



GALILEO & EGNOS

THE EU SATELLITE NAVIGATION PROGRAMMES EXPLAINED



EU SATNAV

Satellite
Navigation

TABLE OF CONTENT

EUROPE MEETS SPACE	3
GALILEO, A SATELLITE NAVIGATION SYSTEM FOR EUROPE.....	4
HOW DOES SATELLITE NAVIGATION WORK?	4
GALILEO, THE SYSTEM EXPLAINED	7
GALILEO, LAUNCH SCHEDULE	9
GALILEO SERVICES	10
GALILEO APPLICATION AREAS.....	12
WHY GALILEO?	13
EGNOS	15
THE EGNOS SYSTEM EXPLAINED	16
HOW DOES EGNOS WORK?	17
EGNOS & OTHER SBAS	18
EGNOS - THREE SERVICES ON STREAM SINCE 2009	21
EGNOS APPLICATIONS AREAS.....	22
FACTS & FIGURES.....	24
GOVERNANCE	26

EUROPE MEETS SPACE

Since the dawn of time, space has been believed to wield some kind of power on our lives and for centuries it has tickled our fancy with its endless dimension.

Can you imagine how many heads have been lifted to look towards the sky in search of answers, directions, bravery or just out of curiosity? And how often men and women have stood in awe and felt overwhelmed by the majestic show performed every night by the terrific contrast between the brightest stars and the darkest mantle of the sky?

As it has always been, thirst for knowledge brought humanity to lean towards the unknown, in an effort to control it and use it to enrich its existence. For thousands of years man has looked to the sky to navigate his way. European ancestors made ground breaking discoveries laying the fundamental principles for navigation. This guidance from space takes on a new form today with the ultimate technology used in satellite navigation systems.

This booklet on Europe's satellite navigation (SatNav) programmes – **EGNOS and Galileo** - will take you through how the systems work, what elements go into making them and what they offer or will offer us all.

You thought SatNav was mainly for finding your way to your destination? That's certainly one use that simplifies our daily lives. The different ways in which satellite navigation systems can improve our lives is limited only by our imagination.



GALILEO • EGNOS • EU SATELLITE NAVIGATION

GALILEO

A SATELLITE NAVIGATION SYSTEM FOR EUROPE

GALILEO IS THE EUROPEAN GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) UNDER CIVILIAN CONTROL, PROVIDING A RANGE OF POSITIONING, NAVIGATION AND TIMING SERVICES TO USERS WORLDWIDE.

Galileo was conceived in the 1990s when the European Union identified the need for its own independent global navigation satellite system. The United States and Russia already had their own systems, GPS and GLONASS respectively. In the meantime, China has been developing its BEIDOU system, whilst Japan and India are moving ahead with their own regional SatNav systems. By early 2020 there will be more navigation satellites in the sky than ever before, introducing more frequencies, signals and potential for satellite navigation services. These advances will boost signal availability, accuracy and reliability, responding to demands of today's users.

The ever growing importance and dependence of satellite navigation applications for both businesses and European citizens makes the potential disruption of a satellite navigation service unacceptable. It would be very costly in terms of revenues to business e.g. in the banking sector, for communications, for energy supply, for transport and aviation and more importantly, in terms of human safety.

