GNSS MARKET REPORT

ISSUE 3

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Satellite Systems
Agency

GNSS MARKET REPORT

ISSUE 3

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Dear Reader,

I am pleased to present the 3rd edition of the GSA GNSS Market Report. The Market Development team has travelled a long way to build this comprehensive market knowledge source. We are glad to know that companies and organisations use GSA forecasts to assist in building their strategies.

Over the years, the report has grown in size, presenting the complexity of the dynamic GNSS market. The previous edition of the report presented segments such as: **Location Based Services, Road, Aviation, Maritime, Agriculture and Surveying**. This release will also guide you through the use of GNSS in **Rail**. In order to allow the reader to have an overview of each market segment, we have introduced a reference page with four key graphs at the end of each section.

To produce this report we used advanced forecasting techniques together with a validation process with market experts and estimated the size of the GNSS market in terms of **shipments**, **revenues** and **installed base of receivers**.

The GNSS market is experiencing rapid developments and the **global installed base of GNSS devices has surpassed 2 billion units**, despite the economic slowdown.

Mindful of recent milestones and the fact that **multi-constellation GNSS** is becoming a reality, the prospects for the future are highly promising.

I look forward to receiving your feedback and comments.

Carlo des Dorides
Executive Director

The European GNSS Agency (GSA)
market@gsa.europa.eu
Prague, October 2013

GNSS market

The Global Navigation Satellite System (GNSS) market comprises products (receivers and devices) and services using GNSS-based positioning as a significant enabler.

Core and enabled markets

This market report primarily considers the core GNSS market. For multi-function devices, such as smartphones, the core market includes the value of GNSS functionality only (rather than the full device price) and service revenues directly attributable to GNSS functionality (e.g. data downloaded by smartphones to use Location-Based Services).

For multi-function devices, a correction factor is taken into account, for example:

- **GNSS-enabled smartphone:** only the value of GNSS chipsets is counted, estimated at 1% of the price.
- **Personal Navigation Devices (PNDs):** 100% of retail value since GNSS is the key enabler.
- **Aviation:** the value of the GNSS receiver inside the Flight Management System is taken into account.
- **Precision agriculture system:** the retail value of the GNSS receivers, maps, and navigation software is counted.

The Executive Summary also presents results for the enabled market. The enabled market represents the services and devices enabled by GNSS, and includes the core market. For the enabled market, the entire retail value of the smartphone is included.

Geographic Coverage

- European Union (EU27)*
- North America (USA, Canada, Mexico)
- Rest of the World (including non-EU European countries)

Market segments

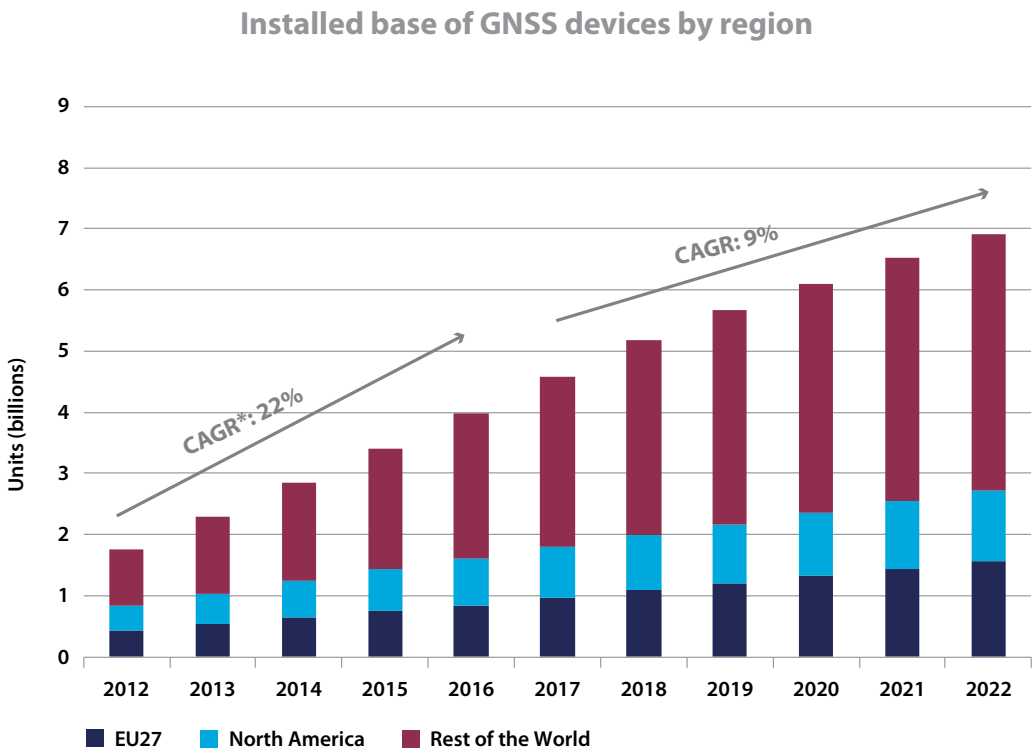
- **Location-Based Services (LBS):** smartphones, tablets, digital cameras, laptops, fitness and people tracking devices, and mobile data revenues.
- **Road:** Personal Navigation Devices (PNDs) and In-Vehicle Systems (IVS) used for navigation; devices used for Road User Charging (RUC), Pay-Per-Use-Insurance (PPUI), eCall, and Advanced Driver Assistance Systems (ADAS); and other devices supporting Intelligent Transport Systems (ITS) applications and data revenues for traffic information services.
- **Aviation:** GNSS-certified devices for commercial, regional, general & business aviation, and uncertified devices aiding pilots flying under Visual Flight Rules (VFR).
- **Rail:** GNSS usage in safety-critical devices supporting signalling (high and low density lines) and non-safety devices supporting other applications (asset management and passenger information).
- **Maritime:** GNSS devices to support general navigation, the Automatic Identification System (AIS), the Long Range Identification and Tracking (LRIT) System, port operations (including portable pilot units), dredging, and search & rescue beacons.
- **Agriculture:** GNSS devices used for tractor guidance, automatic steering, asset management, and Variable Rate Technology (VRT).
- **Surveying:** GNSS devices to support land surveying (including cadastral, mining, construction, and mapping) and marine surveying (including hydrographic and off-shore surveys).

Terminology used in charts

- **Shipments:** the number of devices sold in a given year
- **Installed base:** the number of devices currently in use
- **Revenue:** the revenue from device/service sales in a given year

** Croatia is counted within Rest of the World for this issue of the report. It will be included in the EU28 in the next edition of the Market Report.*

Seven billion GNSS devices by 2022 – almost one for every person on the planet



- Over the coming decade, the installed base of GNSS devices will increase almost four-fold, largely driven by increased penetration in regions outside Europe and North America.
- Such a large number of devices, almost one GNSS receiver for every person on the planet, has the potential to deliver additional significant benefits, not measured in this report, especially in terms of time and fuel savings, as well as efficiency gains.
- It is expected that the number of GNSS devices will increase in Europe and North America from 1 to 3 per inhabitant over the coming decade.
- For the Rest of the World, rapid growth, albeit from a low initial starting point, will see an increase from 1 device per 10 inhabitants to 1 per 2 inhabitants over the coming decade.

** CAGR refers to the Compound Annual Growth Rate.*

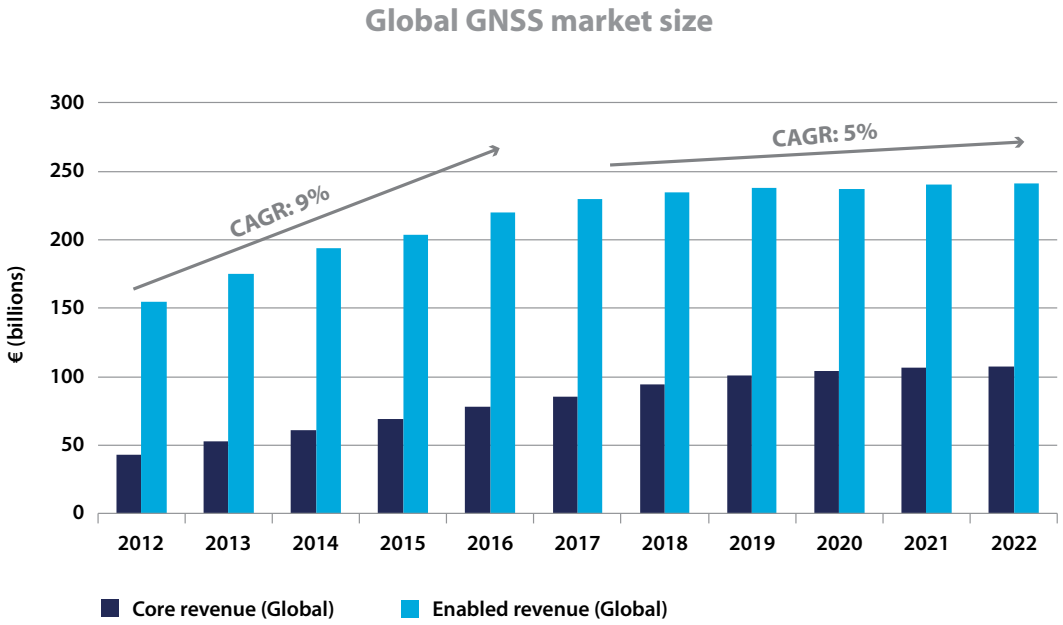
A growing GNSS market offers opportunities in a complex technological landscape

- The projected long-term growth revenues indicates significant business opportunities, however the changing technological environment (e.g. use of communications and other positioning technologies alongside GNSS, and the emergence of new constellations) requires constant innovation on the supply side.

- Although various location technologies are integrated in one device, GNSS will remain one of the main sources of outdoor positioning information.

