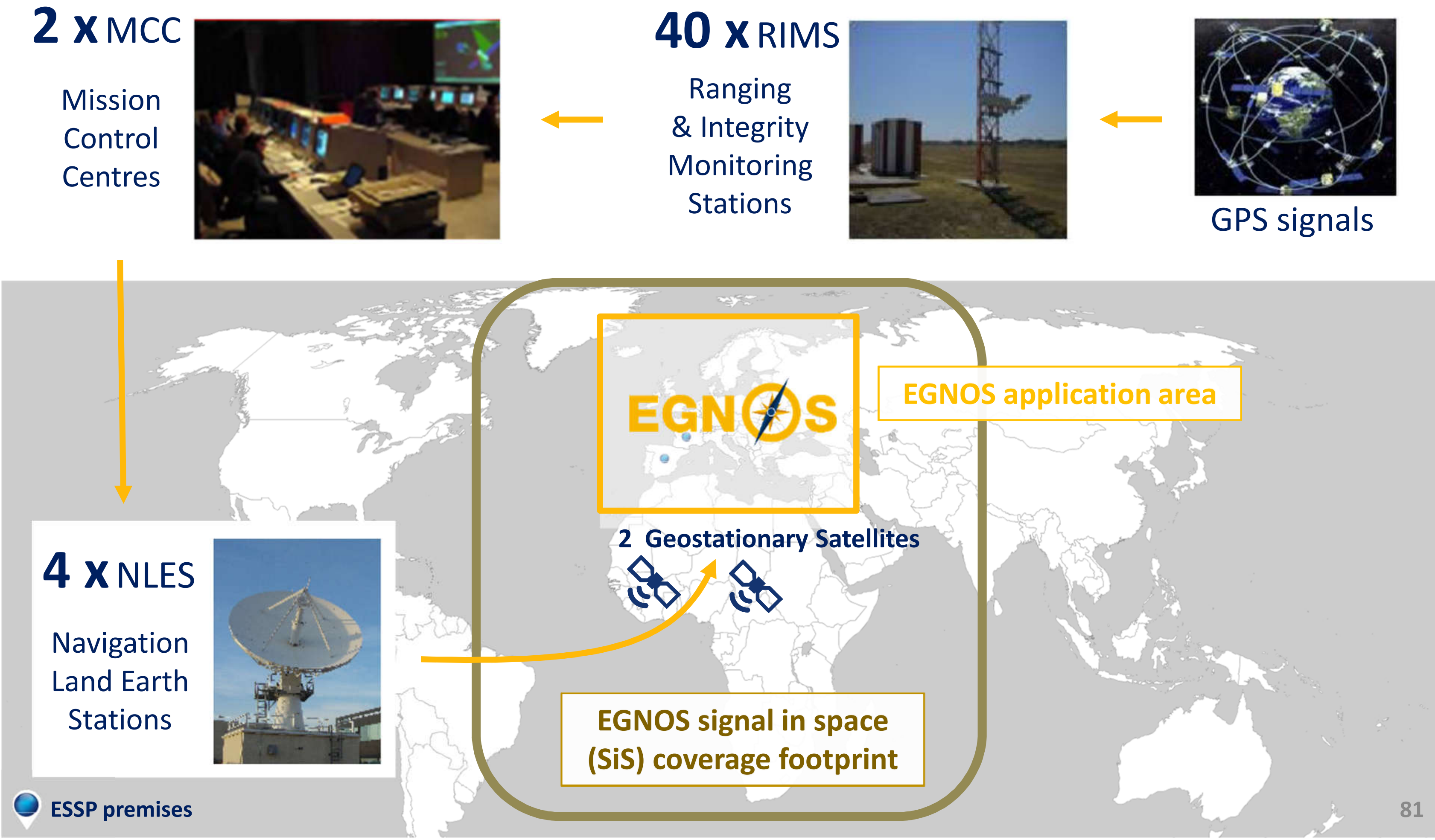
EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS system



EGNOS RIMS sites

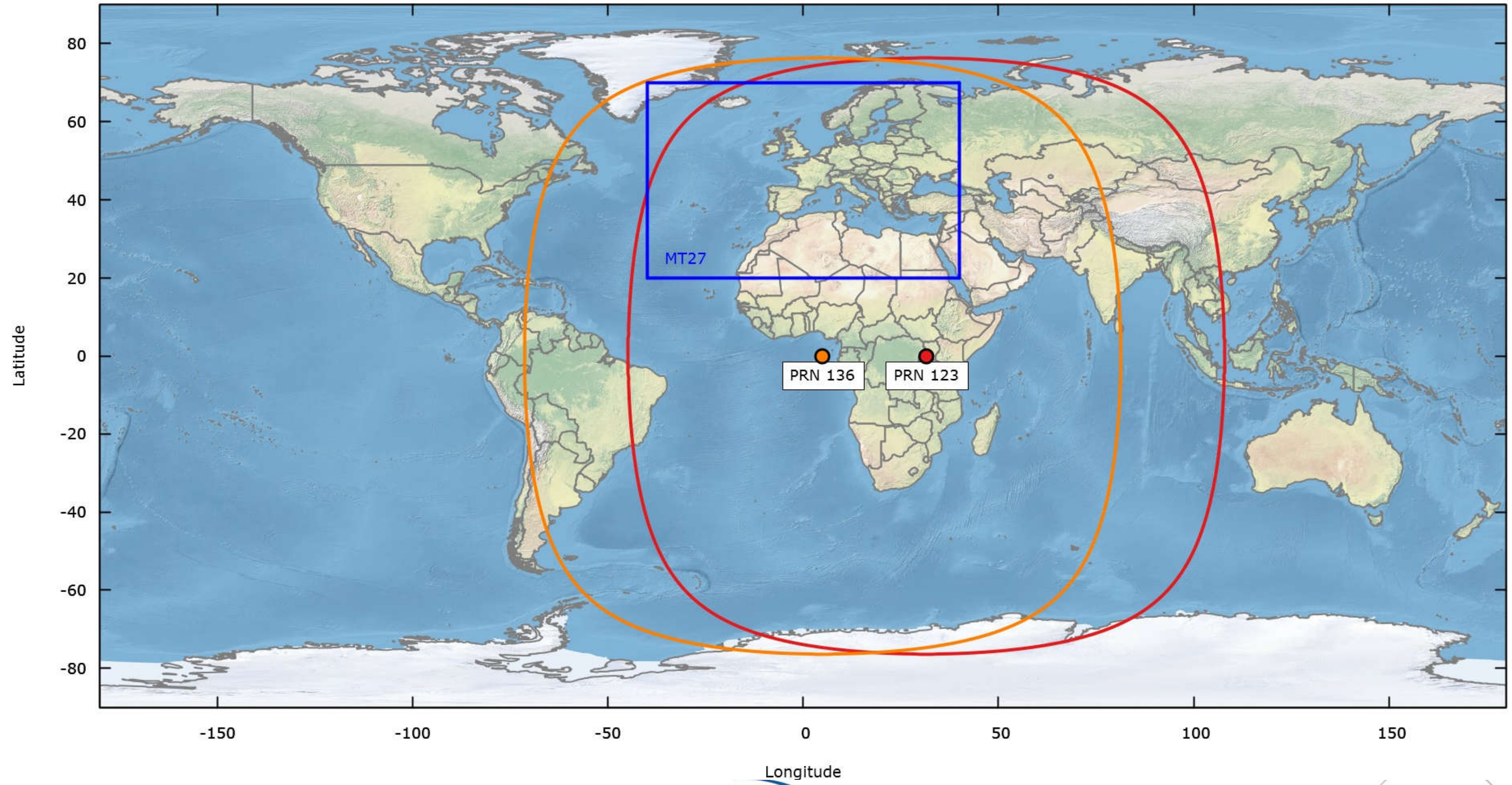
EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS satellites and application area



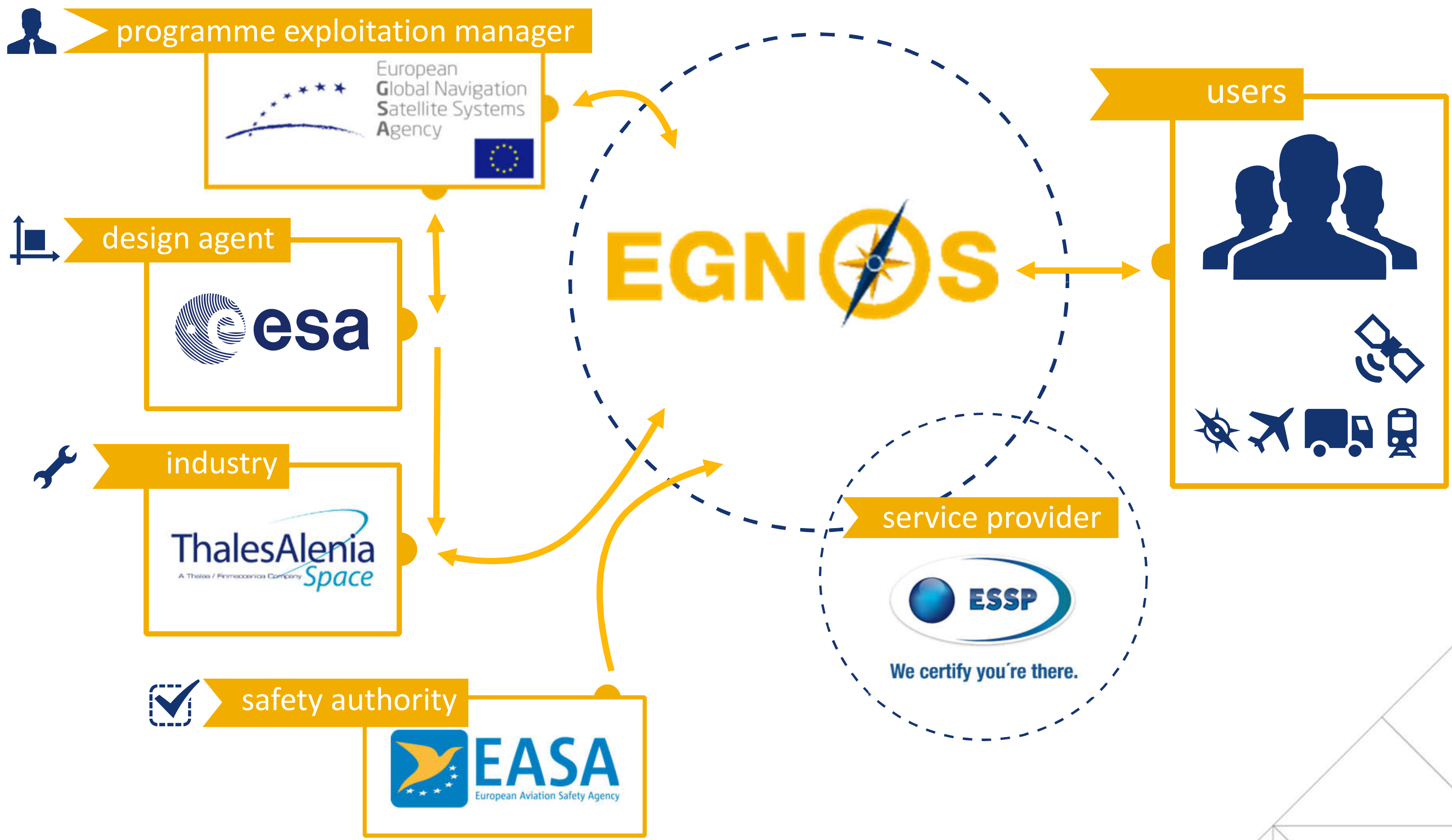
EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS organization



EGNOS services

- OS service release: **1 October 2009**
- EGNOS OS Service Definition Document (SDD)
- Agriculture, maritime, road, rail, mapping and GIS …
- No regulatory framework

- SoL service release: **2 March 2011**
- EGNOS SoL Service Definition Document (SDD)
- Regulatory framework that obliges to use certified EGNOS equipment
- Aviation: LPV landing approaches without depending on ground infrastructure

- EDAS service release: **26 July 2012**
- EDAS Service Definition Document (SDD)
- Provision of EGNOS and other GNSS data via Internet
- DGNSS and RTK corrections in the surroundings of the RIMS

Table of contents

- EGNOS overview
- **EGNOS performance**
- EGNOS benefits in agriculture
- EGNOS configuration in farming equipment
- EGNOS user support