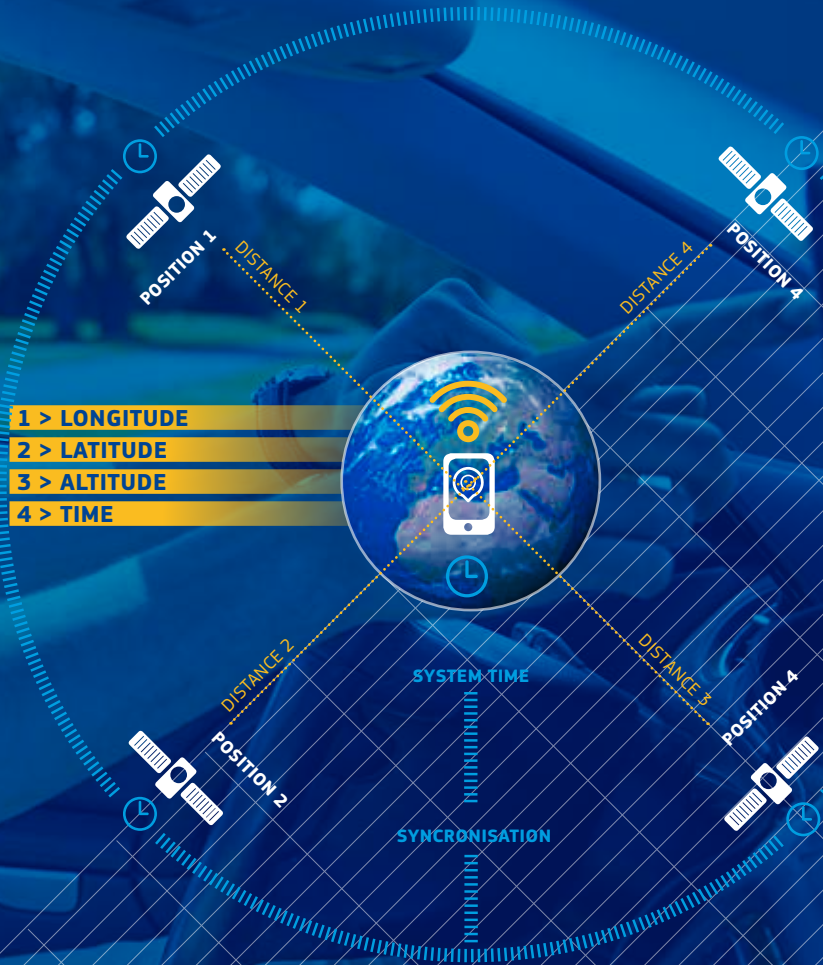
With this in mind, the Galileo satellite navigation system is being developed to ensure independence in this area that is important to the EU economy, securing the availability of those applications and services.

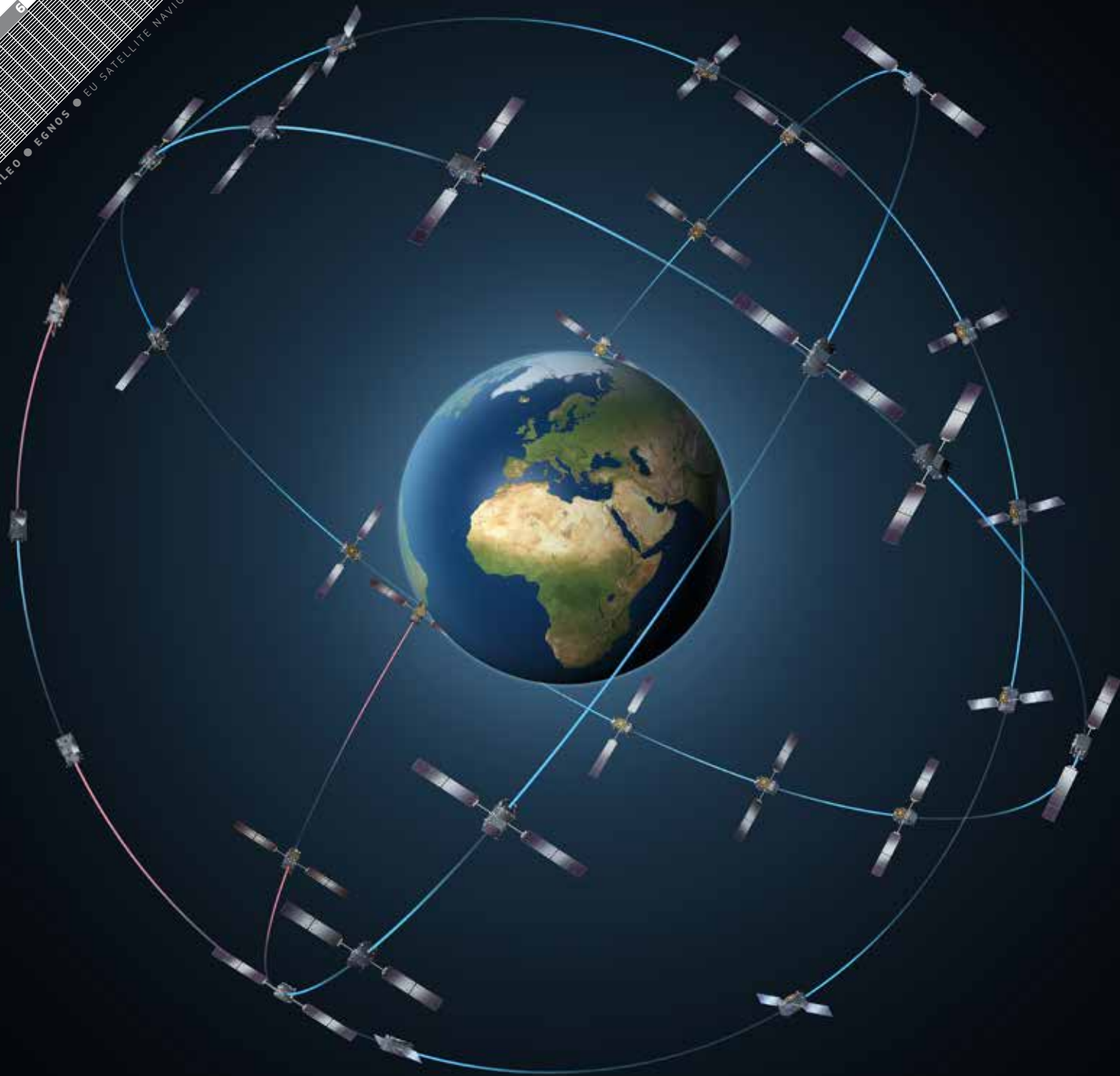
Along with the independence that Galileo will bring, the system will be a cornerstone of what is referred to as “multi-GNSS”. This will allow receivers to use signals from all satellites in view, irrespective of which global system they belong to.