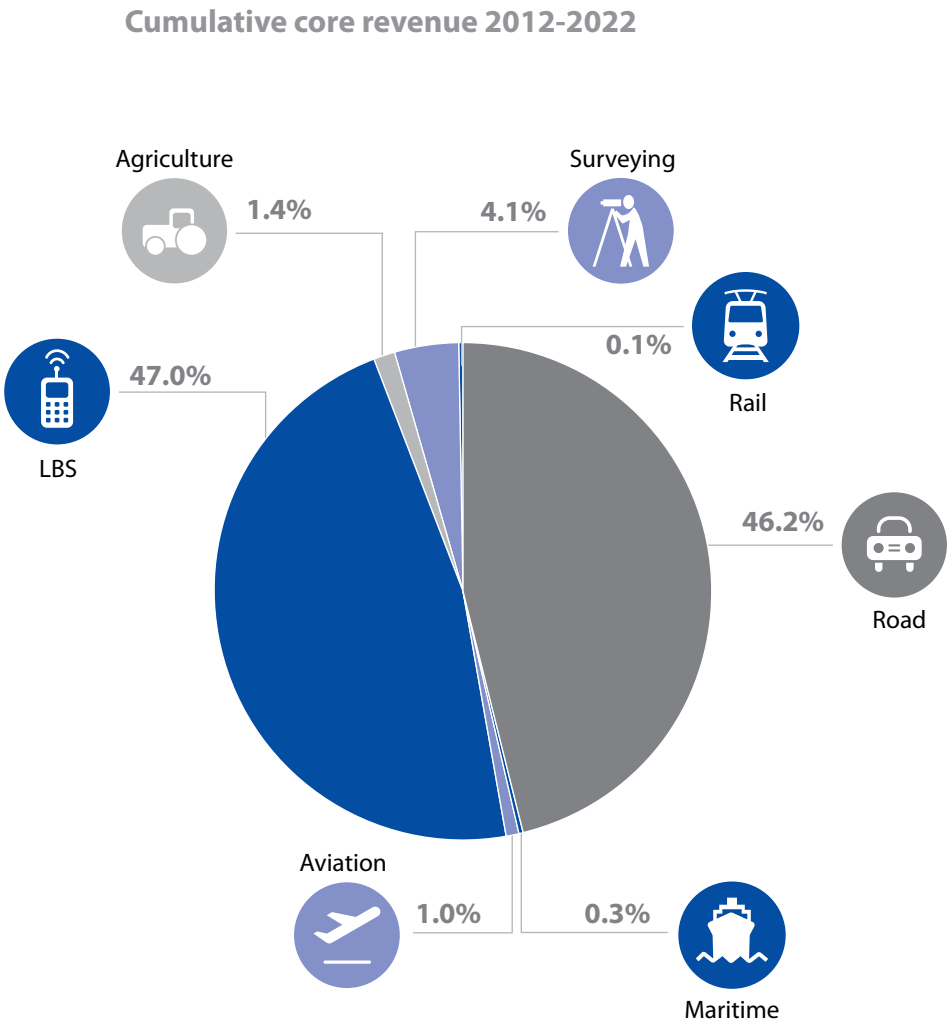
- Global enabled GNSS markets are forecasted to grow to approximately €250 billion per annum by 2022. Core revenues are expected to reach €100 billion in 2019.

- Worldwide regulatory measures are being undertaken in several domains to promote the use of GNSS. For example, regulatory requirements for emergency location sharing, such as the European eCall, the mobile 911 (North America) and 112 (Europe), or Search and Rescue (SAR) services, promise to provide further impetus for growth in Europe and North America over the next five to ten years.



Note: definitions of core and enabled revenues are included in the Market Definition section. In this issue of the market report, the global core revenue projections are lower in absolute terms in respect to the previous issue. This is mainly due to an improvement in the methodology for calculating LBS data revenues, which is modified to better reflect the proportion of mobile internet service revenues attributable to Location-Based Services, and due to actual and forecasted reduction in PND sales.

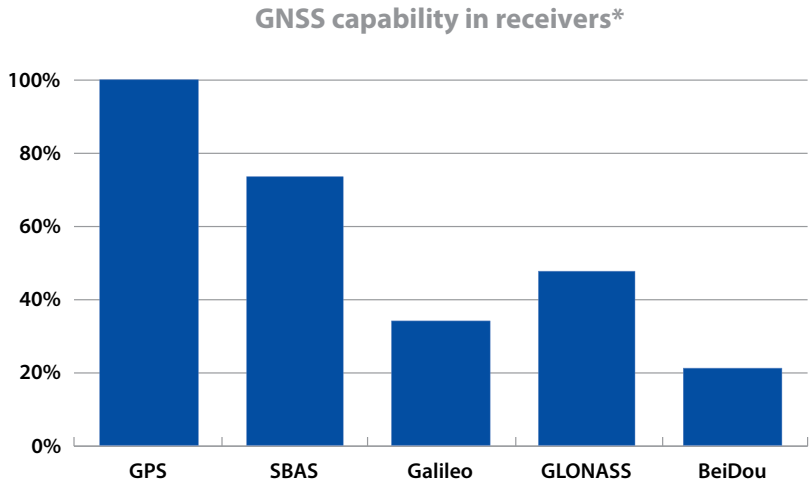
Smartphones dominate global GNSS revenues and are expanding into other market segments

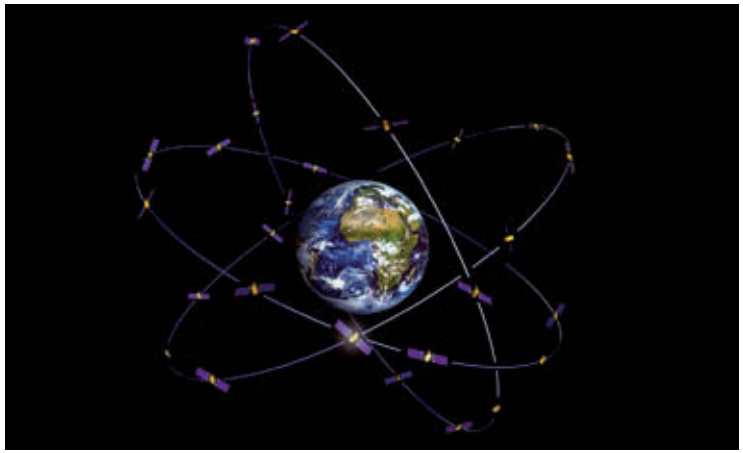


- New smartphone capabilities alongside integrated technologies are blurring the market segment breakdowns, as LBS devices increasingly support navigation and services in other applications.
- LBS is forecasted to be the largest market segment by revenue, overtaking Road, where the PND market continues to decline, being cannibalised by the use of smartphones in cars. LBS devices are also being increasingly used in general aviation and leisure maritime.
- New applications are continually introduced and consumers have begun to appreciate the capabilities of LBS in their daily lives.
- Competitive pricing has made smartphones more affordable and their market share is rapidly increasing compared to traditional mobile phones without GNSS capability; leading to an increase in GNSS penetration, especially in lower income countries.

Multi-constellation receivers become widely available on the market

- Multi-constellation devices that use all navigation signals in view are becoming more common in the market, offering increased availability (appreciated especially in urban environments) and more robust performance in professional applications (e.g. in Surveying).
- More than 70% of models available on the market are GPS-SBAS capable (SBAS comprising WAAS, EGNOS, and MSAS) and the penetration will grow further with the expansion of SBAS coverage around the globe.
- Galileo is recognised as a valuable element in multi-constellation systems, and it is already present in more than 30% of receiver models, well ahead of its full operational capability.
- GLONASS is the second constellation of choice after GPS.
- BeiDou published its Interface Control Document in December 2012. Several equipment manufacturers, particularly those based in Asia-Pacific have started to offer BeiDou-enabled models.

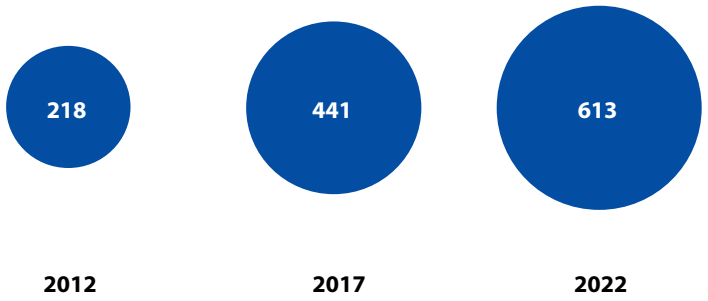




** Source: GSA analysis based on GPS World Survey 2013. Percentages based on number of models available, not sales*

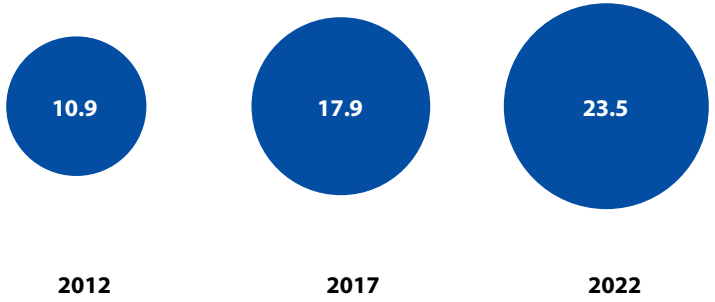
EU shipments and revenues will increase strongly over the next decade

Shipments (in millions) of GNSS devices to the EU27



*__Note:__ *The sizes of the bubbles and number represent shipments to end-users in the EU27.*

Revenue (in billion €) raised in the EU27



*__Note:__ *The sizes of the bubbles and number represent revenues raised from end-users in the EU27.*

- The shipments of GNSS-enabled devices in the EU27 will grow from 218 million to more than 600 million per annum by 2022. Revenues are expected to more than double over the decade to €24 billion in 2022.
- The EU market will continue to grow (both in terms of shipments and revenues), indicating that even in the developed world the market remains far from saturated.
- The growing LBS market, with EU unit sales projected to reach almost 450 million units by 2017, remains the largest segment, followed by Road, which together account for c. 99% of all shipments.
- On the supply side, EU-based companies have strong positions in antenna manufacturing, automotive, rail, surveying, defence/public utilities, and telecoms. A recent GSA study found the EU share in global market volume in these fields to be between 27% and 45% in 2011.