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

EGNOS Open Service

Measured accuracy

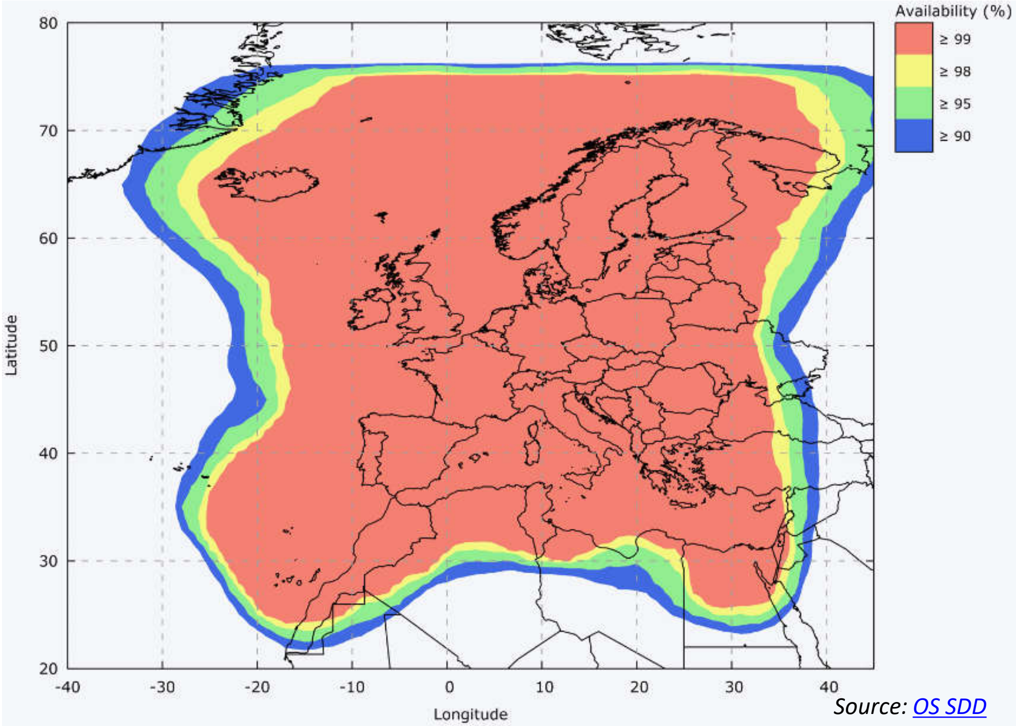
RIMS	Horizontal (95%)	Vertical (95%)
Aalborg	1.0 m	1.4 m
Berlin	0.9 m	1.3 m
Málaga	0.8 m	0.9 m
…	…	…

January 2020 (monthly reports)

General accuracy in practice

Horizontal (95%)	Vertical (95%)
< 1 m	< 2 m

EGNOS Open Service application area



Source: OS SDD

EGNOS augments GPS providing sub-metric horizontal accuracy

24-h comparison between EGNOS and GPS is provided every hour for all RIMS

EGNOS

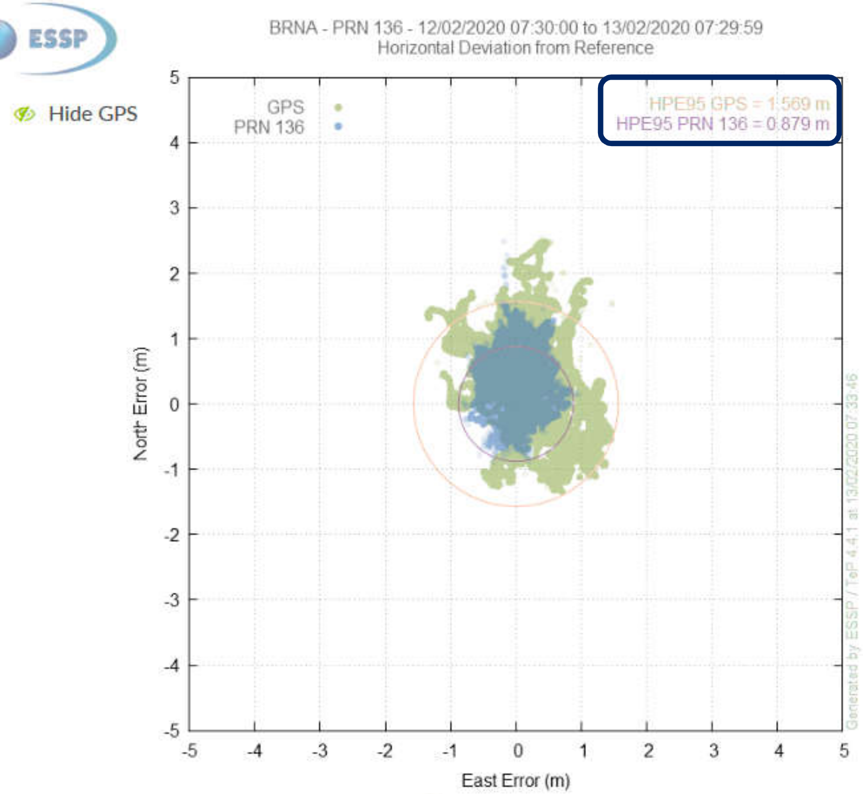
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS augments GPS providing sub-metric horizontal accuracy

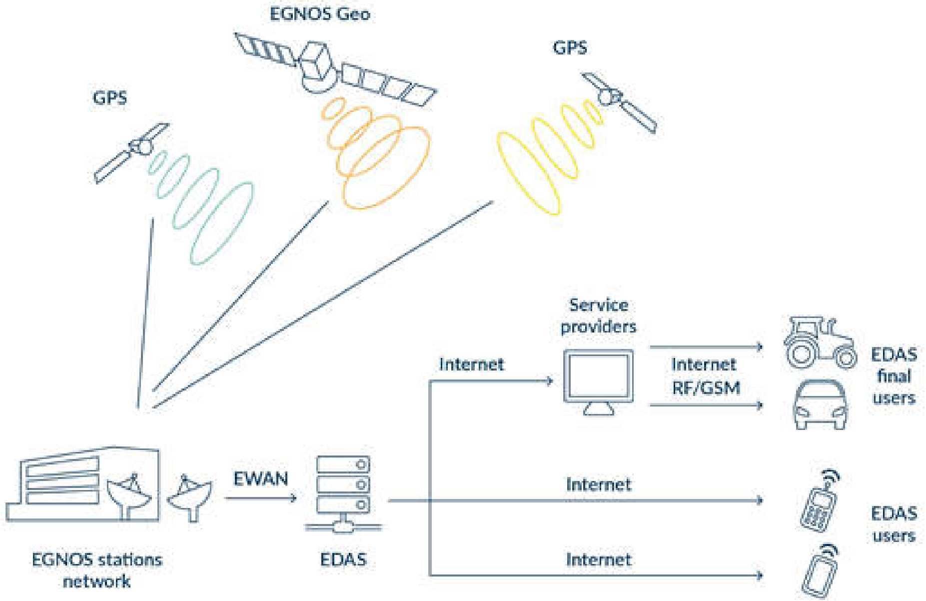
24-h comparison between EGNOS and GPS is provided every hour for all RIMS



EDAS

- ❑ Provision of EGNOS and GPS data through the Internet

- ❑ DGPS and RTK corrections in the surroundings of the RIMS



EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EDAS

- ❑ Provision of EGNOS and GPS data through the Internet
- ❑ DGPS and RTK corrections in the surroundings of the RIMS
- ❑ EDAS provides then four different types of data:

1) GNSS observations and navigation data collected by the entire network of EGNOS ground stations
2) SBAS augmentation messages of EGNOS satellites
3) RTK (Real-Time Kinematic) NTRIP messages
4) Differential GNSS (DGNSS) NTRIP corrections

Table of contents

- EGNOS overview
- EGNOS performance
- EGNOS benefits in agriculture
- EGNOS configuration in farming equipment
- EGNOS user support

EGNOS in farming activities

	Farming applications	Accuracy
	Livestock positioning and virtual fencing Agricultural stations and sensors	< 5 m
	Geo-traceability Post harvest pick-up	< 2.5 m
	Boundary mapping and updating Field measurement	< 1.5 m
	Machinery guidance for dry soil crops Variable rate application	< 1 m

EGNOS

Machinery guidance with EGNOS

EGNOS is the basic service for machinery guidance in Europe

Almost 80% of farming guidance systems integrate EGNOS (*)

(*) 2015 GNSS Market Report

EGNOS advantages w.r.t. GPS alone:

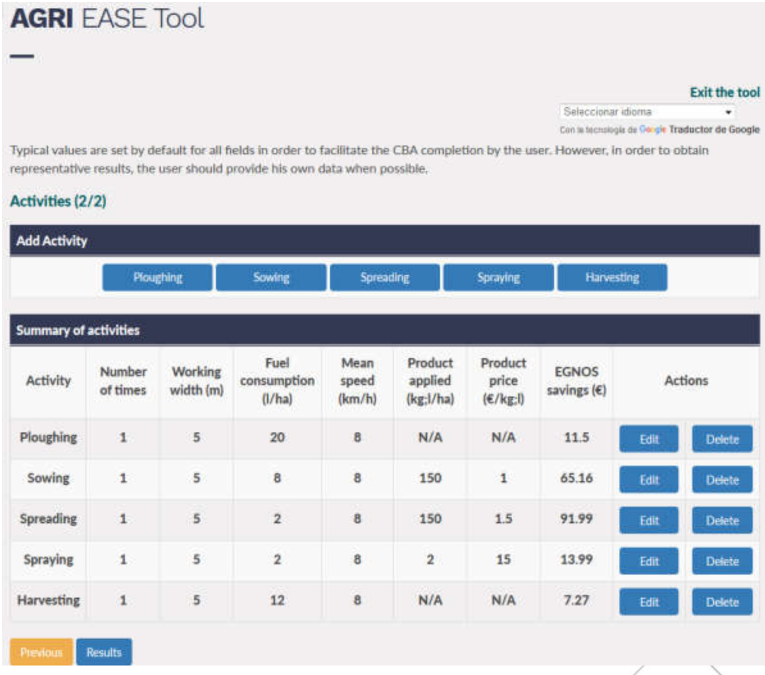
- Enhance accuracy
- Avoid waste of fertilisers and herbicides
- Save time and money
- Reduce fatigue
- Optimize crop yields
- Increase profit margins

EGNOS advantages w.r.t. other high-accuracy solutions:

- No subscription fee (w.r.t. commercial services)
- No radio base station (w.r.t. RTK)
- No dependency on GPRS coverage (w.r.t. NTRIP)

EGNOS economic benefits (1/3)

EASE (Egnos sAvingS in AgriculturE) tool available online provides farmers with economic cost-benefit assessments on the use of EGNOS for their typical agricultural labours.



AGRI EASE Tool

Exit the tool

Seleccionar idioma

Con la tecnología de Google Traductor de Google

Typical values are set by default for all fields in order to facilitate the CBA completion by the user. However, in order to obtain representative results, the user should provide his own data when possible.

Activities (2/2)

Add Activity

Ploughing | Sowing | Spreading | Spraying | Harvesting

Summary of activities

Activity	Number of times	Working width (m)	Fuel consumption (l/ha)	Mean speed (km/h)	Product applied (kg;l/ha)	Product price (€/kg;l)	EGNOS savings (€)	Actions	
Ploughing	1	5	20	8	N/A	N/A	11.5	Edit	Delete
Sowing	1	5	8	8	150	1	65.16	Edit	Delete
Spreading	1	5	2	8	150	1.5	91.99	Edit	Delete
Spraying	1	5	2	8	2	15	13.99	Edit	Delete
Harvesting	1	5	12	8	N/A	N/A	7.27	Edit	Delete

Previous | Results

EGNOS economic benefits (2/3)

EGNOS savings calculated with the EASE tool, considering the following typical set of labours and costs and a working width of 5 meters:

Summary of activities

Activity	Number of times	Fuel consumption (l/ha)	Mean speed (km/h)	Product applied (kg;l/ha)	Product price (€/kg;l)
Ploughing	2	20	8	N/A	N/A
Sowing	1	8	8	150	1
Spreading	1	2	8	150	1.5
Spraying	2	2	8	2	15
Harvesting	1	12	8	N/A	N/A

Fuel price (€/l) *	1.32
Labour cost (€/h) *	9.38

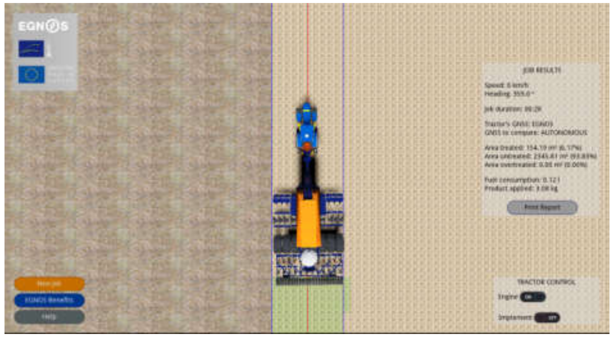
EGNOS savings of ~20€/ha

200€ per campaign for a crop field of 10 ha

A 1500€ typical EGNOS investment is amortized after 8 campaigns

EGNOS economic benefits (3/3)

[GEAR (eGnos dEmonstrator for AgRriculture)]() is an interactive virtual demonstrator available online to discover in a friendly and entertaining way the benefits of EGNOS for machinery guidance.



Environmental benefits

EGNOS improves the tractor guidance by enhancing precision

Reduction of greenhouse gas emissions such as carbon dioxide (CO2)

Better distribution of seeds, fertilizers and phytosanitaries.

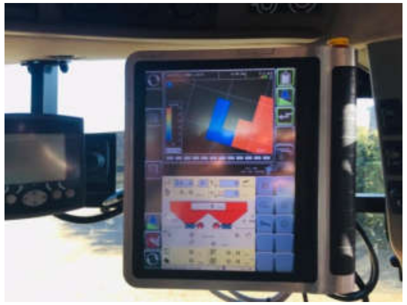
Extend equipment lifetime by optimising its use

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

Implement control with EGNOS

EGNOS allows farmers to perform efficient section control and/or variable rate application for:

- Ploughing
- Sowing
- Spreading
- Spraying




Success Story: European farmers benefit from EGNOS for variable rate applications with Teejet Technologies systems

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Common Agricultural Policy with EGNOS

Paying agencies can accurately update Land Parcel Identification Systems (LPIS) updates as well as perform On-the-Spot Checks (OTSC) using EGNOS. The future is relying on continuous monitoring thanks to Copernicus

Multiple types of portable GNSS devices are EGNOS-enabled and certified for CAP OTSC.

Smart irrigation with EGNOS

Modern both pivot and linear irrigation equipment relies on GNSS instead of mechanical encoders for automatic irrigation.

EGNOS submetric accuracy allows irrigation systems to apply water to crops precisely in space and time.