HOW DOES SATELLITE NAVIGATION WORK?

Global Navigation Satellite Systems send signals to receivers, giving time and positioning information to users. To get an accurate measurement of your time and position, a minimum of four satellites in view are needed. The number of satellites in view of the user's receiver is what determines how accurately time and location can be worked out. The more satellites in view, the more precise the information received will be.

4 SATELLITES IN VIEW ARE NECESSARY





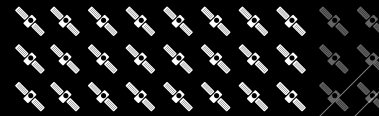
GALILEO

THE SYSTEM EXPLAINED

→ IN SPACE

The Galileo constellation in space will comprise 30 satellites in total. There will be 24 operational satellites, plus 6 spare satellites, circulating in medium Earth orbit on three orbital planes. Ten satellites will be spread evenly around each plane.

30 SATELLITES IN TOTAL



24 OPERATIONAL + 6 SPARE SATELLITES

→ ON EARTH

The Galileo ground segment in place is essentially to monitor the satellites, checking that they are functioning correctly and generating the navigation data to be sent to end users. There are two Galileo control centres, computing information and synchronising the time signal of the satellites, five telemetry, tracking and control stations to monitor and control satellites in orbit, five uplink stations for transmitting navigation signals, and up to sixteen Galileo sensor stations for receiving and monitoring the navigation signal from the constellation. All of these systems are linked via a dedicated, globally distributed communication network.