EGNOS consolidating the market position

EGNOS, the European Satellite Based Augmentation System, increases the accuracy of GPS positioning and provides information on its reliability (integrity), making it suitable for safety-critical applications. EGNOS has been fully operational since 2009.

Consisting of three geostationary satellites and a network of ground stations, EGNOS is interoperable with WAAS (US), MSAS (Japan), and GAGAN (India).

Designed primarily for Aviation, EGNOS has been widely adopted in other segments, such as Agriculture and Road.

An enhanced version of EGNOS is currently under development. It will offer Galileo corrections and a wider coverage area expanding into Africa and the Middle East.

Early Services on the horizon

Galileo, Europe's own Global Navigation Satellite System, will provide highly accurate global positioning services worldwide firmly under civilian control and wholly interoperable with GPS, GLONASS, and BeiDou. Many GNSS receivers and chipsets in the marketplace are already "Galileo-ready".

Galileo is currently finalising its In-Orbit Validation (IOV) phase using an initial group of 4 satellites launched during 2011-2012. On 12th March 2013, Galileo passed an historic milestone for European space when the very first determination of a ground location fix was achieved.

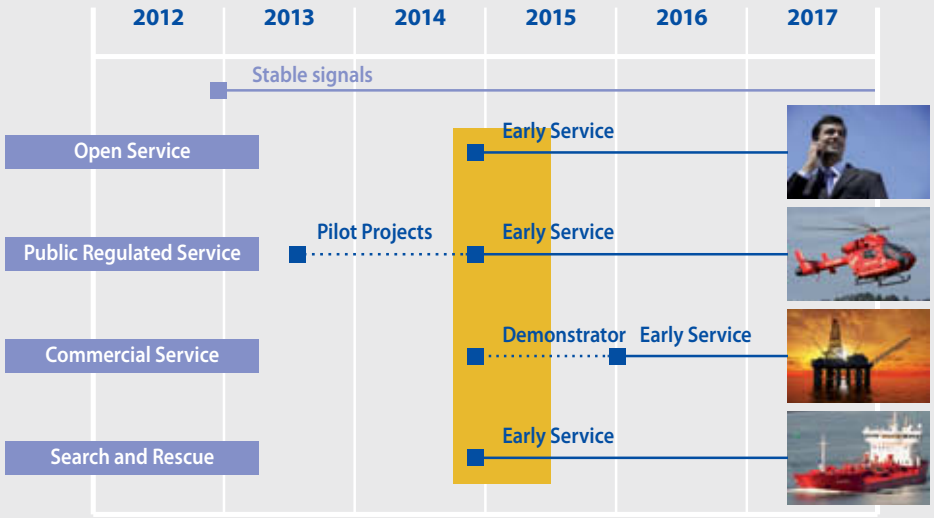
Galileo Services

Open Service (OS) – a freely accessible service for positioning, navigation and timing, utilising the dual-frequency Galileo Signal in Space (SIS). The Open Service is global and free to use.

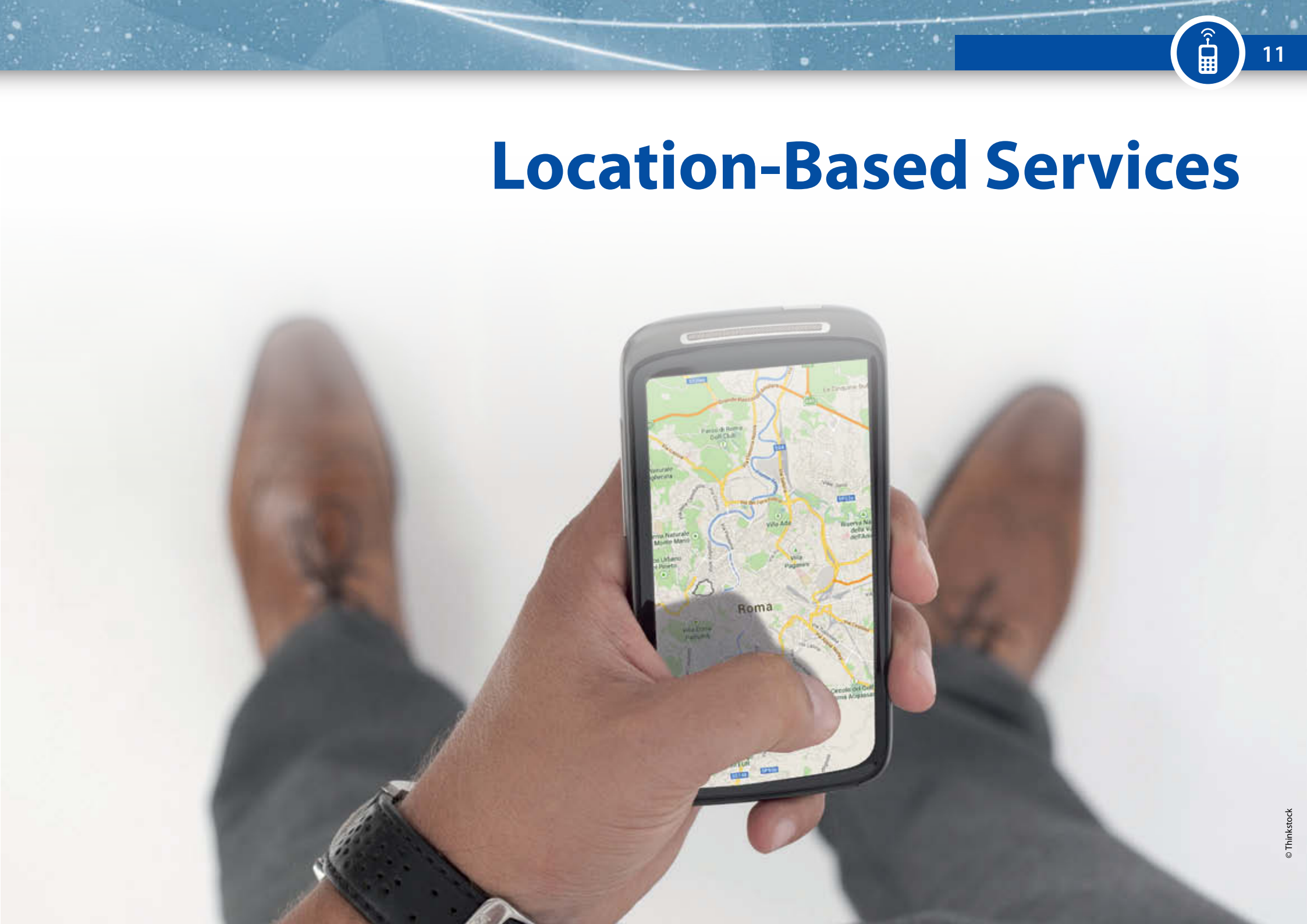
Public Regulated Service (PRS) – an encrypted, secure service with additional advanced features designed for greater robustness and higher availability, primarily directed at government/public sector operations.

Commercial Service (CS) – delivers authentication and high accuracy services for commercial applications.

Search and Rescue Service (SAR) – assists in locating people, vessels and aircraft in distress, with confirmation that help is on the way.



Location-Based Services



Mobile applications getting closer to where you are

Key market trends:

- **Growing diversity of mobile applications, also integrating location-based information in camera view (augmented reality).**
- **Use of GNSS in devices traditionally unrelated to location.**
- **Increasing number of devices per user and regional expansion towards developing countries.**

Complexity of LBS segment

Applications: personal navigation, point of interest search, LBS advertising, person and objects tracking, emergency caller location, location based gaming, sport and entertainment, weather information and news, social networking

Application Stores:
Apple App Store
Windows Phone Store
Google Play
Amazon App Store

Devices: Smartphones, tablets, digital cameras, fitness and tracking devices, binoculars

Technology:
Cell ID, Wi-Fi, GNSS, INS

Recent developments:

- Augmented reality – an information overlay in mobile devices on top of the physical world.
- Indoor positioning – location of people and objects inside large buildings, such as airports and shopping centres.

Upsurge in number of applications:

- 775,000 in Apple App Store in 2013.
- 700,000 in Android Apps compared to 88,000 in 2011.
- An estimated 40% of applications use location information.

- Integration of positioning into devices such as cameras, watches, and binoculars.
- Location information sent from devices to application layers to enable sharing and tracking (e.g. for recording the distance run, social networking).

- Various positioning technologies integrated into one device.
- GNSS remains the primary positioning solution outdoors, offering better accuracy than Cell ID and Wi-Fi .
- Technological developments concentrate on seamless integration and the switch from outdoor to indoor positioning.

** Indoor Messaging System*

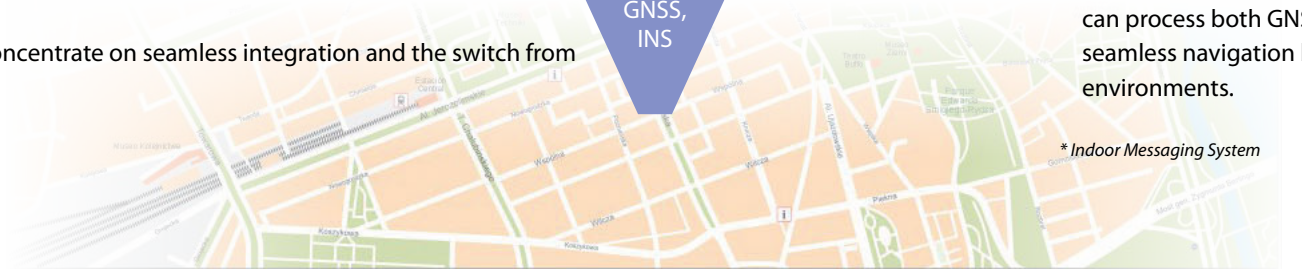
Examples of applications:

- Foursquare – users "check in" at a certain location, enabling social networking, finding points of interest and recommending places.
- Wikitude – augmented reality application, adding information to camera view on points of interest, tourist information, etc.
- Find Me Maybe – sends geo-localized SMS to Facebook and Twitter informing contacts of the user's situation.