Success Story: [EGNOS for smart irrigation in agriculture with Proxima Systems' devices]

EGNOS | European Global Navigation Satellite Systems Agency | ESSP | NAVIGATION MADE IN EUROPE

EGNOS contribution to cereal production cycle

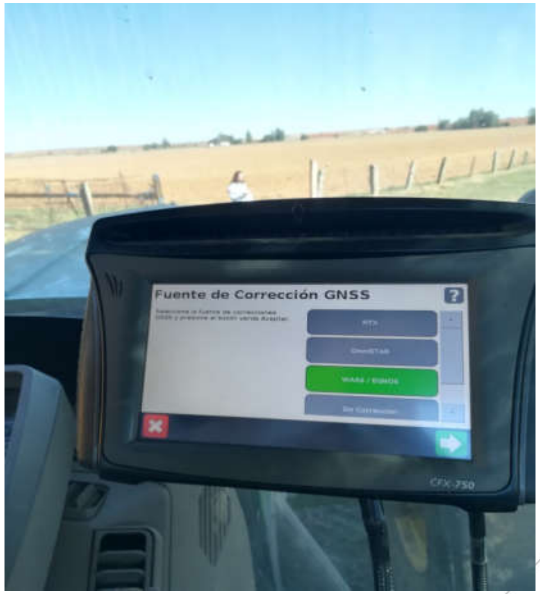
EGNOS is a cost-efficient tool in agriculture which supports machinery guidance in crop cultivation tasks.

The submetric accuracy provided by EGNOS satisfies the farmer requirements.

EGNOS is free and does not require base stations neither subscriptions.

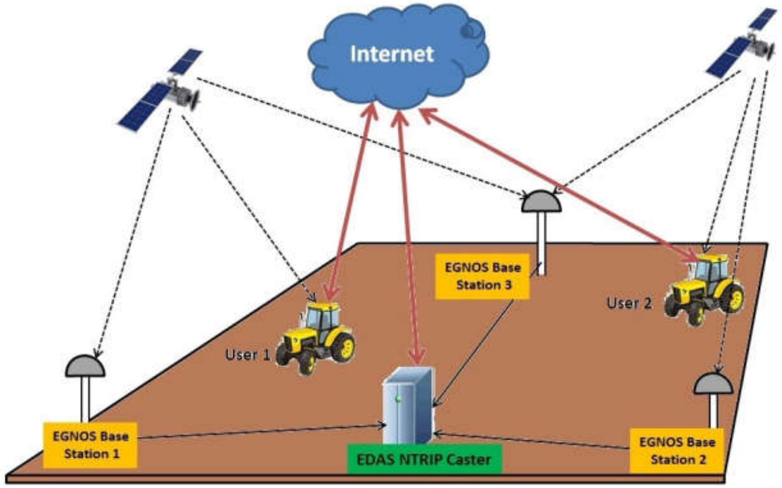
Discover EGNOS

For additional information about how EGNOS can play an important role in agriculture activities, watch the video "A Cerealist´s diary"



EDAS NTRIP Service

EDAS NTRIP provides through the Internet free DGNSS and RTK corrections in the surroundings of the multiple EGNOS RIMS.



A DGNSS and/or RTK receiver compatible with the NTRIP protocol is required.

EDAS RTK and DGNSS coverage

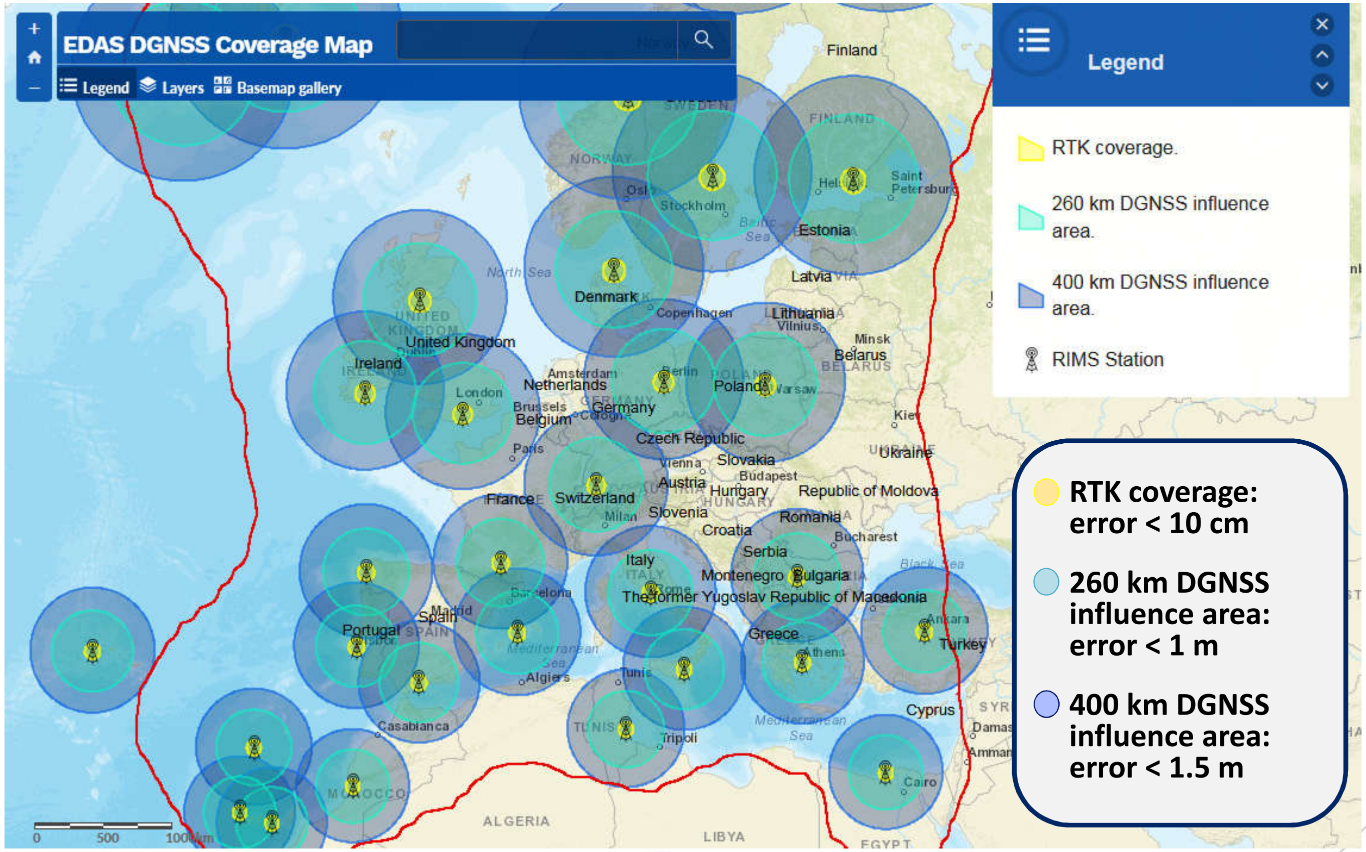


Table of contents

- EGNOS overview
- EGNOS performance
- EGNOS benefits in agriculture
- **EGNOS configuration in farming equipment**
- EGNOS user support

GPS/SBAS receivers in agriculture

Almost all (97%) the GPS agricultural receivers are EGNOS enabled

Septentrio satellite navigation

AvMap SATELLITE NAVIGATION

Ag Leader® Trimble® TOPCON CLAAS

sat plan

Leica Geosystems

TeeJet® TECHNOLOGIES

ALTUS POSITIONING SYSTEMS

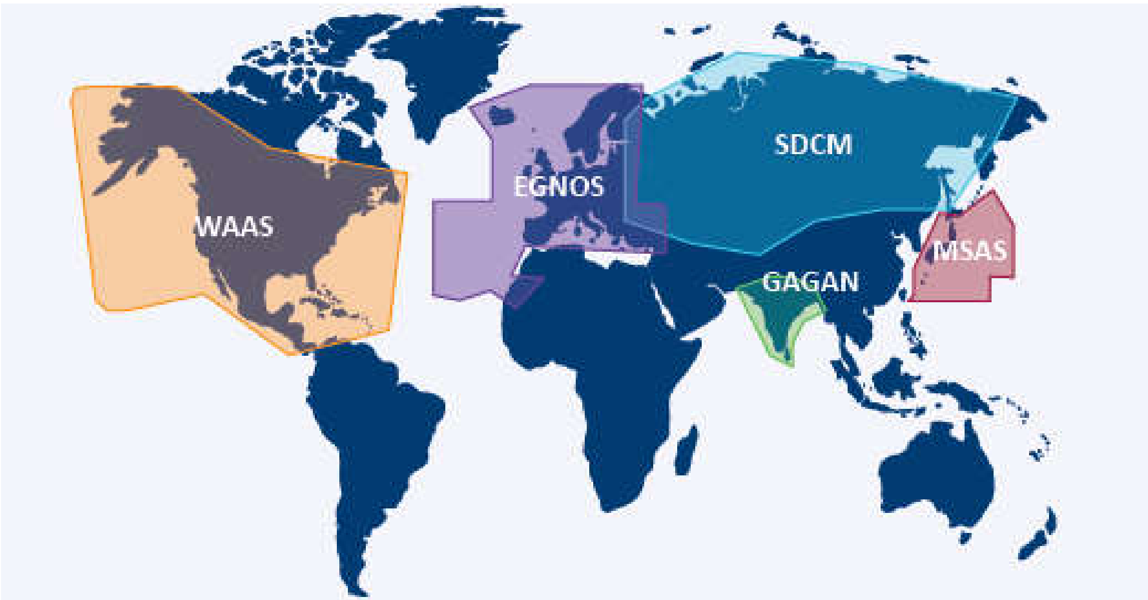
NovAtel

Outback GUIDANCE by Hemisphere GPS

NAVCOM A John Deere Company

Configuring EGNOS in your equipment

1. Check that the device is EGNOS-enabled
2. Activate SBAS/EGNOS

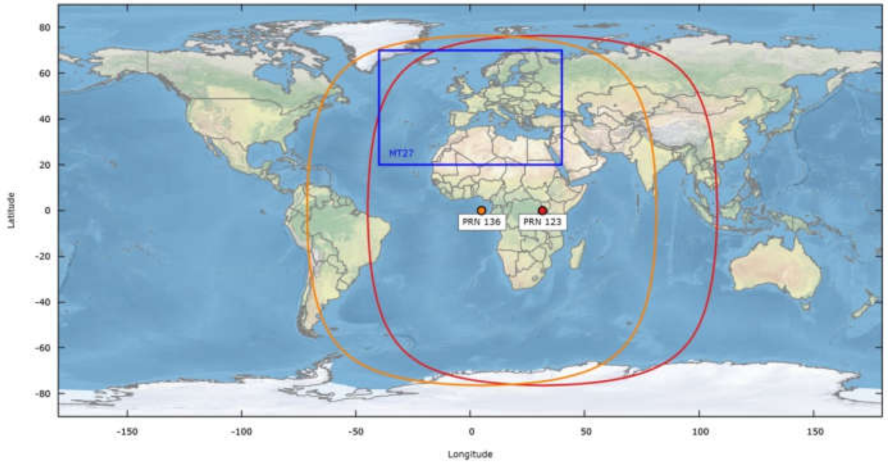


Configuring EGNOS in your equipment

1. Check that the device is EGNOS-enabled

2. Activate SBAS/EGNOS

3. Set current EGNOS satellites. E.g. PRN=123 and PRN=136. Up-to-date information in the EGNOS website



Configuring EGNOS in your equipment

1. Check that the device is EGNOS-enabled
2. Activate SBAS/EGNOS
3. Set current EGNOS satellites. E.g. PRN=123 and PRN=136. Up-to-date information in the EGNOS website

How to perform the aforementioned steps?