2 GALILEO CONTROL CENTRES



5 TRACKING AND CONTROL STATIONS



5 UPLINK STATIONS



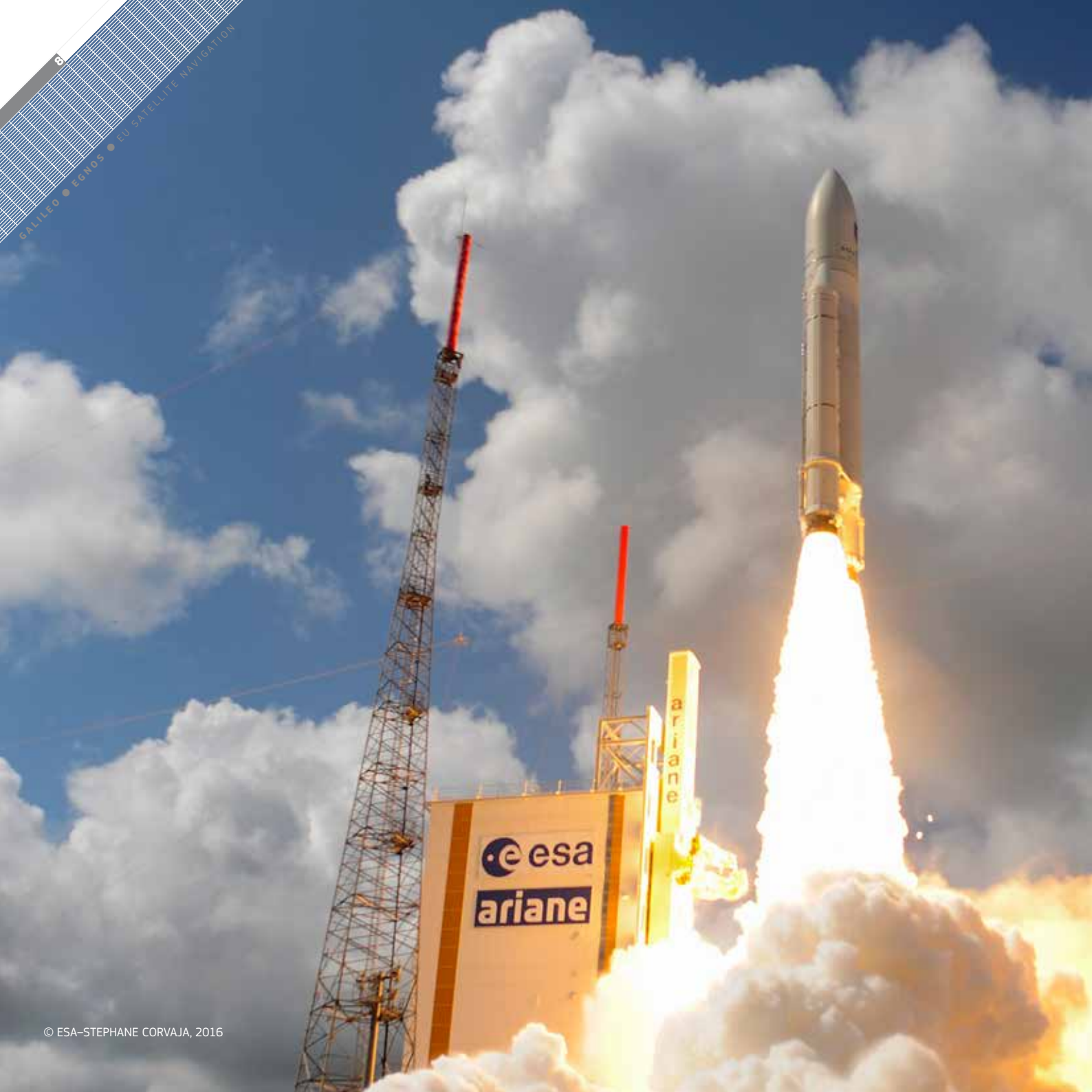
16 GALILEO SENSOR STATIONS

→ USERS & RECEIVERS

The users, both professional users and non-professional users, are the most valuable part of the system. With Galileo receivers that receive and transform the signals into coordinates and accurate time, the users can benefit from a range of services. Galileo will only improve thanks to new ideas that come straight from you. Enjoy being a protagonist on the Galileo stage.



WIDE RANGE OF SERVICES



GALILEO LAUNCH SCHEDULE

Ever wondered where Galileo satellites are launched from? The answer to that question is from the European spaceport in Kourou, in French Guiana. This location is perfectly suited for satellite launches because its proximity to the equator gives extra momentum to the rockets from the speed of the Earth's rotation.

The first 14 Galileo satellites have been carried into space in pairs aboard the Russian Soyuz launcher. In November 2016, for the first time, the European Ariane 5 launcher was used to launch four Galileo satellites simultaneously, bringing the total number of satellites in orbit to 18. Further launches are planned with both Ariane 5 and Soyuz, leading to deployment of the full constellation in orbit by 2020.