- Binoculars – built-in GPS receiver automatically geo-tags video clips and photos.
- Fitness devices – GPS watches for runners, cyclists, and swimmers.
- Augmented reality glasses.

- IMES* – provides 3D position in indoor locations with an accuracy of about 10 m. The same GNSS receiver can process both GNSS and IMES signals leading to seamless navigation between outdoor and indoor environments.

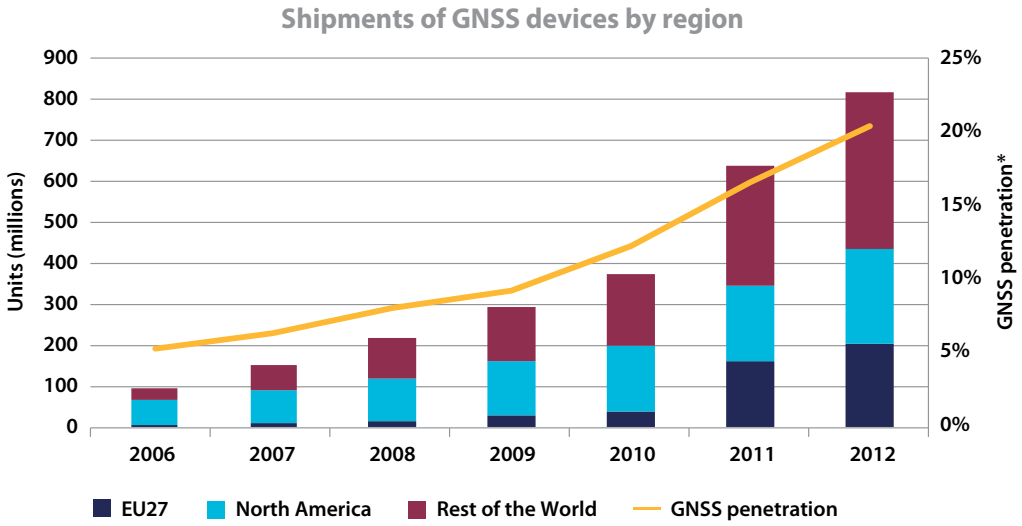
** Indoor Messaging System*



LBS value chain

	Chipset Manufacturers	Device Vendors	Service & Content Providers	App Developers & Retailers	App Stores
Examples of key players	• Broadcom • CSR-SiRF • Fujitsu Ltd • Intel • Mediatek • Qualcomm • Skytraq • STM • Texas Instruments • U-Blox AG	• **Smartphone/tablet:** Apple, HTC, Huawei, Malata, Nokia, RIM, Samsung, ZTE • **Cameras:** Canon, Nikon, Sony • **Watches:** Garmin, Suunto, Timex • **PCs:** Apple, Dell, HP, Lenovo • **People tracking:** Garmin, Pocket Finder, Spot • **OEMs:** Pegatron, Wistron	• Apple • Garmin • Google • Nokia • TomTom • Assistance data providers • Mobile Network Operators	**App developers:** • Apple, Electronic Arts, Google, Microsoft, TripAdviser, Yelp, Zynga **Retailers:** • Airlines • Banks • General retailers • Media companies • Mobile Network • Operators • Transport providers • Vehicle manufacturers	• Apple App Store • Amazon App store • Google Play • Windows Phone Store
Market Trends	• Integration of sensors and RF technologies (GNSS, GSM, Wi-Fi) together with GNSS multi-constellation. • Continuous improvements in cost, power consumption and performance.	• Highly competitive global market with rapid innovation and integration along the value chain, tying together content, platforms, and applications. • Increasingly GNSS is a standard feature in many platforms, such as digital cameras, laptops, watches, and personal tracking.	• The increasing demand for location-based applications opens up new opportunities for service providers. • Increasing value perceived in controlling mapping solutions e.g. Apple Maps set up so as to be independent of Google Maps data. • The decline of the automotive PND market pushed many important players to utilise their assets (such as map and traffic information data) to become a service provider.	• Retailers commission apps and benefit from new opportunities for customer relationship management and vehicles for location-based advertising. • App developers are increasingly consolidated, however there are many small scale hobbyists who develop highly useful apps.	• The market is dominated by the major platform developers, Apple and Google, that have become particularly strong players in the value chain.

The LBS market has seen phenomenal growth



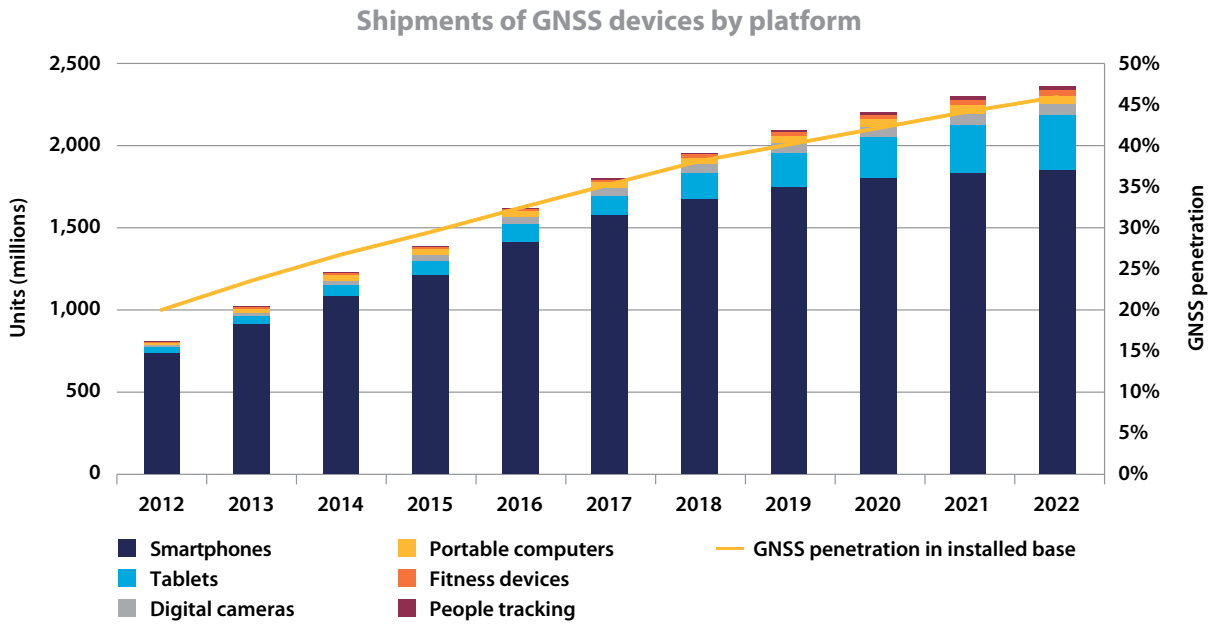
- GNSS penetration worldwide increased from 5% in 2006 to 20% in 2012. In Europe and North America, more than half of mobile phones have GNSS capability.
- Global shipments of GNSS-enabled LBS devices have grown from 150 million to 800 million in the last five years (40% CAGR).
- The Rest of the World represents approximately 50% of the market and is growing quickly due to rapid economic growth in these regions and decreasing device prices, making them more affordable.

** The penetration represents the percentage of LBS devices in use that are GNSS enabled*

Rapid evolution of GNSS capability in LBS:

- The first LBS services were launched in 2001 by TeliaSonera in Sweden and by EMT in Estonia, relying on the Ericsson mobile positioning system.
- The first advertisement for iPhone was broadcast during the 79th Academy Awards in 2007.
- Mobile apps exploded onto the market in 2008 with the launch of the App Store – allowing 3rd party developers access to the iPhone platform for the first time.
- In 2009 Google introduced turn-by-turn directions as a feature of its Android operating system, hastening the demise of the Road Portable Navigation Device (PND) market whilst providing greater access to driving, cycling, and walking directions.
- MTS launched the first GLONASS smartphone in 2011.
- In 2013 Google announced an open beta test of its Google Glass augmented reality glasses.

Further growth will be additionally stimulated by new GNSS platforms



- Location-Based Services are a perfect fit with the increasingly fast pace of life, especially in large cities. They respond to the growing needs for mobility in urban environments and for getting to destinations more quickly. They also facilitate faster social networking in scarce free time.
- This, combined with increased affordability of smartphones and other GNSS-enabled platforms, will drive the future growth of the LBS market; expected to be 10% CAGR over the next decade.
- Smartphones comprise 90% of LBS devices sold. However, with the growing penetration of tablets and increased GNSS usage in digital cameras, the smartphone share will decrease over the next decade.
- There has been a substantial increase in the number of forecast smartphone shipments since the last issue of the market report. This is driven by the falling price of smartphones relative to users' incomes.

Galileo offers benefits for advanced LBS applications

The most important GNSS characteristics for the LBS market are Time-To-First-Fix (TTFF) and availability. Use of assisted GNSS lowers **TTFF** by transferring part of the data used to determine the position over mobile networks.

Several test results show that **availability** is significantly improved (especially in urban canyons) by the existence of additional satellite constellations.