- Product datasheet/manual
- Manufacturer/dealer assistance
- EGNOS user support: egnos-helpdesk@essp-sas.eu

Topcon AGI-4 Receiver

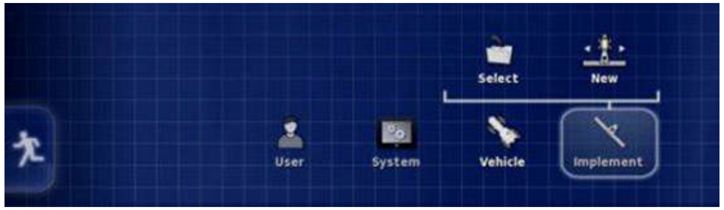
TOPCON

Model: AGI-4

- EGNOS enabled
- GPS/SBAS receiver integrated in the antenna
- **X30** display

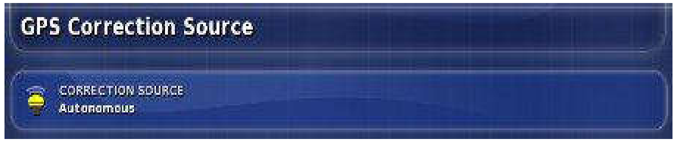
Topcon AGI-4: EGNOS Configuration

1. After start-up, the X30 **main setup screen** is shown:



2. To select the EGNOS corrections, the user must tap **System,** then **GPS** and then **Correction**:

3. Then, users must tap **GPS Correction Source**:



4. Finally, the user must select **EGNOS**:

Ag Leader GPS 6500 Receiver

Ag Leader®

Model: GPS 6500

- EGNOS enabled
- GPS/SBAS receiver integrated in the antenna
- **InCommand** display

Ag Leader GPS6500: EGNOS Configuration

1. After start-up, the **InCommand home screen** layout is shown:

2. To start the EGNOS setup, the user must tap the **Setup icon**:

3. Users must tap the following sequence of icons:

4. Finally, the user can configure one of the EGNOS **GEO satellites** (123 or 136) or leave it in **Automatic**:

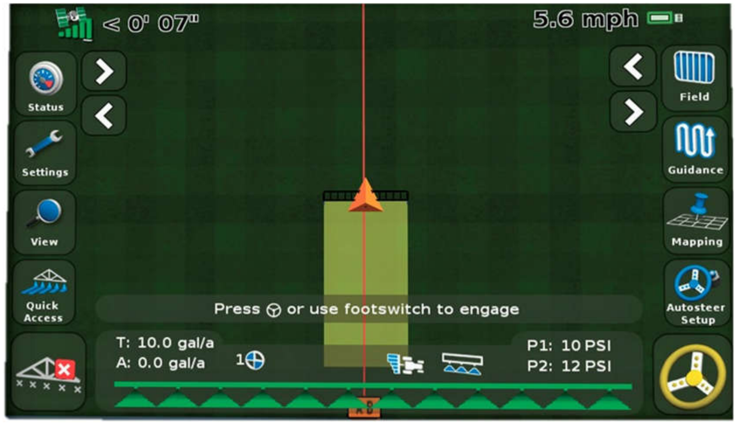
Trimble CFX-750 Receiver

Model: CFX-750

- EGNOS enabled
- GPS/SBAS receiver integrated in the display

Trimble CFX-750: EGNOS Configuration

1. After start-up, the CFX750 **guidance screen** is shown:



2. To start the EGNOS setup, the user must tap the **Settings** icon:

3. At the **Settings** screen, users must tap the **GNSS** icon:

4. At the **GNSS** screen, the user must tap **GNSS setup**
5. Users must tap **GNSS Correction Source** and choose **WAAS/EGNOS**. Then tap:

6. At the **WAAS/EGNOS** screen, tap **Satellite**
7. At the **Satellite** screen, users must tap **EGNOS 123** or **EGNOS 136**. Then tap:

How to ensure your equipment is using EGNOS corrections (1/2)

Usually the Signal to Noise ratio (SNR) for each satellite tracked is displayed on the screen (the higher the bar the higher SNR experienced by the device). Look for EGNOS GEO operational PRNs(*)

Check EGNOS the User Support Website and/or EGNOS APP to find [PRNs for operational EGNOS satellites]

(*) Some devices display NMEA PRN codes that are the satellite PRN minus 87

How to ensure your equipment is using EGNOS corrections (2/2)

- Check the specifications and user manual to confirm if the device outputs NMEA sentences (and how to command the logging of such sentences)
- Log NMEA sentences and look for command $GGA
- The output of the **GGA** NMEA sentence shall be checked, especially the field so called "**Fix quality**". If it appears a **2**, then the equipment is using SBAS/EGNOS in the PVT solution

GGA - essential fix data which provide 3D location and accuracy data.

```
 $GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

Where:
     GGA          Global Positioning System Fix Data
     123519       Fix taken at 12:35:19 UTC
     4807.038,N   Latitude 48 deg 07.038' N
     01131.000,E  Longitude 11 deg 31.000' E
     1            Fix quality: 0 = invalid
                               1 = GPS fix (SPS)
                               2 = DGPS fix
                               3 = PPS fix
                               4 = Real Time Kinematic
                               5 = Float RTK
                               6 = estimated (dead reckoning) (2.3 feature)
                               7 = Manual input mode
                               8 = Simulation mode
     08           Number of satellites being tracked
     0.9          Horizontal dilution of position
     545.4,M      Altitude, Meters, above mean sea level
     46.9,M       Height of geoid (mean sea level) above WGS84
                      ellipsoid
     (empty field) time in seconds since last DGPS update
     (empty field) DGPS station ID number
     *47          the checksum data, always begins with *
```

EGNOS

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

How to test the error obtained with your equipment when using EGNOS

You can verify whether EGNOS corrections are being applied by placing your receiver at a well-known position (with known coordinates):

- Perform a measurement campaign of 15-30 min configuring the device in "GPS only mode" and log the PVT file
- Just after (or in parallel if you have two devices), perform another measurement campaign of 15-30 min configuring the equipment in "EGNOS-enabled mode"
- Assure that the coordinates of the known-position are in the same geographic coordinates that your device sorts out the PVT solution and compare both
- Compute the error done in each set of measurements, and then compare both sets of errors. The ones obtained with EGNOS should be smaller that the ones obtained with using just GPS (specially noticeable in the vertical component)

NOTE*: it is not possible to compute with NMEA sentences the real error the PVT solution has. In some devices, it is provided an estimated accuracy (by means of proprietary sentences, implemented by each manufacturer and not even in all their models)*

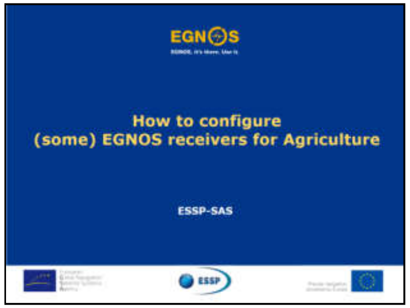
Table of contents

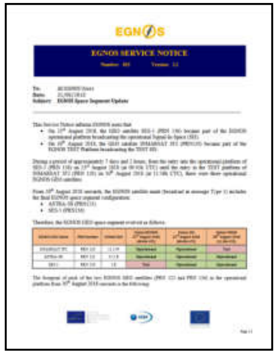
- EGNOS overview
- EGNOS performance
- EGNOS benefits in agriculture
- EGNOS configuration in farming equipment
- **EGNOS user support**

EGNOS User Support Website

EGNOS webpages for farming

- Service Notices (e.g. PRN modifications)
- Real-time performance:
  - EGNOS vs GPS
  - EDAS
- Guidance material
- Pass to Pass accuracy
- EASE tool
- GEAR
- EDAS coverage maps
- EGNOS bulletin
- EGNOS helpdesk





European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS mobile app

Freely available for **Android** and **iOS**

GET IT ON Google Play

EGNOS Helpdesk
Accessible from the app

Signal in Space
EGNOS system information

Docs and tools
Browse official documents & tools

EGNOS performance
SoL, EDAS, OS services

Download on the App Store

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

EGNOS

THANK YOU FOR YOUR ATTENTION

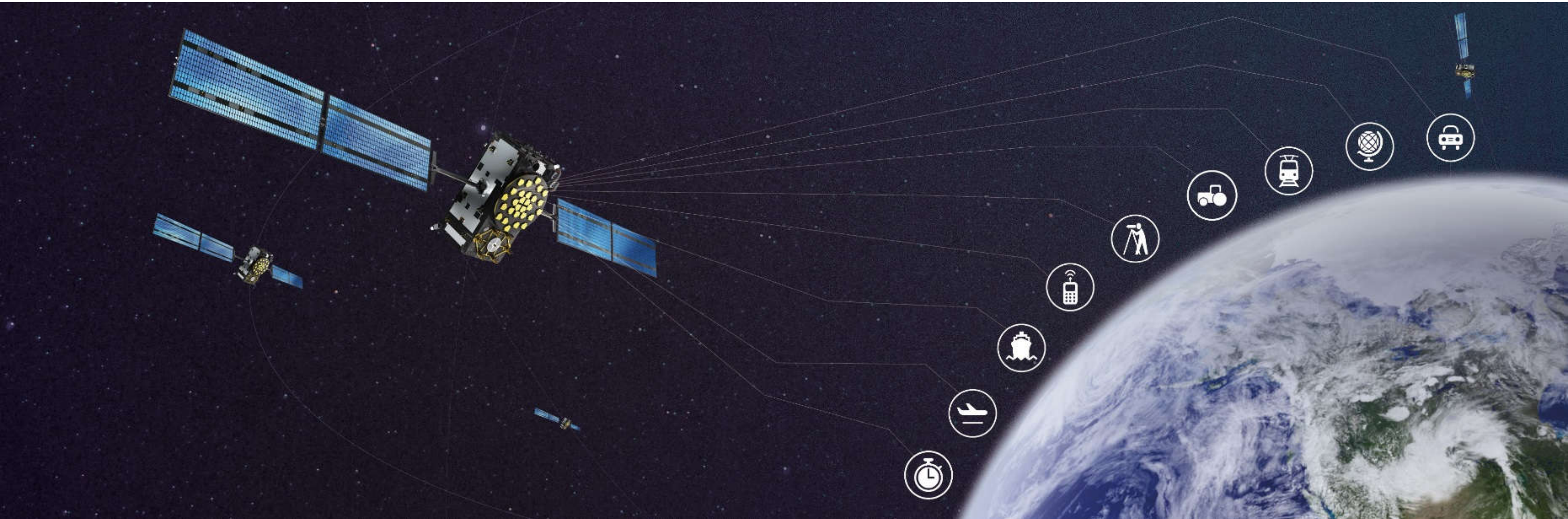
http://egnos-user-support.essp-sas.eu

egnos-helpdesk@essp-sas.eu

+34 911 236 555 (H24/7)

www.essp-sas.eu

Corporate Video



Synergies between EGNSS and Copernicus

Máster Universitario en Ingeniería Agronómica

Joaquín REYES GONZÁLEZ

September 28th, 2020

15 Years of EU Satellite Navigation

GSA

GALILEO EGNOS

NAVIGATION MADE IN EUROPE

Copernicus
Europe's eyes on Earth

The GSA is evolving to EUSPA

GSA

15 Years of EU Satellite Navigation

GSA

GALILEO

EGNOS

NAVIGATION MADE IN EUROPE

European Commission

GALILEO

EGNOS

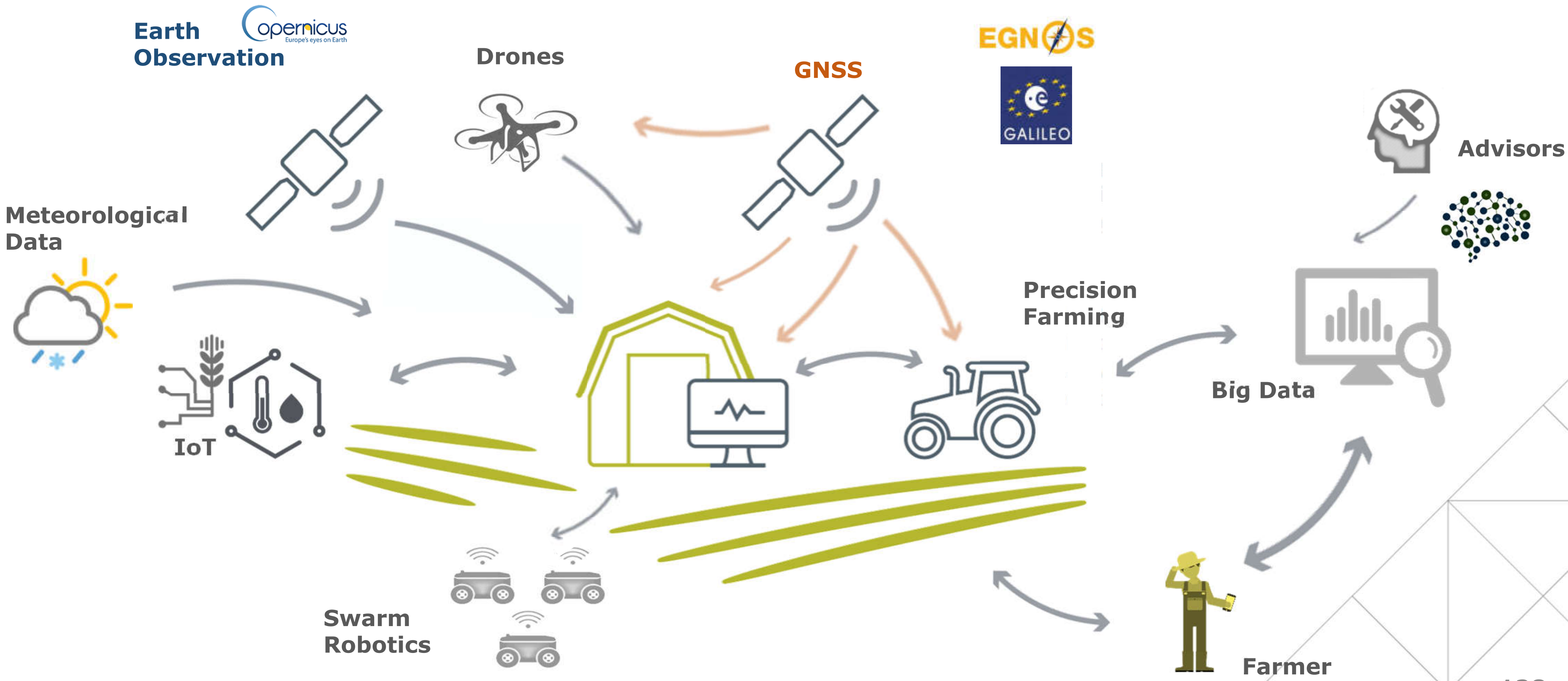
Copernicus

Europe's eyes on Earth

govsatcom

PRECURSOR

GNSS and Copernicus are the core components in the digital farming



Synergies EGNSS-Copernicus support various agriculture applications

Environmental management

Variable rate application (VRT)

Harvest monitoring

Biomass monitoring

Soil sampling

Risk management

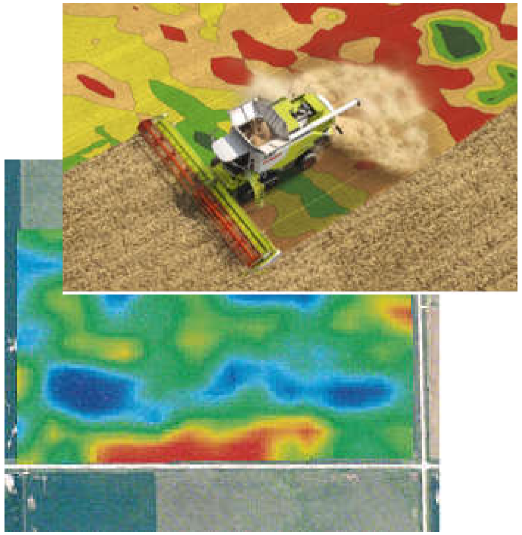
Insurance

Common Agricultural Policy (CAP)

In-situ data collection to validate EO data (e.g. automatic crop detection)

Synergies EGNSS-Copernicus to support various agriculture applications (1/3)

Variable Rate Applications



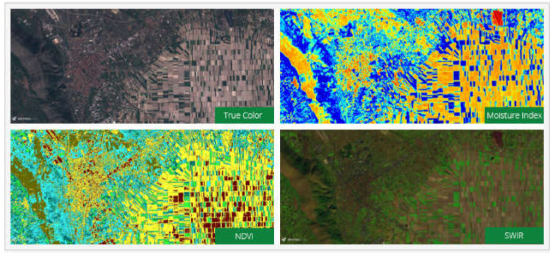
Prescription map: A geo-referenced map which contains rate information controllers shall apply (NDVI index, health of crops, soil moisture, etc.)