10
GALILEO • EGNOS • EU SATELLITE NAVIGATION

GALILEO SERVICES FROM INITIAL SERVICES TOWARDS FULL SERVICE LEVELS

Like the internet, satellite navigation has become a technology on which we depend in our daily lives. With Galileo satellites working together with GPS, there will be more satellites available, meaning more accurate and reliable positioning for the end users. Galileo will be fully operational by 2020 and will offer five services:

1. GALILEO OPEN SERVICE (OS)

The Galileo Open Service is Galileo's freely accessible service for positioning, navigation and timing. It will be used for many mass-market applications, including smartphones and in-car navigation. This service offers a very high accuracy of 30 nanoseconds which can be essential for critical infrastructure such as time synchronisation of the power grids or time-stamping of financial transactions.

2. GALILEO SEARCH AND RESCUE (SAR)

The Galileo Search and Rescue (SAR) service is an important tool for locating people in distress. It provides a 'forward link' for the detection of distress beacon and a unique 'return link' message which allows the person in distress to know that help is on the way. This service is Europe's contribution to an international co-operative effort on search-and-rescue activities - known as COSPAS-SARSAT. Thanks to this service, the time it takes to detect a person lost at sea or in the mountains is reduced from three hours to just 10 minutes after a distress beacon is activated.

3. GALILEO PUBLIC REGULATED SERVICE (PRS)

The Galileo Public Regulated Service (PRS) is an encrypted service designed for greater robustness and assured availability. The signal will be resistant to unintentional interference, malicious jamming, spoofing and meaconing.

4. GALILEO COMMERCIAL SERVICE (CS)

The Galileo Commercial Service will deliver various added-value features, including a strong positioning service with high accuracy down to a few centimetres, and an authentication feature, allowing validation of signals and position. These unique characteristics will allow development of new applications taking advantage of previously unavailable SatNav system capabilities.

5. GALILEO'S CONTRIBUTION TO INTEGRITY-MONITORING SERVICES

The contribution to Integrity-monitoring Services will be aimed at users of safety of life applications that are in compliance with international standards.





 GALILEO • EGNOS • EU SATELLITE NAVIGATION

GALILEO APPLICATION AREAS

Innovative uses of satellite navigation are emerging in many fields. So how can you use Galileo? Here are some key areas with wide use of satnav applications:



LOCATION BASED SERVICES: the high accuracy in positioning offered by Galileo will help you to find the fastest way to get where you need to go. All you need is a mobile telephone or a hand-held device.



INTERNET OF THINGS (IOT): The Internet is central to an endless number of services on which we rely every day. IOT represents the next step towards the digitisation of our society and economy, where objects are interconnected by creating communication networks through data exchange. Thanks to Galileo's signals accuracy and availability, users will enjoy an even wider and stronger data network.



TRANSPORT: Travelling by plane, train, boat or by car, Galileo will make transport safer and more comfortable – whether it is by identifying traffic jams or reducing travelling time and costs for the transport industry, transport will be optimised with Galileo.



AVIATION: The Galileo system will ease air-traffic-control operations, increase traffic safety and efficiency and reduce costs of infrastructure management and operations.



MARITIME: Galileo improves safety at sea. By performing ship-to-ship coordination, tracking containers and helping boats in port, approaching manoeuvres will be even more precise thanks to Galileo's signals. In 2016, the International Maritime Organisation (IMO) officially recognised Galileo, marking an important milestone for the adoption of Galileo for use in commercial shipping.



AGRICULTURE: Want to boost crop yields while maintaining a money-saving and an environment-friendly approach at the same time? Thanks to precise positioning, Galileo can help you work out just the right amount of seeds to sow, how much fertilisers to use and optimise water resource management.



SURVEYING, GEOMETRY: Galileo will enable the use of new surveying and civil engineering tools that are more accurate and reliable. This will boost productivity and reduce costs in a sector where a small error can have serious consequences.