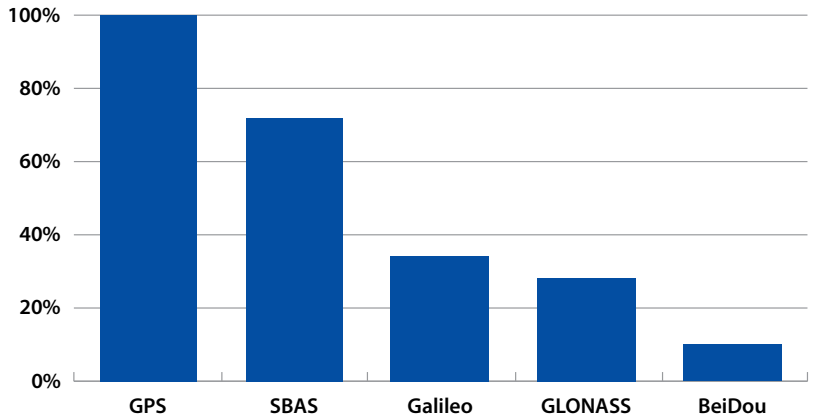
Galileo will contribute to better performance in LBS

Availability will be further improved by the use of Galileo satellites, enhancing continuity of service in urban environments.

Galileo, as a part of a multi-constellation solution, can respond to the need for higher accuracy for some more demanding applications. For example, the ability to locate a user in front of a particular shop opens new opportunities for location-based advertising.

State-of-the-art signal characteristics of Galileo will have better resistance to multipath interference (interference from reflected signals).

GNSS capability of LBS chipsets*



Example of R&D project: i-Going

Although 90% of phone usage occurs indoors, there are no suitable services yet to provide accurate positioning of these devices inside buildings.

i-Going project develops a service that generates specific indoor signals by making use of a network of pseudolites, which are installed inside buildings and are connected to a localisation server that manages them.

More information can be found at: http://www.igoing.eu

Example of R&D project: PERNASVIP

Visually disabled people have striking needs for trustful navigation systems that improve their day-to-day autonomy. Existing positioning and navigation technologies still lack accuracy and reliability or they rely on costly infrastructures.

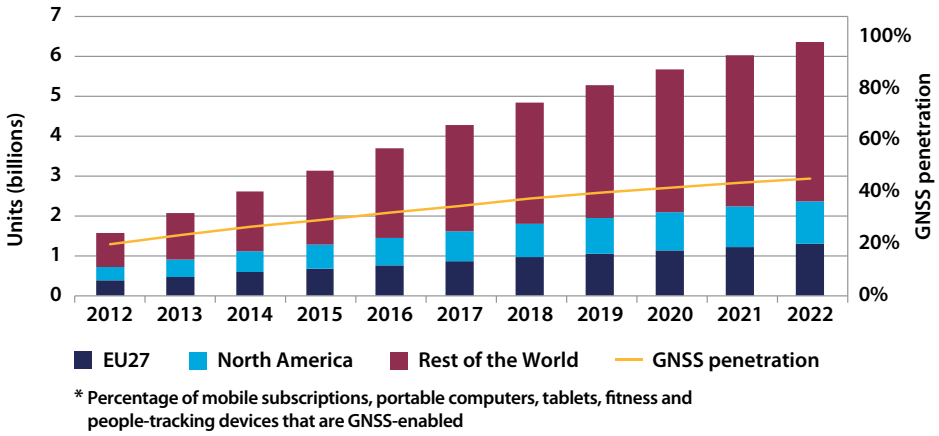
PERNASVIP aims to develop a GNSS-based mobility service with EGNOS/Galileo capabilities that solves these problems in an urban environment. The service meets the 4m level of accuracy and reliability, enabling efficient mobility in daily life.

More information can be found at: http://pernasvip.di.uoa.gr/index.php

** Source: GSA analysis based on GPS World Survey 2013. Percentages based on number of models available, not sales.*

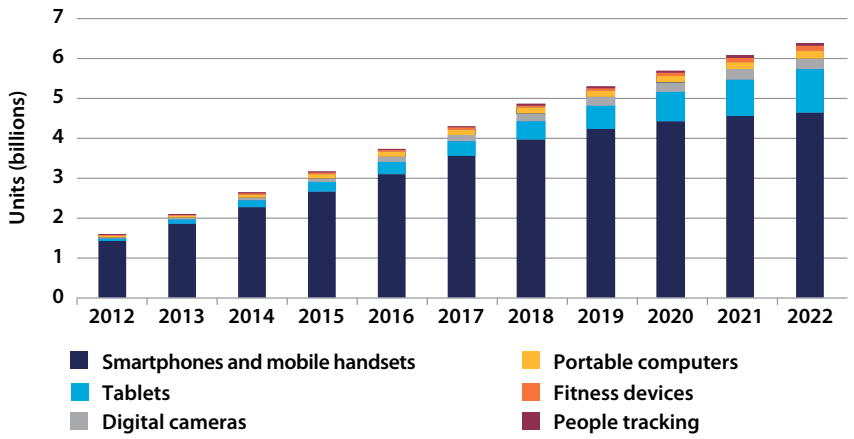
LBS Reference Charts

Installed base of GNSS devices by region

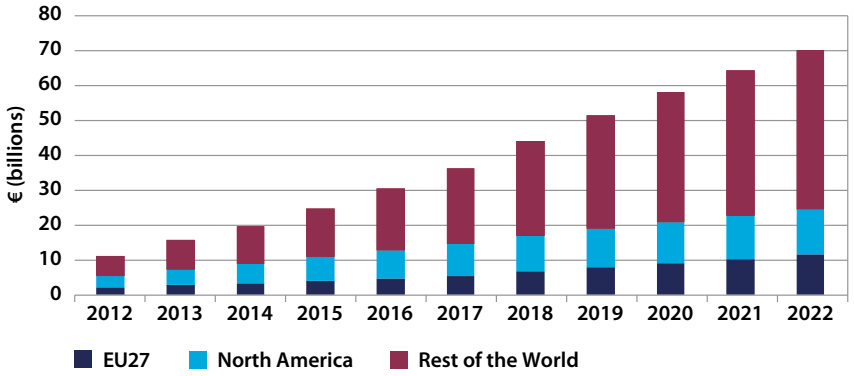


* Percentage of mobile subscriptions, portable computers, tablets, fitness and people-tracking devices that are GNSS-enabled

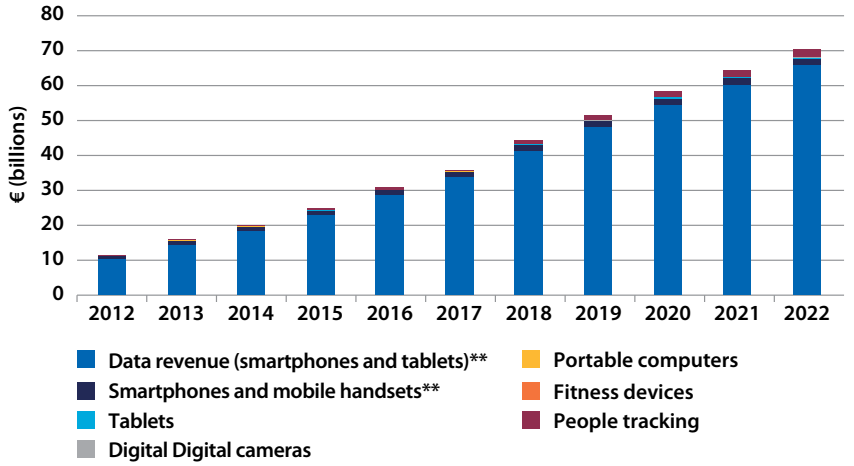
Installed base of GNSS devices by platform



Core revenue from GNSS device sales and services by region



Core revenue from GNSS device sales and services by platform



** Includes only value attributable to GNSS functionality

In comparison with Issue 2 of the market report, smartphone sales forecasts have been revised upwards due to faster penetration growth than expected. In addition, the methodology for projecting LBS data revenues has been refined to only consider location-enabled LBS applications; whereas previously location-assisted LBS applications (substantially more numerous) had also been included. This refinement results in an overall reduction in the LBS data revenues which is attributable to the methodological refinement and not to real shrinkage of the market.

Road

GNSS consolidates its position in vehicles

Key market trends:

- **Increased regulatory pressure for emergency location sharing and safety-related applications drives the demand for telematics equipment, which serves as a platform for innovative applications.**
- **Dedicated nomadic GNSS devices (PNDs) are becoming redundant with increasing use of smartphones and better affordability of In-Vehicle Systems (IVS).**

Current industry view

Lower costs of data connectivity and consumer electronics drive the development of new applications. The number of embedded devices and On-Board Units (OBUs) is growing, replacing traditional nomadic devices (e.g. PNDs). Smartphones are increasingly used for road navigation purposes. New Intelligent Transport System (ITS) services are expected to be deployed in the coming years, taking the use of GNSS far beyond in-vehicle navigation.

The following applications beyond traditional navigation are selected for this report:

- **Pay-per-use insurance (PPUI)** enabling pricing policies based on timing, location and driving behaviour.
- **Advanced Driver Assistance Systems (ADAS)** and connected vehicles where GNSS, complemented by sensors (e.g. camera, radar) and communications systems (e.g. Wi-Fi, 3G), is used to enhance intelligent vehicle safety systems (e.g. intelligent speed adaptation, lane change assistance, curve speed warning, collision avoidance, automated driving).
- **Road User Charging (RUC)** solutions, determining the position of vehicles using GNSS data received by OBUs, which calculate road tolls based on distance travelled at a particular location and time.
- **Satellite road traffic monitoring** using real-time traffic information. The floating car location data, collected in real-time from vehicles, are sent to a central processing centre and shared with interested parties.
- **eCall** - see description on the right side of the page.

EU policies drive GNSS adoption:

Digital Tachograph (DT)

- EU policy has made DTs mandatory for vehicles with a mass of more than 3.5 tonnes in goods transport and those carrying more than 9 persons in passenger transport, in order to enforce rules on driving times and rest periods, guaranteeing fair competition and road safety.
- The new regulation introduces the use of GNSS positioning in future DTs. GNSS technology will help automate operations so far performed manually to record the position of the vehicle at determined points, with estimated cost-saving of €350 million per year for the sector. The presence of GNSS in DTs will also foster the use of the satellite-based positioning to guarantee to origin and the integrity of the DT records and will open up further possibilities for the introduction of a standardised interface to support Intelligent Transport Systems (ITS) applications.

eCall

According to a new regulation proposed by the European Commission, all new types of passenger cars and light vehicles will need to have an eCall system from 2015.