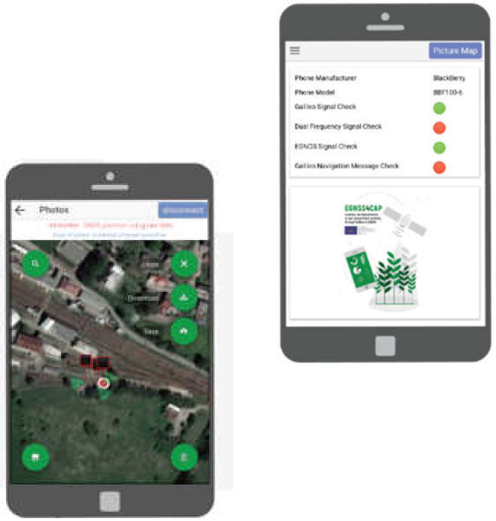
+

Highly accurate positioning of the machinery that show where fertiliser/pesticides should be applied

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

Synergies EGNSS-Copernicus to support various agriculture applications (2/3)





Common Agricultural Policy

Sentinel satellite imagery – the main component of the ''checks by monitoring'' approach for modernised and simplified CAP and CAP after 2020

+

Highly-accurate and robust positioning for the geo-tagged photo application or drones to complement Sentinel monitoring approach

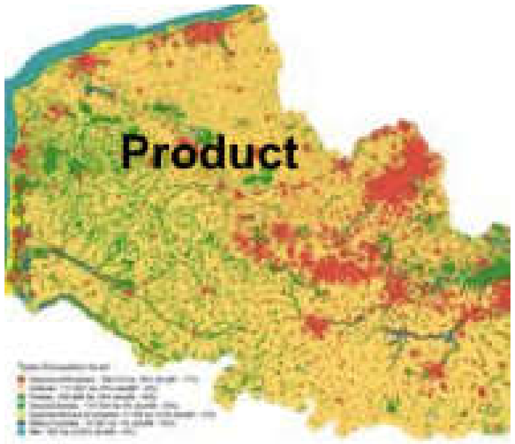
- Simplify and digitise the processes related to subsidies control
- More efficient checks while saving the costs (less on-the-spot checks)
- Also, GNSS used for in-situ data collection to improve automatic monitoring by Sentinel

Synergies EGNSS-Copernicus to support various agriculture applications (3/3)

Soil moisture monitoring

EO data such as Copernicus (also, GNSS reflectometry) is used to obtain precipitation forecasts, soil moisture content and evapotranspiration data

+



GNSS technology is used to derive the current location of the user to provide, directly on a smartphone or tablet, specific local data for geotagging the in situ measurements required for validation and calibration

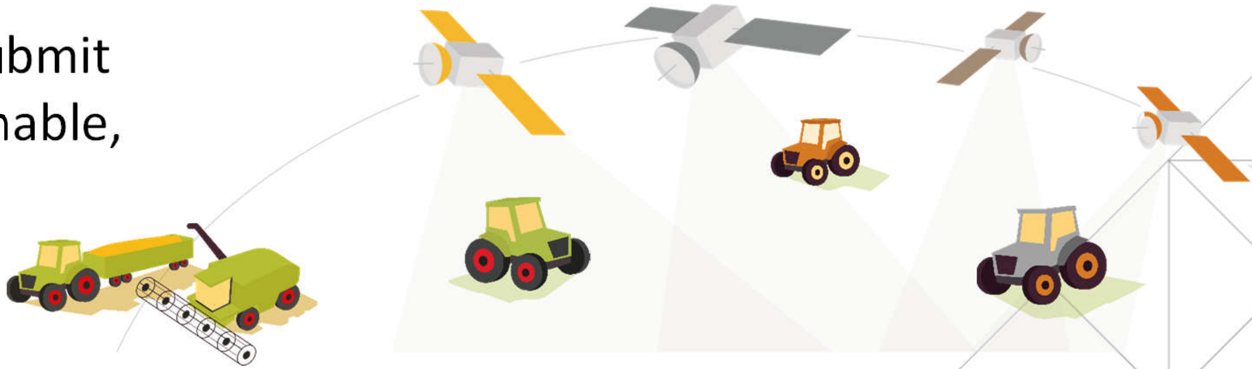
- Proper and timely information on water availability that is the most important requirement for water management activities within agriculture
- Reduces the amount of water used by linking it to the moisture level needed in the soil for a particular crop

How can we use Satellite Technologies to improve Agriculture and reduce Environmental Impact?

The Farming by Satellite Prize rewards young innovators exploring the use of satellite technologies to improve agriculture and reduce environmental impact.

An initiative of the European GNSS Agency and the European Environment Agency, the prize aims to boost the awareness of Europe's space programmes Galileo, EGNOS and Copernicus amongst the next generation.

Applicants were invited to submit their ideas for a more sustainable, productive and efficient agriculture.




FARMING BY
SATELLITE
PRIZE
Discover Galileo, EGNOS & Copernicus
Which satellites should we use?
Let's find out!
Looking forward the synergies
between EGNSS and Sentinels


FARMING BY SATELLITE PRIZE
THE PRIZES:
Rewarding success and innovation
Win your share of €10,000
Don't miss out!
1st
€5,000
2nd
€3,000
3rd
€1,000
Special Africa Prize
€1,000

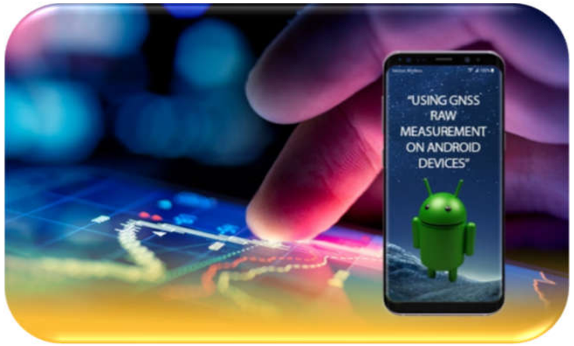
GNSS Raw Measurements Taskforce Workshop

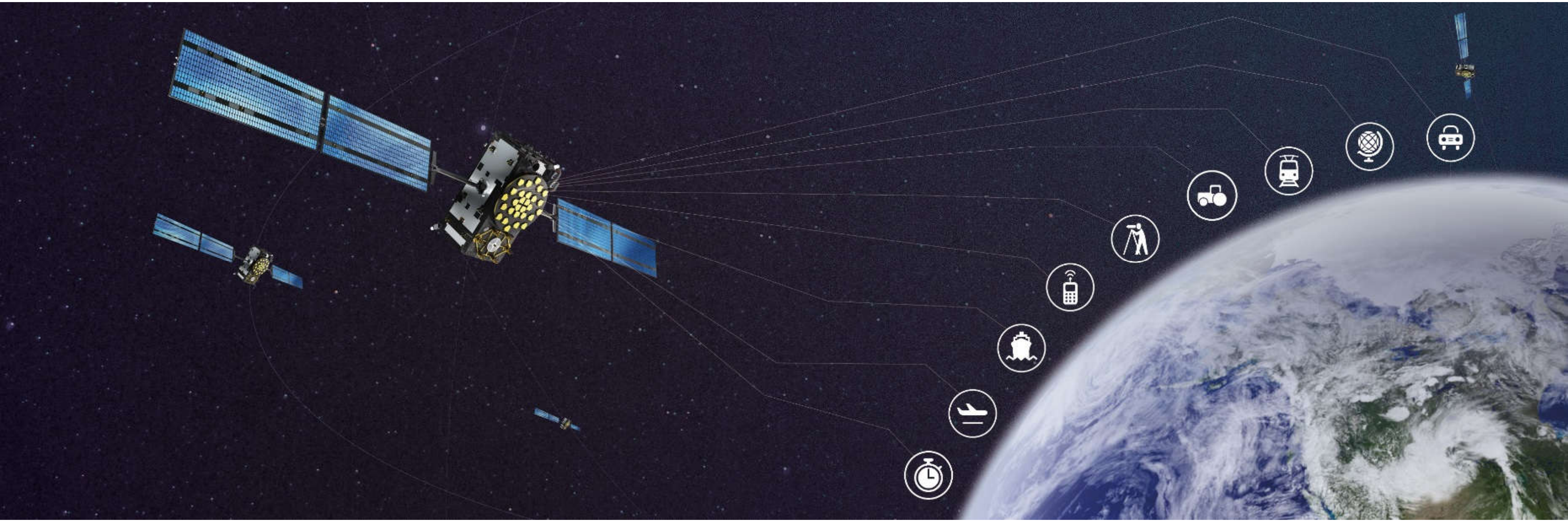
As of Android 7.0, access to GNSS raw measurements has been made available, allowing:

- Developers to use the carrier and code measurements.
- Enables the creation of advanced GNSS positioning algorithms that lead to the development of more ambitious smartphone-based services.
- Access to data contained in the navigation message.

Until not too long ago, these data were restricted to more professional GNSS receivers, now they are literally in the palm of our hands. Two additional tools are available to the Task Force members:

- A dedicated discussion forum.
- A measurement database where members can upload data logs and relevant documents.





Q&A Discussion

Máster Universitario en Ingeniería Agronómica

ALL

September 28th, 2020

Linking space to user needs

How to get in touch:

15 Years of EU Satellite Navigation

www.GSA.europa.eu

EGNOS-portal.eu

GSC-europa.eu

UseGalileo.eu

Exercise: Estimation of EGNOS accuracy for agricultural labours

Maria Ruiz
(maria.ruiz@external.essp-sas.eu)

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Table of contents

- Introduction
- Field test implementation
- Preparation of the field data
- Calculation of EGNOS accuracy

Table of contents

- Introduction
- Field test implementation
- Preparation of the field data
- Calculation of EGNOS accuracy

Objectives and tools

Objectives

- Learn a practical procedure to assess the accuracy of a specific guidance solution, in this case EGNOS, employed in agricultural labours.
- Learn how to interpret and use the output information provided by the guidance system's display of agricultural machinery.
- Learn to derive and analyse the following accuracy metrics, which are typical in agriculture: Cross Track Error (CTE) and Pass to Pass (P2P) error.

SW tools

- Plain text viewer/editor: notepad++, Windows notepad, WordPad or similar.
- Spreadsheet viewer/editor (for ".xls" files): Microsoft Excel or similar.
- Optional: MATLAB (the code could be easily adapted for Octave).