TIMING SERVICES: Galileo satellites have synchronized clocks that provide an extraordinary level of accuracy and deliver a critical timing signal, which is useful in many fields. In **Finance**, electronic banking and stock exchange transactions need certified time stamps. In the **Energy** field, accurate timing and positioning systems are necessary in the design, construction and operation of modern energy networks. **Communication** and in particular wireless telecommunication networks will use Galileo timing for network management, time tagging and synchronisation of frequency references.

WHY GALILEO?

Satellite navigation applications are now numerous and varied and play key roles both in business and in the daily lives of citizens and communities. Independence in this area is important to the EU's economy: it is estimated that today some 11% of the EU's yearly GDP depends on the availability of satellite navigation technology. European access to reliable and accurate satellite navigation services is therefore essential.

INDEPENDENCE AND CONTROL OVER CONTINUITY OF SERVICE

Galileo represents independence for Europe in satellite navigation, a sector now extremely important for its economy and the well-being of its citizens. This means the ability to deliver and control a guaranteed global satellite navigation service, even if other systems become less precise or are switched off.

SAFEGUARD PEOPLE WHOSE LIVES DEPEND ON SATELLITE NAVIGATION

Galileo is a civil system, designed with the needs of the public sector in mind. The Galileo services will have a reserved capacity for governmental use only to support local community emergency services like the police or peace-keeping missions, and result in a fast response to any kind of emergency situations.

THE ENVIRONMENT MATTERS

Less pollution can be achieved thanks to the more efficient transport routes that Galileo allows for. With precision farming methods, considerable reduction in the use of fertilisers and chemicals can be reached and healthier food can be grown. Smart food production can be sustained with the help of Galileo to match the growing world populations.

STIMULATING EUROPEAN INNOVATION

The tangible technological advances and general know-how generated by years of research and development under the Galileo programme represent a wealth of resources for Europe and in particular European industry. European companies, including the many innovative small and medium-sized enterprises that generate so much of the world's economic activity, are now better equipped than ever to 'get down to business'. Jobs and business are being created for companies of all sizes, while spin-offs, coming out of the technology being developed, can be used by entrepreneurs and researchers outside the space industry.

INTERNATIONAL CO-OPERATION AND COMPATIBILITY

Compatibility refers to the ability of global navigation satellite systems and the services they provide to be used together, providing better capabilities at the user level than would be achieved by relying solely on one system. Galileo will co-operate with other existing satellite navigation systems, so users everywhere, both in Europe and around the world, will see a real improvement in existing services, as well as a widening of the range of new and innovative products and services.



EGNOS – THE EUROPEAN REGIONAL SATELLITE-BASED AUGMENTATION SYSTEM

Great acronyms have great responsibilities! EGNOS, the European Geostationary Navigation Overlay Service, is Europe's first concrete venture into satellite navigation and the precursor to the Galileo programme.

A regional satellite-based augmentation system (SBAS) like EGNOS can make information received from GPS, Galileo or other GNSS, even more accurate by correcting for errors such as those linked to ionospheric disturbances.

Furthermore, EGNOS is able to check the integrity of the information received, by providing an alarm in case the position information is unreliable. This is fundamental for safety critical applications such as flying aircraft or navigating ships through narrow channels.

THE EGNOS SYSTEM EXPLAINED

The EGNOS system is made up of communication transponders aboard three geostationary satellites over Europe. The satellites are interconnected with an EGNOS ground network consisting of

- 40 ranging and integrity monitoring stations (RIMS) which receive signals from the GPS, Galileo or other GNSS satellites;
- 6 navigation land earth stations (NLES) that manage accuracy and reliability data for sending to the 3 satellite transponders for relay to end-user devices;
- 4 mission control centres (MCCs) that handle data processing and differential corrections counting.