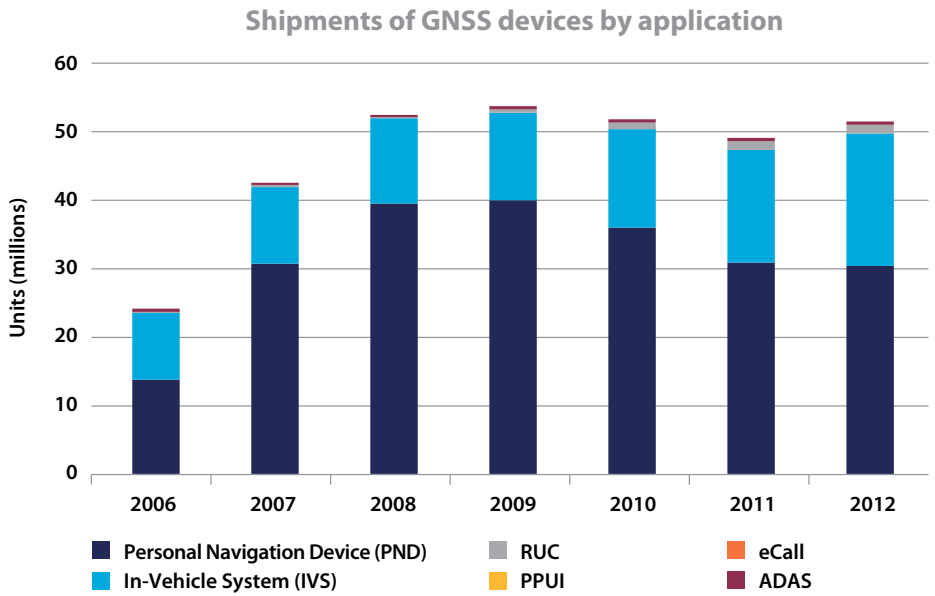
The eCall system will automatically:

- send an emergency call to 112 in case of accident, offering rapid assistance to drivers in every part of the European Union.
- provide vehicle identity and GNSS-based location, shortening the intervention time.

Road Value Chain

	Chipset Manufacturers	Tier 1 and Device Vendors	Service Providers	Original Equipment Manufacturers	Users
Examples of key players	• Broadcom • CSR-SiRF • Furuno • Japan Radio Co. • Mediatek • Pulse Electronics • Qualcomm • ST Micro • U-Blox	• Bosch • Continental • Denso • Ficosa • Garmin • Magneti Marelli • Siemens • TomTom	• Fuel/fleet card issuing companies • Mobile network operators • Traffic information providers • Telematics service providers • Toll operators	• BMW • Daimler • Fiat • Ford • General Motors • Jaguar Land-Rover • Peugeot Citroen • Renault Nissan • Toyota • Volkswagen • Volvo	• Car owners • Fleet operators • Insurance companies • Member States
GNSS Market Trends	• GNSS performance continues to improve through availability of new modern signal processing techniques and closer integration with various technologies (Assisted GNSS, Wi-Fi, and other sensors). • New products include multiple constellation capability – essential for many urban ITS applications.	• The use of nomadic devices in cars is decreasing which, together with price erosion, results in lower revenues. • PND market is strongly cannibalised by the use of smartphones in vehicles. • The share of embedded devices, supported by regulation and consumer demand, is increasing.	• Apart from map data providers, this market is not yet consolidated and includes many business models. • The level of innovation is high and convergence with internet and mobile applications is taking place. • In ITS deployed scenarios GNSS-enabled services are expected to become a key revenue driver.	• Platform convergence is expected, driven by common data standards, lower data tariffs, and interest in vehicle connectivity. • EU eCall regulations by 2015 will support the market for embedded devices and could be an incentive to leverage development costs through a wider service offering (e.g. ADAS, infotainment).	• The socio-economic benefits coming from GNSS help to overcome some of the challenges on the road such as rising congestion, pollution, and costs of fuel and insurance. • These challenges drive new service offerings e.g. asset tracking, PPUI insurance, and real-time traffic information.

PNDs further replaced by embedded devices

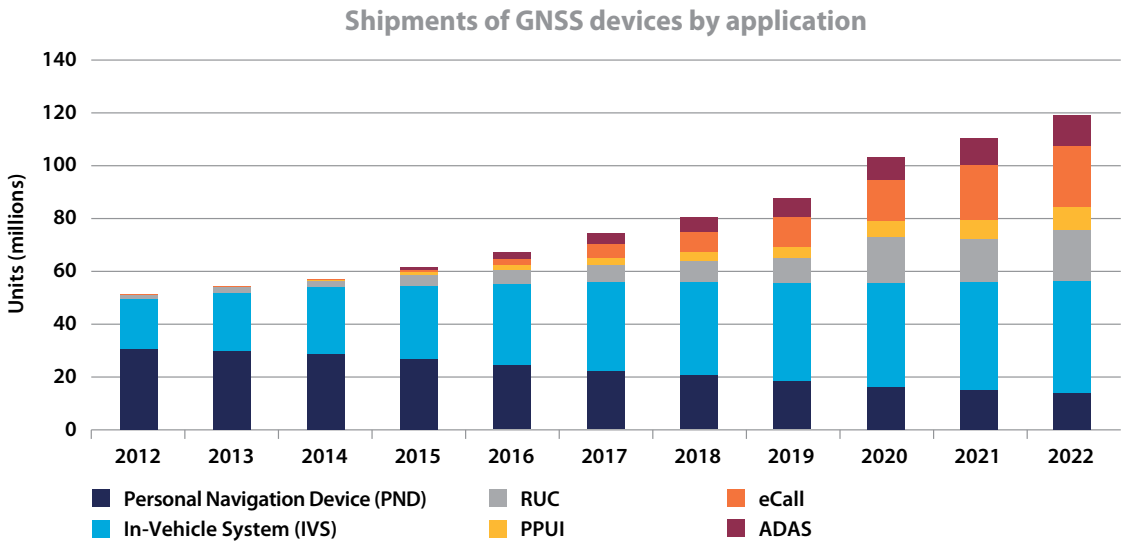


- With smartphone navigation becoming increasingly popular, the PND market has been declining since 2009*.
- Lower connectivity costs and emergence of innovative solutions linked with infotainment platforms have resulted in increased uptake of IVS. The IVS market grew by approximately 13% CAGR between 2009 and 2012.

- The appearance of the first GNSS-based RUC schemes resulted in the uptake of dedicated OBUs with the market share increasing from almost zero in 2009 to more than 2% of all road devices sold in 2012.
- The installed base of GNSS devices quadrupled from 2006 to 2012, reaching over 200 million devices (see reference page).
- Significant growth in installed base was observed in all regions, as average device prices fell and GNSS-based Intelligent Transport Systems (ITS) became more common in vehicles.

** Smartphones used for navigation in vehicles are excluded in the Road segment device shipments charts and presented as part of the LBS market.*

New ITS applications drive market growth



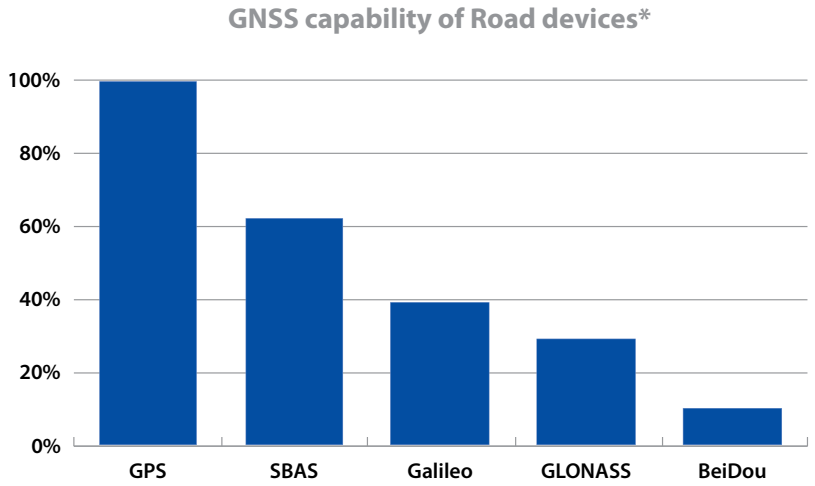
- Increased connectivity of vehicles and GNSS multi-constellation capabilities expand new products and urban ITS applications in Road.
- PNDs, replaced by multi-function devices, are forecast to account for only 10% of total Road GNSS device shipments by the end of the decade.
- New applications in use from 2015 are driven by the eCall initiative and related to reliable telematics devices. Common data standards and lower tariffs will foster IVS uptake, accounting for about one third of total shipments in 2022.
- Market needs for cheaper and more sustainable transportation systems favour GNSS-based RUC schemes and PPUI applications. Combined shipments of devices in these two applications will grow to around 20% in 2022.
- Competition in the automotive industry and from smartphones, combined with declining prices in consumer electronics in general, will result in price erosion for both PND and IVS.
- Traffic information services enabled by GNSS are forecast to be the primary driver of growth in service revenues until 2018. Thereafter, fierce competition in this segment will result in total revenues declining to around 2012 levels by 2022 (see reference page).

European GNSS enhances Intelligent Transport Systems

Galileo is expected to bring immediate benefits in the Road segment, even from Early Services, as part of a multi-constellation solution. It will add value in all applications by providing increased availability, especially in urban environments where the number of satellites in view can be limited. This will result in better accuracy and reliability of positioning. Additional benefits are expected when the dual-frequency capacity of Galileo is fully exploited by consumer devices.

Many new GNSS chipsets aimed at the automotive market include Galileo tracking capabilities (see chart on the right) and the share is expected to increase rapidly with the upcoming eCall implementation.