Table of contents

- **Introduction**
- **Field test implementation**
- **Preparation of the field data**
- **Calculation of EGNOS accuracy**

EGNOS

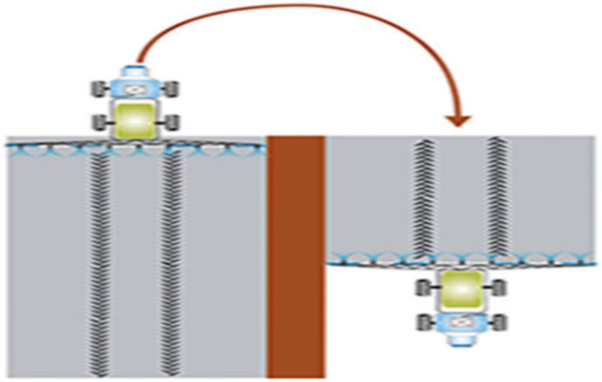
European Global Navigation Satellite Systems Agency

ESSP

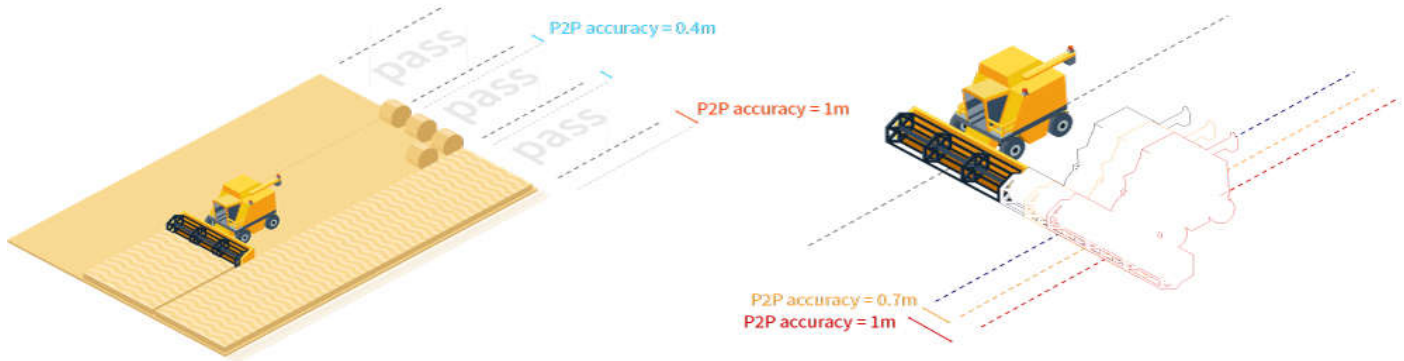
NAVIGATION MADE IN EUROPE

EGNOS accuracy: Pass to Pass error

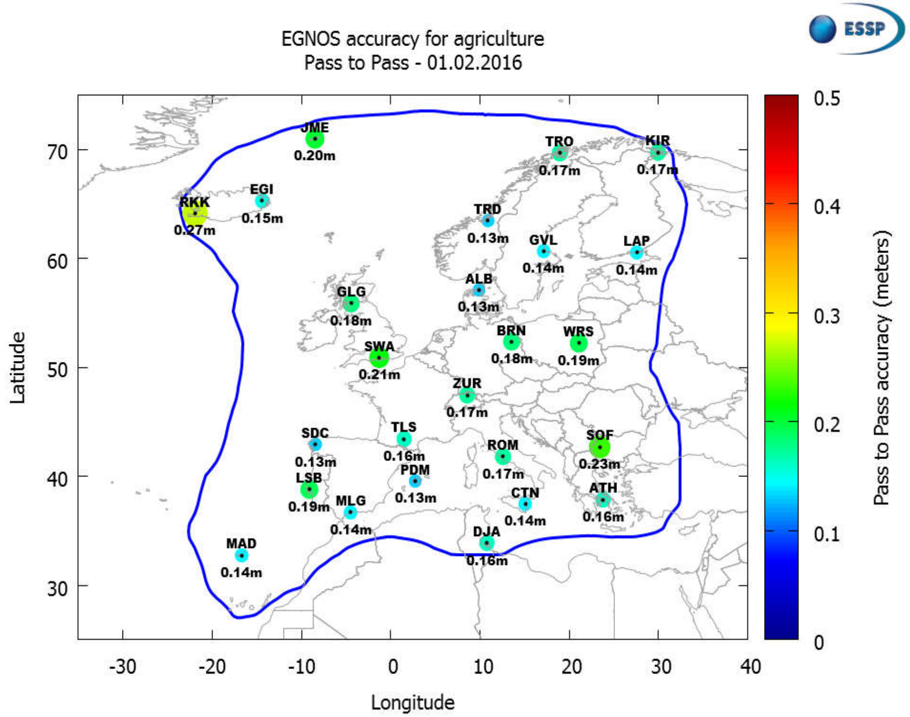
- Relative error between consecutive passes with the tractor.
- A maximum time window of 15 minutes is considered.
- The crops can be overlapped (treated twice) or missed (not treated).



*Additional exercise ("Estimation of EGNOS accuracy for agricultural labours") provided to the professor.



Pass to pass error with EGNOS



EGNOS PASS TO PASS < 0.3 m

The Pass to Pass error is measured daily in all RIMS and the results are published in the [EGNOS User Support Website]

EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

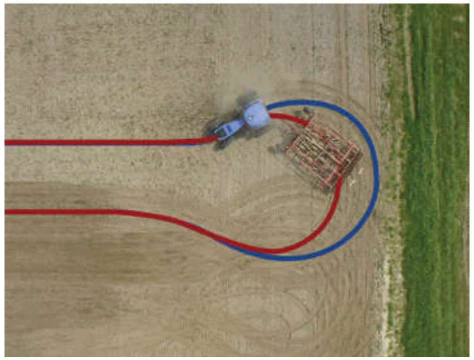
Test description (1/4)

1. We use a tractor with a guidance system using EGNOS. The tractor drives several parallel passes over a specific field. These passes were programmed beforehand in the guidance system's reference map of the parcel, covering the area that wanted to be laboured.

Test description (2/4)

2. In order to remove any manual error from the driver, an autosteering system is employed to do the passes with EGNOS. Thanks to the autosteering system, the tractor follows automatically the passes of the reference map according to the EGNOS positioning data that is constantly received, without the farmer controlling the steering wheel.

   NOTE: The U-turns at the end of each pass need to be carried out manually by the driver, but these parts of the tractor's trajectory are not taken into account for the accuracy calculations, just the straight passes.



Test description (3/4)

3. To derive the accuracy provided by EGNOS in practice, we need the actual trajectories that the tractor follows, which will be compared with the positioning data provided by EGNOS. For this purpose, a second guidance system is installed in the tractor, but this one applying RTK (Real Time Kinematics) corrections, which are highly accurate (error < 2 cm), from a nearby base station.

EGNOS

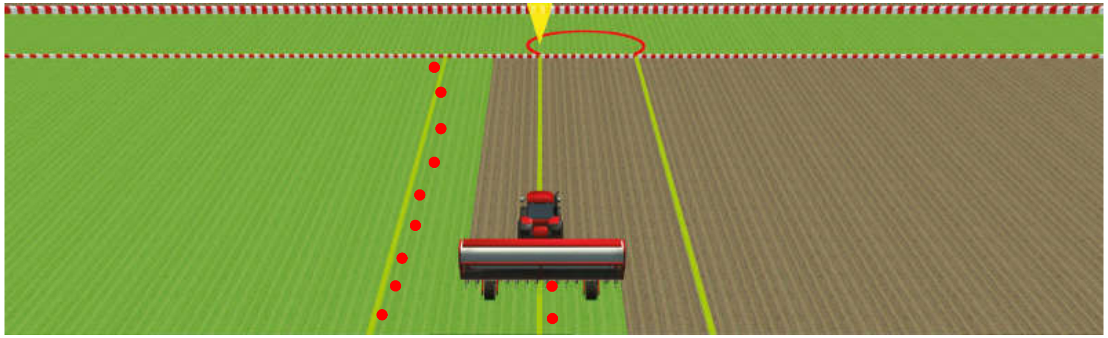
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Test description (4/4)

4. In this way, EGNOS error can be seen as the difference between the trajectories that EGNOS assures are being followed (green lines in the figure) and the real ones measured with RTK (red points in the figure).



5. The output data of the field test is provided through the following two log files, one from each guidance system's display (both Topcon brand): EGNOS and RTK.

   EGNOS4_20171130_103104.csv

   RTK4_20171130_103100.csv

Task 1

- **Open the ".csv" files with a plain text viewer/editor and try to identify and interpret the different parameters provided.**
- **Which parameters are relevant for our purposes of estimating EGNOS accuracy?**

EGNOS4_20171130_103104_data.csv

```
2017.11.30-10:31:04:859,Console,Event,ceSoftwareState,,Initial Parameter Values:
2017.11.30-10:31:04:860,GPS Receiver,Param,gpLatitude,53.98523476,Latitude
2017.11.30-10:31:04:860,GPS Receiver,Param,gpLongitude,-0.71692862,Longitude
2017.11.30-10:31:04:860,GPS Receiver,Param,gpEasting,649695.04,Easting
2017.11.30-10:31:04:861,GPS Receiver,Param,gpNorthing,5984291.82,Northing
2017.11.30-10:31:04:861,GPS Receiver,Param,gpAltitude,213.805 m,Altitude
2017.11.30-10:31:04:862,GPS Receiver,Param,gpHeading,346.1°,Heading
2017.11.30-10:31:04:862,GPS Receiver,Param,gpSpeed,0.0 km/h,Speed
2017.11.30-10:31:04:862,GPS Receiver,Param,gpNumberOfSatellites,12,Satellites
2017.11.30-10:31:04:862,GPS Receiver,Param,gpGpsSatellites,14,GPS Satellites
2017.11.30-10:31:04:863,GPS Receiver,Param,gpCorrectionSource,DGPS,Correction Source
2017.11.30-10:31:04:863,GPS Receiver,Param,gpCorrectionAge,0 s,Correction Age
2017.11.30-10:31:04:863,GPS Receiver,Param,gpHRMS,0.383 m,HRMS
2017.11.30-10:31:04:864,Steering Controller,Param,spEngageStatus,Disengaged,Engage Status
2017.11.30-10:31:04:864,Steering Controller,Param,spCrossTrackError,0.068 m,Cross Track Error
2017.11.30-10:31:05:454,Steering Controller,DTC,8004,GroupID: M  RR Msg: 8004,RR message from group ID: M
2017.11.30-10:31:05:454,Steering Controller,DTC,8001,GroupID: M  RR Msg: 8001,RR message from group ID: M
2017.11.30-10:31:05:837,GPS Receiver,Param,gpLatitude,53.98523476,Latitude
2017.11.30-10:31:05:837,GPS Receiver,Param,gpLongitude,-0.71692862,Longitude
2017.11.30-10:31:05:837,GPS Receiver,Param,gpEasting,649695.04,Easting
2017.11.30-10:31:05:838,GPS Receiver,Param,gpNorthing,5984291.82,Northing
2017.11.30-10:31:05:838,GPS Receiver,Param,gpAltitude,213.805 m,Altitude
2017.11.30-10:31:05:839,GPS Receiver,Param,gpHeading,346.1°,Heading
2017.11.30-10:31:05:839,GPS Receiver,Param,gpSpeed,0.0 km/h,Speed
2017.11.30-10:31:05:839,GPS Receiver,Param,gpNumberOfSatellites,12,Satellites
2017.11.30-10:31:05:840,GPS Receiver,Param,gpGpsSatellites,14,GPS Satellites
2017.11.30-10:31:05:840,GPS Receiver,Param,gpCorrectionSource,DGPS,Correction Source
```

European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Table of contents

- **Introduction**
- **Field test implementation**
- **Preparation of the field data**
- **Calculation of EGNOS accuracy**

Data processing (1/3)

1. The original output format of the guidance systems' data is not very friendly for viewing neither processing. For this reason, their format will be enhanced in order to:

   - Facilitate their visualization and interpretation.

   - Remove unnecessary data and keep only the interesting one for the calculation of EGNOS accuracy.

2. Import the data of the ".csv" files into the spreadsheet editor to facilitate their visualization and understanding. In this way, we create the "original" sheet of the following files:

   egnosdata.xlsx

   rtkdata.xlsx

Data processing (2/3)

3. A first filtering phase, which comprises the tasks below, is performed, storing the results in the sheet “filter1” of the aforementioned “.xls” files:

   - Convert the “time” into “epochs”, which correspond to the seconds of a certain day, so: epoch = seconds + minutes · 60 + hours · 3600

   - Order the data of the same epoch in columns

   - Discard the DTC (diagnostic trouble code) data of the “Steering Controller”, as they are not useful for our purposes.

1	Time (epoch)	Latitude (°)	Longitude (°)	Easting (m)	Northing (m)	Altitude (m)	Speed (kph)	Heading (°)	NumberOfSatellites	GPSSatellites	CorrectionSource	CorrectionAge (s)	HRMS (m)	EngageStatus	CrossTrackError (m)
2	37864	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.383	Disengaged	0.068
3	37865	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.383	Disengaged	0.068
4	37866	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.385	Disengaged	0.068
5	37867	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.391	Disengaged	0.068
6	37868	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.391	Delayed Engage	0.068
7	37869	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.391	Delayed Engage	0.068
8	37870	53.98523476	-0.71692862	649695.04	5984291.82	213.805	0	346.1	12	14	DGPS	0	0.391	Delayed Engage	0.068
9	37871	53.98525549	-0.71693491	649694.55	5984294.12	212.266	2.1	345.9	12	14	DGPS	0	0.39	Engaged	0.136
10	37872	53.98526194	-0.71693776	649694.34	5984294.83	212.277	2.9	343.8	12	14	DGPS	0	0.39	Engaged	0.141
11	37873	53.98527094	-0.71694251	649694	5984295.82	212.299	3.8	342.3	12	14	DGPS	0	0.39	Engaged	0.108
12	37874	53.98528141	-0.71694808	649693.6	5984296.97	212.33	4.4	342.4	12	14	DGPS	0	0.39	Engaged	0.059
13	37875	53.98529244	-0.71695385	649693.18	5984298.19	212.364	4.6	343.1	12	14	DGPS	0	0.371	Engaged	0.013
14	37876	53.98530398	-0.71695984	649692.74	5984299.46	212.4	4.9	343.8	12	14	DGPS	0	0.37	Engaged	0.031
15	37877	53.98531401	-0.71696481	649692.38	5984300.56	212.42	3.4	344.2	12	14	DGPS	0	0.367	Engaged	0.058
16	37878	53.98531817	-0.71696679	649692.24	5984301.02	212.431	1.5	344.7	12	14	DGPS	0	0.366	Engaged	0.063
17	37879	53.98531986	-0.71696763	649692.18	5984301.21	212.437	0.6	344.8	12	14	DGPS	0	0.368	Delayed Engage	0.067

Data processing (3/3)

3. A second filtering phase, which comprises the following tasks, is carried out, storing the results in the sheet "filter2" of the aforementioned ".xls" files:

   - Leave the numbers alone in the cells, removing the units.

   - Discard the data obtained when the tractor presents very low movement, as in those cases the tractor is not likely to be driving along a straight pass: "Speed < 1kph"

   - In the case of EGNOS, the data obtained when the autosteer is not completely engaged is also discarded

   - To leave only the data of the straight passes and discard the U-turns, we limit the heading range to:

     - odd passes: "Heading" within 345º ± 5º

     - even passes: "Heading" within 165 ± 5º

   - Classify the data by pass number (new last column).