3 GEOSTATIONARY SATELLITES



40 RANGING AND INTEGRITY MONITORING STATIONS



6 NAVIGATION LAND EARTH STATIONS

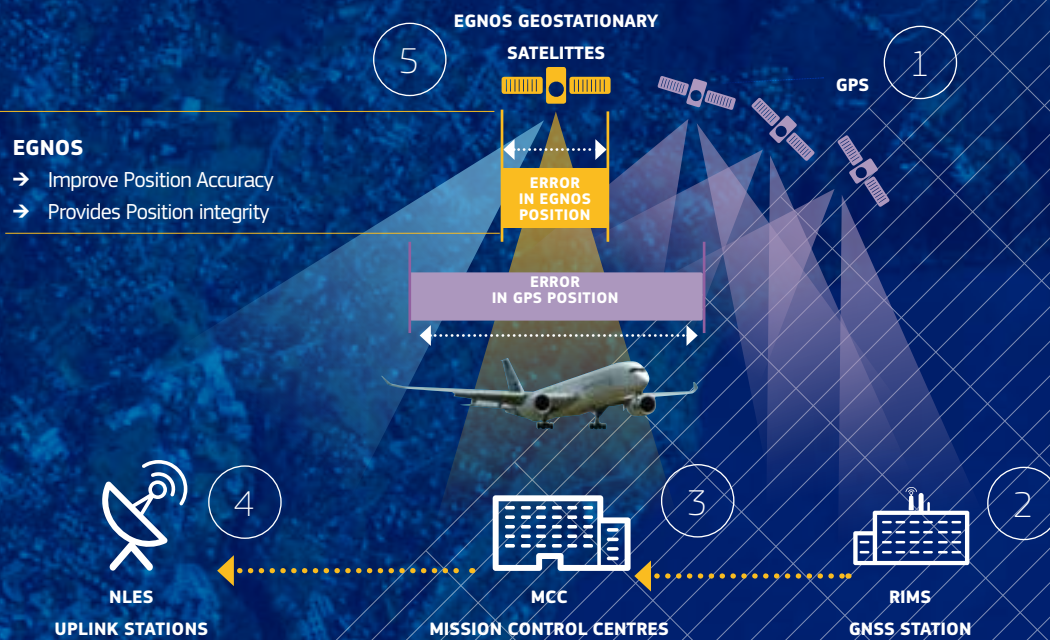


4 MISSION CONTROL CENTRES (MCCS)



Enabled user devices receive the broadcast EGNOS signals in addition to GPS or Galileo signals, and can make use of the received information to significantly improve accuracy and reliability.

HOW DOES EGNOS WORK?



WAAS

- The USA uses the Wide Area Augmentation System (WAAS).

EGNOS & OTHER SBAS

All satellite-based augmentation systems (SBAS) are interoperable, so with the same receiver, users can benefit from augmentation of satellite navigation everywhere in the world.



EGNOS

- The European Geostationary Navigation Overlay Service (EGNOS) covers Europe and neighbouring countries.

SDCM

- Russia is active in the field with its GLONASS-based system called SDCM.

SNAS

- China is developing the SNAS system under its Beidou programme.

MSAS

- Japan is covered by its Multi-functional Satellite Augmentation System (MSAS).

GAGAN

- India has its own SBAS, GAGAN, which covers the Indian subcontinent.



EGNOS - THREE SERVICES ON STREAM SINCE 2009

Thanks to EGNOS, impressive performance levels can be obtained. The accuracy of positioning is improved up to 1 and 2 meters horizontally and between 2 and 4 meters vertically and the accuracy of timing information services is improved to better than 10 nanoseconds.

1. EGNOS OPEN SERVICE (OS) is available since October 2009 and is offered free of charge to anyone with a receiver compatible with satellite-based augmentation systems.
2. EGNOS SAFETY-OF-LIFE SERVICE (SOL) was launched in March 2011 for civil aviation, providing an indispensable alarm to users within six seconds in case of a GPS or Galileo malfunction. When lives are potentially at stake, such a warning is indispensable.

3. EGNOS DATA ACCESS SERVICE SERVICE (EDAS): This terrestrial commercial data service has been operational since 2012. EGNOS signals are made available through a dedicated internet connection. All information collected and generated by EGNOS is also available through a ground network, meaning that in situations where satellite signals are blocked or disturbed, the information can still be accessed. This is especially relevant in dense cities where tall buildings can block the EGNOS signals.

EGNOS APPLICATIONS AREAS



AVIATION

Global satellite navigation systems alone do not meet the necessary operational requirements set by the civil aviation authorities. EGNOS has been certificated for civil aviation use since 2011. Today, more than 200 airports in almost 20 European countries have EGNOS-based landing approach procedures and the number is increasing. Access to smaller and regional airports is improving.