By improving accuracy and providing information on the reliability of GPS signal, at no additional cost, EGNOS is now included in many automotive GNSS chipsets and has started to be valued in applications such as road charging and dangerous goods transport monitoring.



Example of R&D project: TACOT

The TACOT (trusted multi-application receiver for trucks) project promotes the use of EGNOS and Galileo in the road industry through trusted GNSS function in Digital Tachographs (DT). Benefits include:

- The possibility to record start and end positions for truck journeys.
- Usage in other ITS domains: pay as you drive services, anti-theft systems, fleet management, and new applications using the trusted Position, Velocity and Time (PVT).

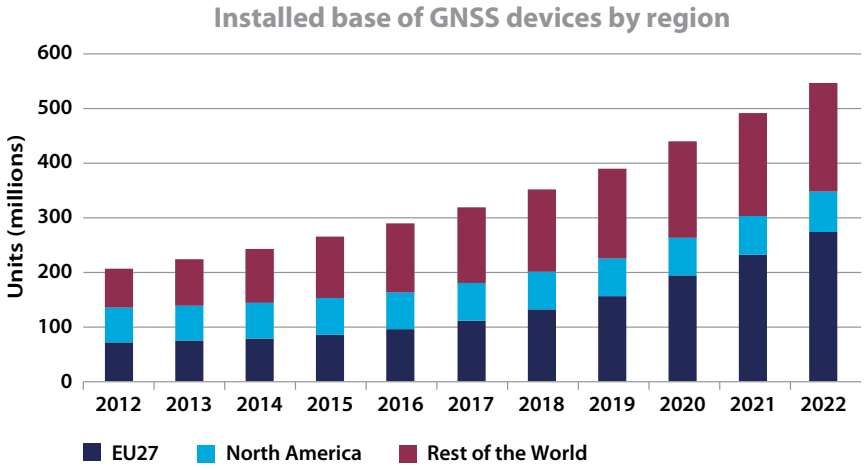
TACOT aims to demonstrate that a GNSS-based "trusted" PVT enabling liability critical and legally binding applications, can be achieved at relatively low cost using EGNOS and Galileo.

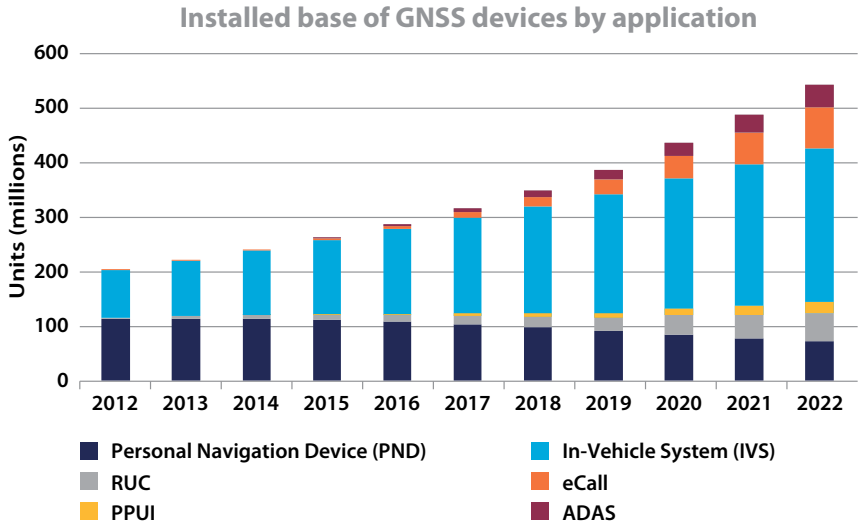
More information can be found at:
http://www.gsa.europa.eu/trusted-multi-application-receiver-trucks

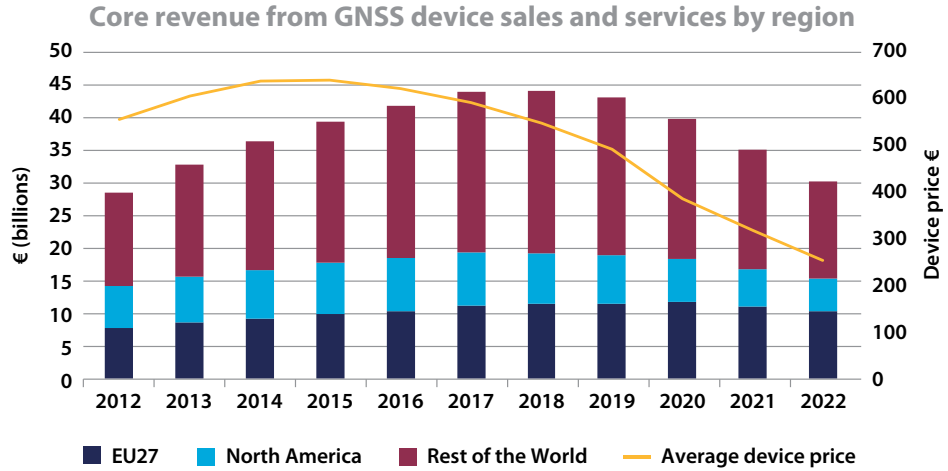
SEVENTH FRAMEWORK PROGRAMME

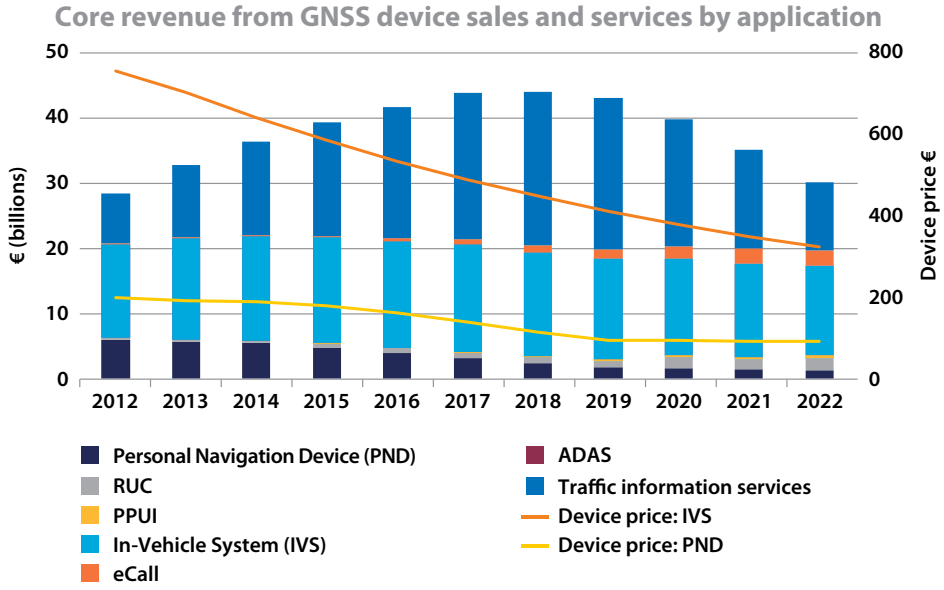
** Source: GSA analysis based on GPS World Survey 2013. Percentages based on number of models available, not sales.*

Road Reference Charts









Aviation

GNSS as a key enabler for Performance-Based Navigation (PBN)

Key market trends:

- **Transition from traditional routing to GNSS navigation solutions for all phases of flight.**
- **New operational requirements driving the growth of GNSS avionics use.**
- **Growing availability of SBAS-based procedures in European aerodromes.**

The aviation market

Navigation systems in Aviation demand the highest robustness and integrity, and support continuous operations in aerodromes of varying infrastructure complexity.

GNSS applications in Aviation vary greatly depending on the accuracy and integrity of the position needed. Operations relying on GNSS are subject to certification (Instrument Flight Rules), otherwise GNSS can be used as an additional aid to the pilot without requiring regulatory approval (Visual Flight Rules).

The Aviation market has been segmented according to the use of the aircraft/helicopters into: commercial, regional and business & general aviation.

This issue of the market report adds General Aviation Visual Flight Rules (GA VFR) as a sub-segment, the largest aviation application in terms of shipments and with the least demanding requirements (non-certified GNSS devices). Typical users include kit planes, micro lights, ultra lights, gliders, and hot-air balloons.

High-end business aviation and commercial operators tend to have GNSS receivers tightly integrated into their avionics, whilst panel mounted displays provide a cheaper and simpler solution for regional and general aviation users.

Performance-Based Navigation leverages GNSS benefits

GNSS is essential for the introduction of Performance-Based Navigation (PBN) in line with ICAO standards that place requirements on the quality and accuracy of aircraft navigation along predefined routes, on an instrument approach procedure or in designated airspace. It envisages a transition from traditional ground-based navigation towards space-based navigation.

GNSS helps to increase safety, reduce congestion, save fuel, protect the environment, reduce infrastructure operating costs, and maintain reliable all weather operations, even at the most challenging airports.

Growth in the use of GNSS

GNSS use in Aviation will increase as more flight procedures are designed to take advantage of PBN. For example, EGNOS-enabled instrument approach procedures to LPV* minima are being rolled out in Europe, increasing safety and business continuity at aerodromes.