Task 2

- **Take a look at the different sheets of the ".xls" files to check that the aforementioned filtering tasks have been correctly performed.**

1	Time (epoch)	Latitude (°)	Longitude (°)	Easting (m)	Northing (m)	Altitude (m)	Speed (kph)	Heading (°)	NumberOfSate	GPSSa	CorrectionSource	CorrectionAge (s)	HRMS (m)	EngageStatus	CrossTrackError (m)	Pass
2	37871	53.98525549	-0.71693491	649694.55	5984294.12	212.266	2.1	345.9	12	14	DGPS	0	0.39	Engaged	0.136	1
3	37872	53.98526194	-0.71693776	649694.34	5984294.83	212.277	2.9	343.8	12	14	DGPS	0	0.39	Engaged	0.141	1
4	37873	53.98527094	-0.71694251	649694	5984295.82	212.299	3.8	342.3	12	14	DGPS	0	0.39	Engaged	0.108	1
5	37874	53.98528141	-0.71694808	649693.6	5984296.97	212.33	4.4	342.4	12	14	DGPS	0	0.39	Engaged	0.059	1
6	37875	53.98529244	-0.71695385	649693.18	5984298.19	212.364	4.6	343.1	12	14	DGPS	0	0.371	Engaged	0.013	1
7	37876	53.98530398	-0.71695984	649692.74	5984299.46	212.4	4.9	343.8	12	14	DGPS	0	0.37	Engaged	0.031	1
8	37877	53.98531401	-0.71696481	649692.38	5984300.56	212.42	3.4	344.2	12	14	DGPS	0	0.367	Engaged	0.058	1
9	37878	53.98531817	-0.71696679	649692.24	5984301.02	212.431	1.5	344.7	12	14	DGPS	0	0.366	Engaged	0.063	1
10	37919	53.9853244	-0.71696886	649692.08	5984301.71	212.567	2.4	344.9	12	14	DGPS	0	0.343	Engaged	0.013	1
11	37920	53.98533226	-0.71697234	649691.82	5984302.58	212.574	3.6	345.1	12	14	DGPS	0	0.343	Engaged	0.007	1
12	37921	53.98534272	-0.71697707	649691.48	5984303.73	212.594	4.5	344.9	12	14	DGPS	0	0.344	Engaged	0.001	1
13	37922	53.98535515	-0.71698276	649691.06	5984305.1	212.631	5.1	345	12	14	DGPS	0	0.346	Engaged	0.002	1
14	37923	53.9853679	-0.71698861	649690.63	5984306.51	212.669	5.4	344.8	12	14	DGPS	0	0.346	Engaged	0	1
15	37924	53.98538119	-0.71699461	649690.19	5984307.97	212.712	5.6	344.9	12	14	DGPS	0	0.346	Engaged	0.003	1
16	37925	53.98539525	-0.71700111	649689.71	5984309.52	212.762	6	344.6	12	14	DGPS	0	0.347	Engaged	0.004	1
17	37926	53.98540989	-0.71700788	649689.22	5984311.14	212.806	6.1	344.8	12	14	DGPS	0	0.347	Engaged	0	1
18	37927	53.985425	-0.71701484	649688.7	5984312.8	212.845	6.3	344.7	12	14	DGPS	0	0.346	Engaged	0	1
19	37928	53.9854407	-0.71702211	649688.17	5984314.53	212.894	6.6	344.9	12	14	DGPS	0	0.348	Engaged	0.009	1
20	37929	53.9854586	-0.71703046	649687.56	5984316.51	212.964	8.1	344.9	12	14	DGPS	0	0.348	Engaged	0.017	1
21	37930	53.98548098	-0.71704062	649686.81	5984318.98	213.03	9.5	345.1	12	14	DGPS	0	0.351	Engaged	0.01	1
22	37931	53.98550179	-0.71705009	649686.12	5984321.27	213.077	8.3	345	12	14	DGPS	0	0.362	Engaged	0.006	1
23	37932	53.98552196	-0.71705916	649685.45	5984323.5	213.128	8.6	344.9	12	14	DGPS	0	0.372	Engaged	0.007	1
24	37933	53.98554236	-0.71706842	649684.77	5984325.74	213.166	8.6	345	12	14	DGPS	0	0.383	Engaged	0.007	1
25	37934	53.98556317	-0.71707801	649684.07	5984328.04	213.201	8.7	344.8	12	14	DGPS	0	0.394	Engaged	0.009	1
26	37935	53.98558385	-0.7170875	649683.37	5984330.32	213.243	8.7	344.8	12	14	DGPS	0	0.394	Engaged	0.007	1
27	37936	53.98560521	-0.71709723	649682.66	5984332.68	213.295	9	345	12	14	DGPS	0	0.394	Engaged	0.012	1
28	37937	53.98562621	-0.71710704	649681.94	5984334.99	213.341	9	344.9	12	14	DGPS	0	0.395	Engaged	0.002	1
29	37938	53.98564742	-0.7171168	649681.22	5984337.33	213.389	8.8	344.8	12	14	DGPS	0	0.395	Engaged	0.001	1
30	37939	53.98566924	-0.71712695	649680.48	5984339.73	213.429	8.9	344.8	12	14	DGPS	0	0.395	Engaged	0.006	1
31	37940	53.98569032	-0.71713644	649679.78	5984342.06	213.478	8.6	345.1	12	14	DGPS	0	0.395	Engaged	0.003	1
32	37941	53.98571179	-0.71714633	649679.06	5984344.43	213.535	9.1	344.9	12	14	DGPS	0	0.395	Engaged	0.001	1

Table of contents

- Introduction
- Field test implementation
- Preparation of the field data
- **Calculation of EGNOS accuracy**

EGNOS

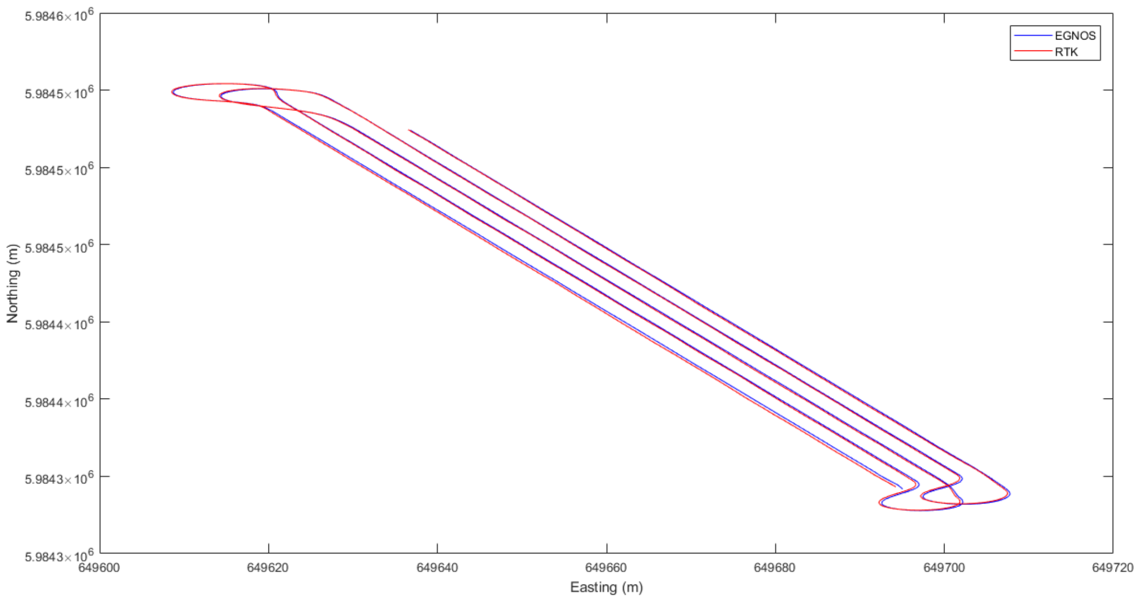
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Tractor trajectories

1. The “Easting” and “Northing” data are used to plot the complete trajectories, as both individual points and interpolated lines. The EGNOS data is plotted in blue and the RTK one in red.

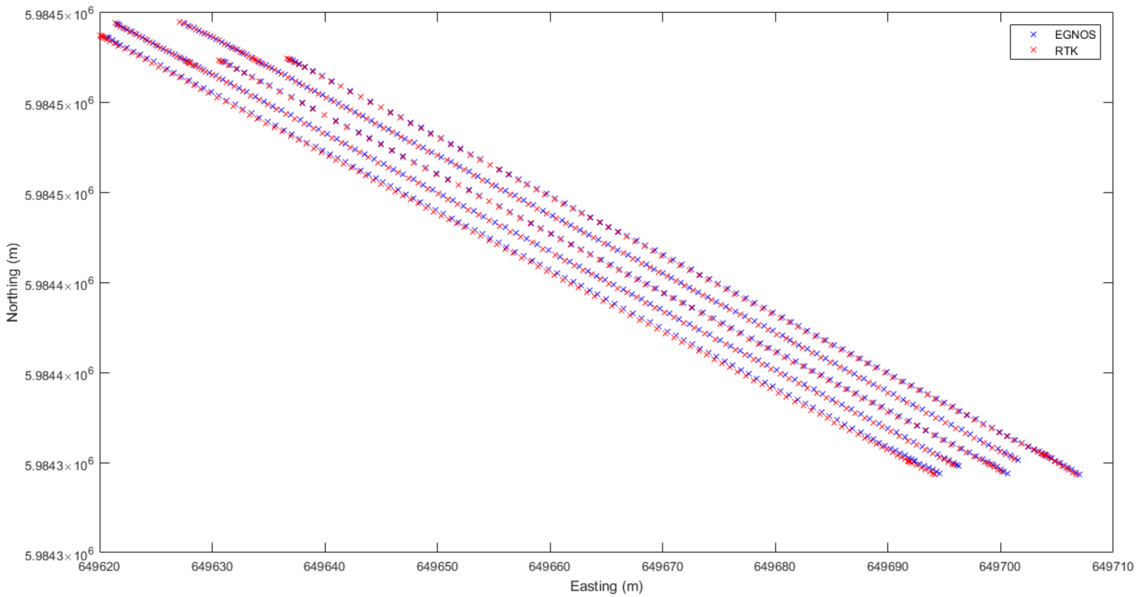


EGNOS · European Global Navigation Satellite Systems Agency · ESSP · NAVIGATION MADE IN EUROPE

Task 3.1

1. **Explain the differences found between the plot from the “filter1” excel sheet and the equivalent one of the “filter2” excel sheet.**

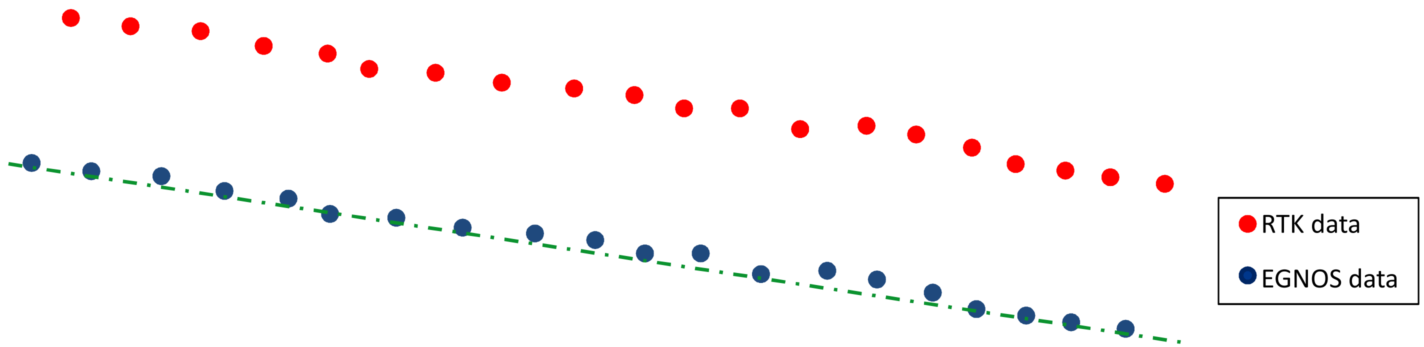
2. **From the data and/or the plots. How can we identify the order of the passes?**



EGNOS European Global Navigation Satellite Systems Agency ESSP NAVIGATION MADE IN EUROPE

Cross track error (1/2)

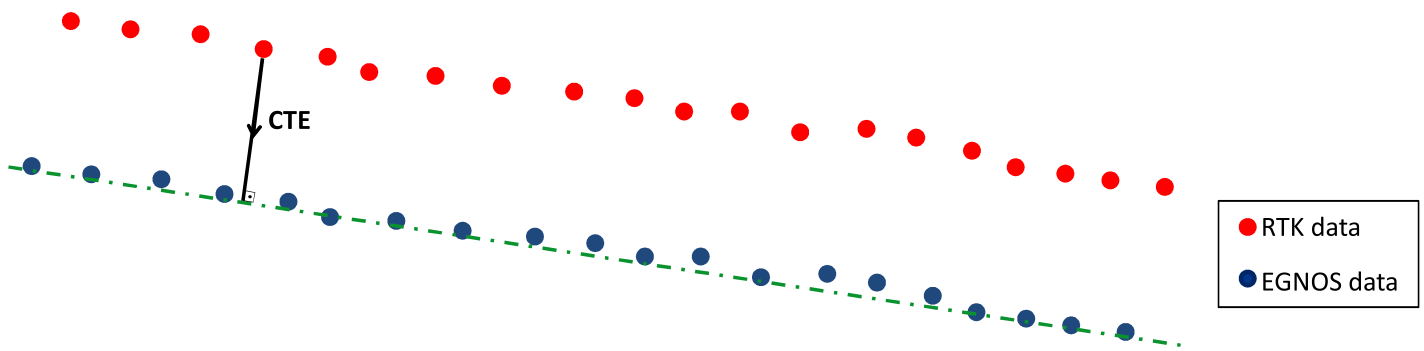
1. If we zoom in the previous MATLAB plots, we can see that the EGNOS and the RTK trajectories are not the same, presenting some kind of shift between them. This difference between the ideal path (EGNOS) and the real one (RTK) is the so called "cross track error" (CTE).