AGRICULTURE

Precision farming techniques based on EGNOS are used by farmers across Europe to reduce the use of fertilisers and lower costs whilst benefiting the environment.



ROAD/RAIL

Terrestrial (Road/Rail) users can benefit from EGNOS enabled tracking systems. Accuracy in localisation is essential for both private and public sectors: it implies more fuel-efficient itineraries, better managed logistics and a fast response to any kind of emergency by the local community emergency services.



MARITIME

EGNOS is able to improve every aspect of maritime operations: from port and coast guard operations to offshore exploration and fisheries management. Maritime users can benefit from the better accuracy for harbour navigation or inland navigation.



MAPPING

The efficient technology of EGNOS contributes to improvement of any GNSS measurements with real time mapping information and solutions provided for free.





FACTS & FIGURES



WITH EVERY
€100 MILLION
INVESTED IN THE
AEROSPACE SECTOR,
**GDP IN EUROPE WILL
INCREASE BY
€ 70 MILLION**
IN OTHER SECTORS.

Global navigation satellite system is a service enabler rather than a standalone service, therefore it acts as a catalyst for economic activities leading to the creation of added value and jobs in a wide range of sectors.

Have you ever heard of the '**spill-over**' effect? It occurs when progresses that come about as a result of research and development (R&D) investment in the space industry are transferred to other sectors.

Research suggests that investment by the aerospace sector could generate a social return of around 70%. In other words, with every €100 million invested in the R&D sector, GDP in Europe will increase by €70 million in other sectors e.g. health and medicine, transport, computer science.

TOTAL ANNUAL GLOBAL MARKET VALUE FOR GLOBAL NAVIGATION SATELLITE PRODUCTS AND SERVICES :

€175
BILLION
IN 2013



€237
BILLION
IN 2020

THE EUROPEAN SPACE INDUSTRY EMPLOYS
OVER **230 000 PROFESSIONALS**.





BY 2019, **7.0 BILLION**
GNSS DEVICES WILL BE
IN USE WORLDWIDE.

3.6 billion GNSS devices are in use in 2014 worldwide. By 2019, this is forecasted to increase to over 7 bln – for an average of one device per person on the planet.



2 DAY DISRUPTION
= 1 BILLION €.

It has been estimated that a 2-day disruption to the satellite navigation services could cost the transport, finance and financial sectors across Europe 1 billion €.



EGNOS and Galileo can fulfil the increasing demand for traceability from consumers and food regulators, which means that you would be able to scan a sack of potatoes at a supermarket and be able to tell from which field those potatoes came from by using geo-traceability.

ECALL



From April 2018, all new type approved vehicles sold in Europe will be Galileo capable as part of a requirement to comply with the EU's eCall emergency response system regulation. Galileo-enabled navigation devices for your car will also start coming on the market in 2017.



Satellite navigation, combined with 3-D sounds is being used to enable visually impaired people to use a new system of sensorial guidance in order to indicate to the user the correct path that is clear of obstacles.

GOVERNANCE

The Galileo and EGNOS programmes are funded and owned by the EU. The European Commission has the overall responsibility for the programmes, managing and overseeing the implementation of all programme activities on behalf of the EU.

The deployment, design and development of the new generation of systems and the technical development of infrastructure of the programmes are entrusted to the European Space Agency (ESA).

The operational management of Galileo and EGNOS are carried out by an EU agency, the European Global Navigation Satellite Systems Agency (GSA).



More info

The European Commission webpages:

→ <http://ec.europa.eu/galileo>

→ <http://ec.europa.eu/egnoss>

The European Global Navigation Satellite System Agency
– GSA

<https://www.gsa.europa.eu/>

The European GNSS Service Centre (GSC) helpdesk for
users:

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

The European Space Agency – ESA

<http://www.esa.int/ESA>

The EGNOS portal:

<https://www.egnoss-portal.eu/>



GALILEO EGNOS

NAVIGATION SOLUTIONS
POWERED BY EUROPE