2. From the set of EGNOS positions, please take the blue points in the figure above as graphical reference, we estimate the corresponding straight line by means of linear regression. This line, the dashed green one in the figure above, represents the theoretical trajectory followed by the tractor.

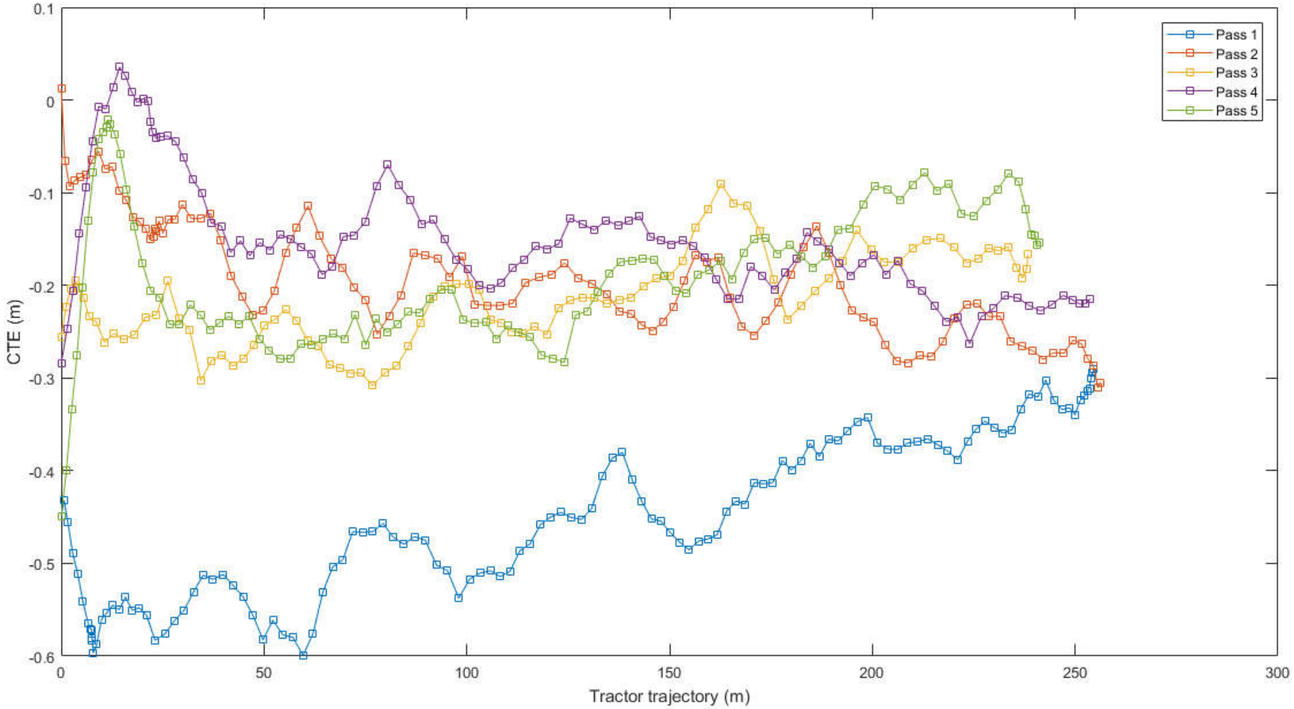
Cross track error (2/2)

3. For each RTK position, corresponding to the real ones of the tractor (red points in the figure below), we derive the straight line with the origin in that precise point and the direction perpendicular to the “Heading” angle. Then we calculate the intersection between this line and the EGNOS one. Finally, we measure the distance between the intersection point and the RTK one, which precisely corresponds to the CTE.



Task 3.2

1. **Analyse the CTE results of the different passes. Why are they negative values?**



EGNOS

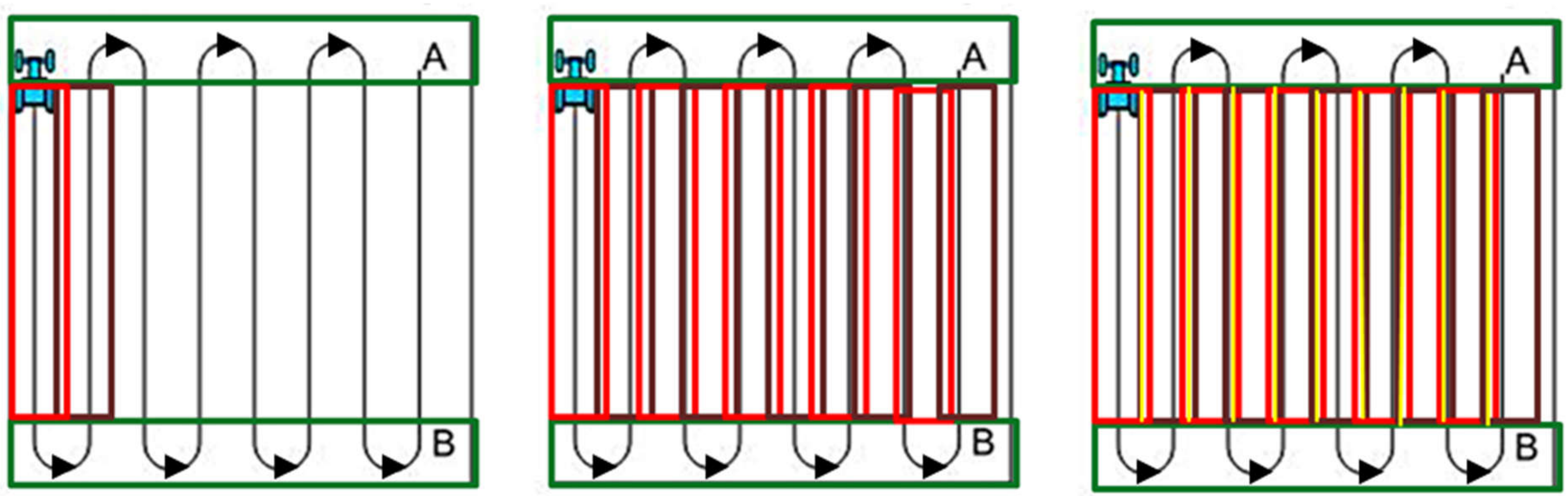
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

Pass to Pass error (1/2)

1. The Pass to Pass (P2P) error can be seen as the difference between the CTE errors of two consecutive passes (yellow areas of the figure below).



EGNOS

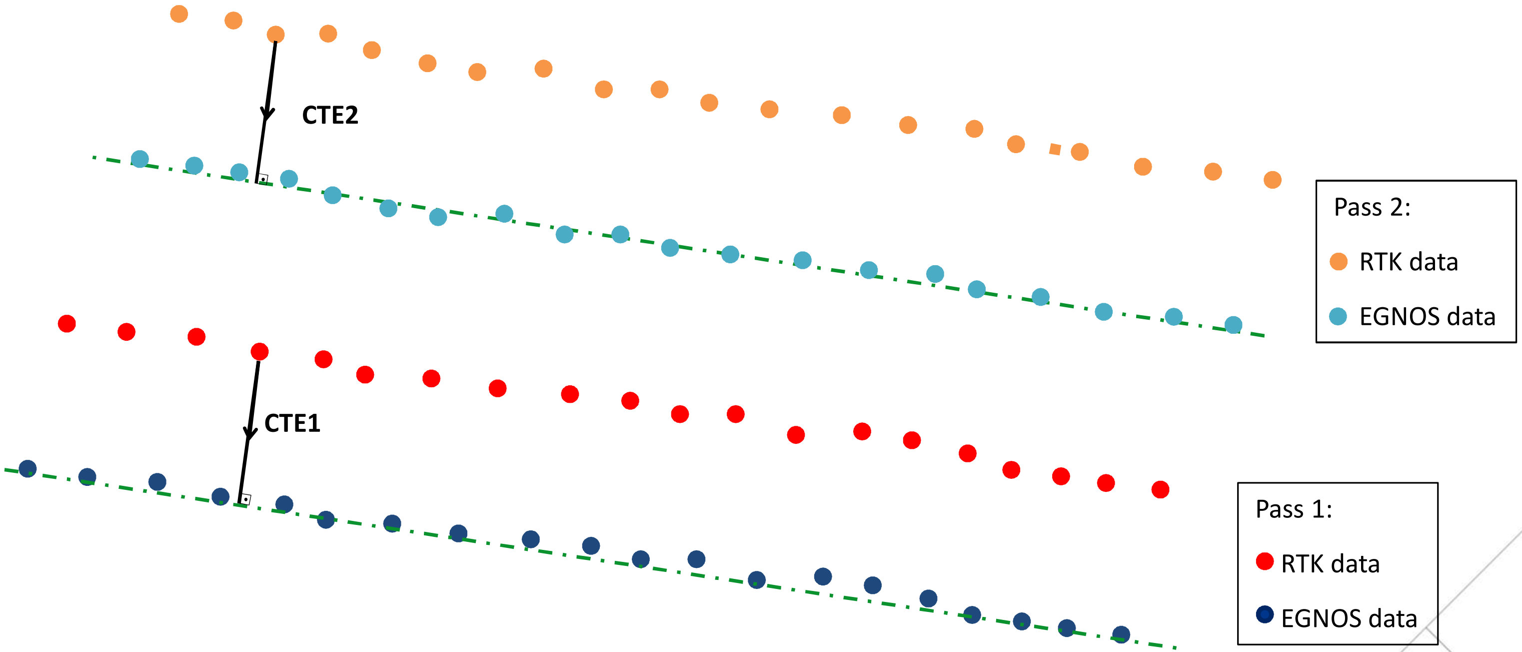
European Global Navigation Satellite Systems Agency

ESSP

NAVIGATION MADE IN EUROPE

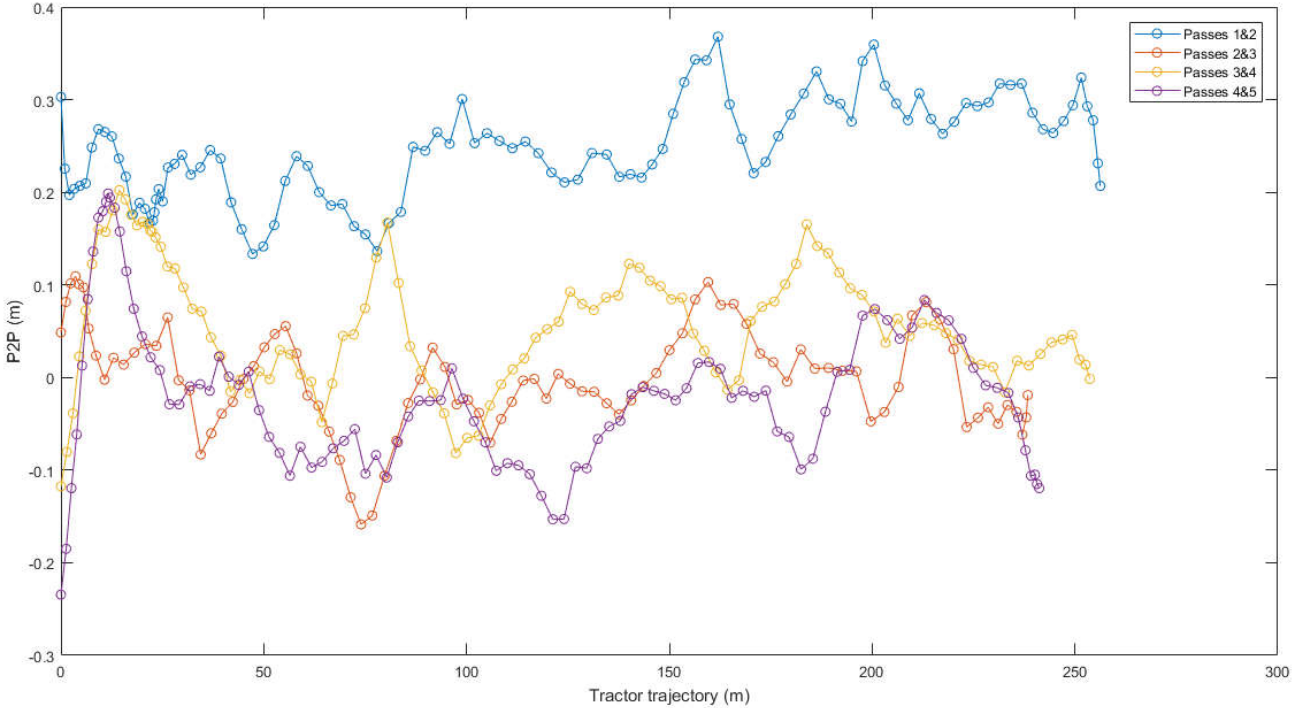
Pass to Pass error (2/2)

2. To derive the P2P error, for each RTK point of a pass, we look for the closest RTK point of the previous pass and compute the difference between their CTE values: P2P error = CTE2 – CTE1.



Task 3.3

1. **Analyse the P2P error results of the different passes. Why are there both positive and negative values?**



THANK YOU FOR YOUR ATTENTION

http://egnos-user-support.essp-sas.eu

egnos-helpdesk@essp-sas.eu

+34 911 236 555 (H24/7)

www.essp-sas.eu

Corporate Video