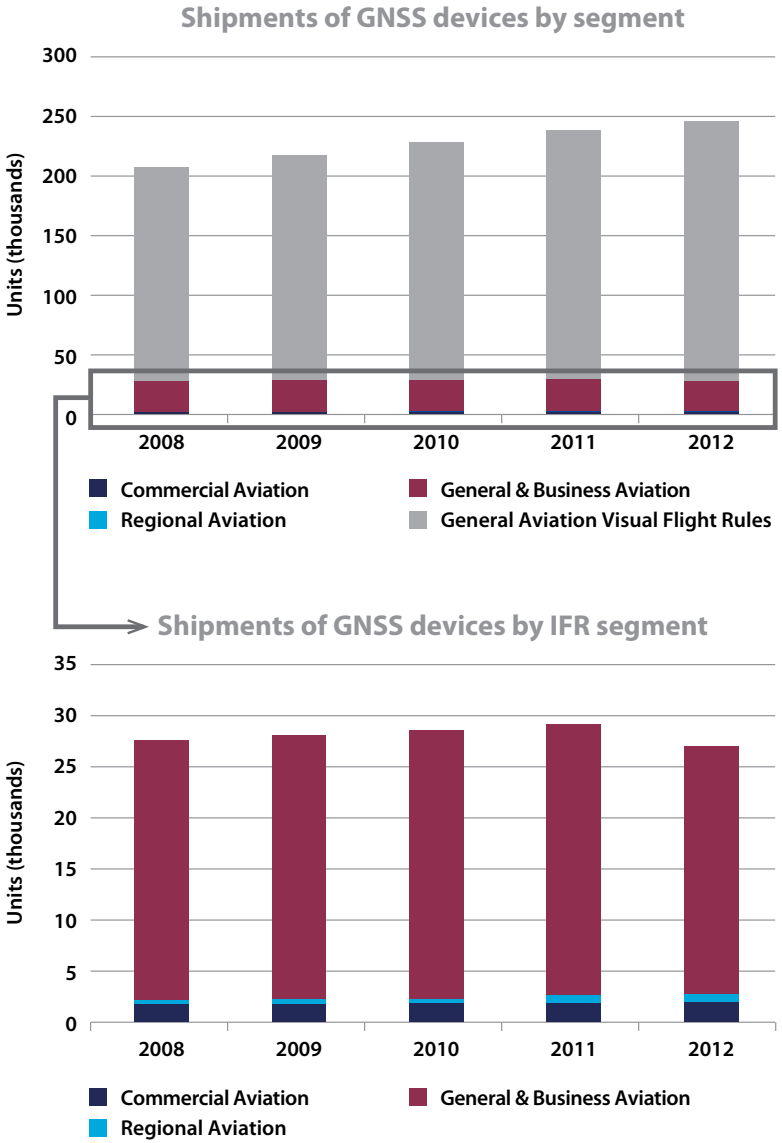
New GNSS constellations are expected to be available in the next few years providing multi-frequency and multi-constellation navigation capabilities, which may improve the performance of existing PBN applications. It is expected to be a key enabler for Ground Based Augmentation Systems (GBAS), resulting in lower minima to CAT II or CAT III standards, demanded by some commercial operators.

** Localiser performance with vertical guidance is an Instrument Approach Procedure that provides later and vertical guidance based on GPS augmented by SBAS (EGNOS/WAAS) down to 250 ft.*

Aviation Value Chain

	Device Manufacturers	Aircraft Manufacturers	Airlines/ Aircraft owners	Air Navigation Service Providers (ANSP)	Aerodromes
Examples of key players	**Main Players (CA/RA):** • Honeywell (US) • Rockwell Collins (US) • Thales Avionics (FR) • Universal (US) **Main Players (BA/GA):** • Garmin (US) • Honeywell (US) • Rockwell Collins (US)	**Main Players (CA/RA):** • Airbus (EU) • Boeing (US) • Embraer (BR) **Main Players (BA/GA):** • Bombardier (CAN) • Cessna (US) • Cirrus (US) • Piper (US)	**Main airline alliances:** • Oneworld • SkyTeam • Star Alliance **General Aviation:** • Aircraft Owners and Pilots Association (AOPA)	**Main Organisations:** • The Civil Air Navigation Services Organisation (CANSO) represents ANSPs worldwide • The International Civil Aviation Organisation (ICAO) codifies the principles of air navigation	**Main Categories:** • International airports • Regional airports • Private airports
GNSS Market Trends	• The capabilities of GNSS devices respond to customer demand and fit within the regulatory environment. • Penetration of GNSS in the VFR sub-segment is increasing. • New features and capabilites from regulated devices are expected to align with the requirements of PBN and the progression towards multi-frequency integration.	• Aircraft manufacturers continue to offer avionics from a limited set of manufacturers due to high investment and certification requirements. • This limitation does not exist for VFR pilots who can make choices purely on personal preference. • GNSS is included in all modern aircraft. Whereas, SBAS capability is a standard mostly in business and general aviation.	• Demand for GNSS - in particular EGNOS - is particularly high in less equipped airfields where precision approach capabilities may not exist. • The move to PBN may result in some retrofit of SBAS capabilities - particularly in regional aviation. • Commercial aviation will continue with APV Baro for approach procedures using current capabilities. It is expected that the availability of GBAS CAT II and CAT III will increase interest in retrofits in this segment.	• ANSPs are moving towards the deployment of PBN operations within the en-route and terminal phases of flight. • It is expected that, as PBN operations become more common and multi-frequency GNSS becomes available, ANSPs will look at rationalisation of traditional navigation infrastructures.	• Regional and private aerodromes are driving the uptake of GNSS approaches as a means to offer near precision approach capabilites for significantly reduced costs. • International aerodromes retain precision approaches and are served primarily by commercial airlines using APV that do not require extensive retrofits. These aerodromes are expected to deploy GBAS CAT II and III, when available.

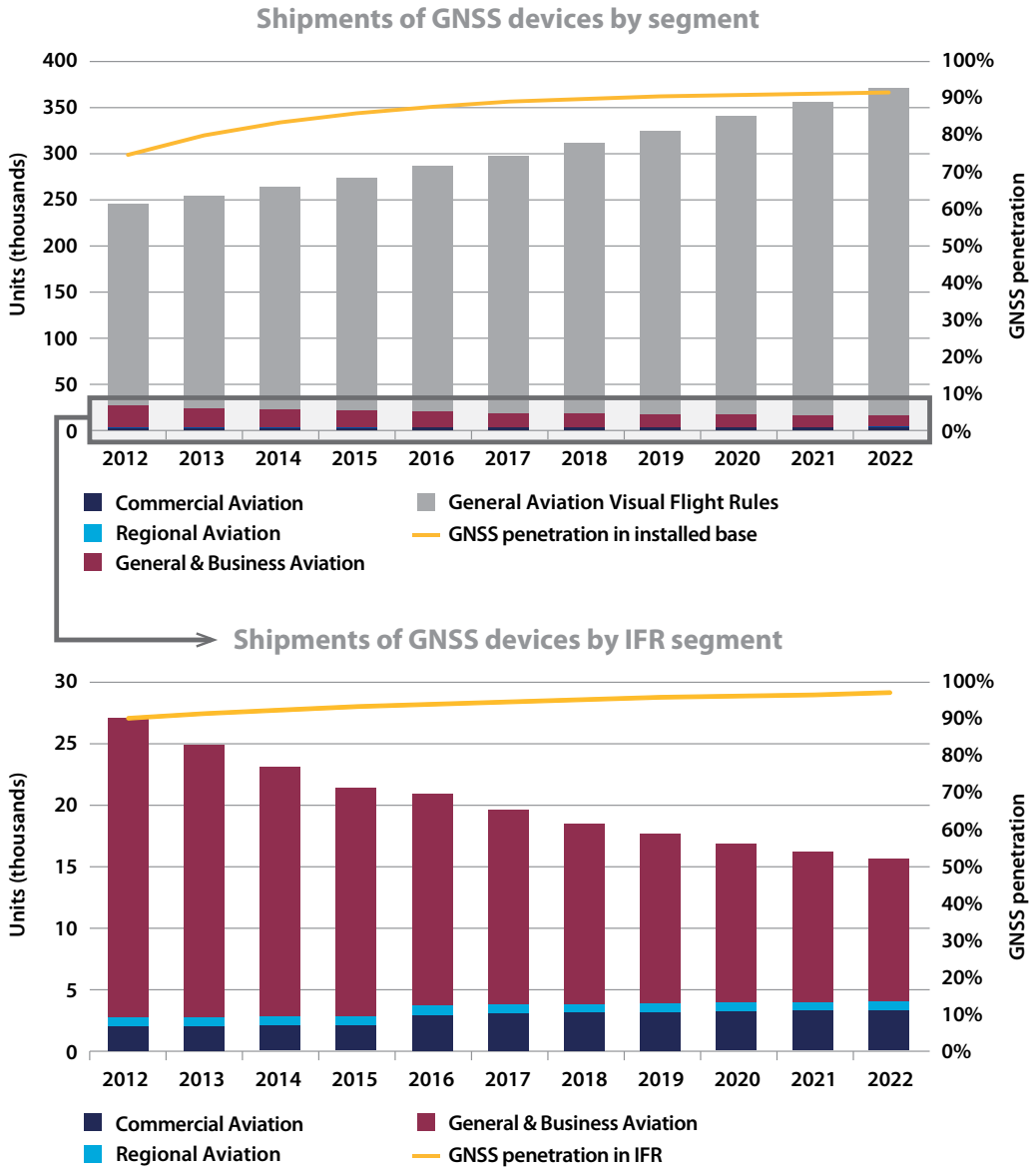
General Aviation VFR dominates the sales of GNSS devices



- General aviation is the largest GNSS aviation sub-segment, which has more aircraft and pilots than the business, regional, and commercial segments combined.
- Sales in general aviation are dominated by VFR users that replace their devices more frequently to have the latest functionalities on board.
- The cost of equipping IFR devices is much higher, therefore commercial, regional, and business aviation retrofit only once during the aircraft operational life (around 30 years).

  The peak in IFR shipments in 2011 is due to the certification of EGNOS and corresponding sales of devices.
- Socio-economic benefits of GNSS are only delivered by the certified aviation products used by IFR aircraft which enable increased access to aerodromes, reduced fuel burn and improved safety.
- The VFR sub-segment is about eight times larger in the US than in Europe. The USA dominates the total shipments, however the Rest of the World is catching up, especially in the BRIC markets.

GNSS solutions will support all Aviation segments



- The use of GNSS within all aviation segments is expected to increase over the next decade reaching a penetration of over 90% in 2022.
- This increase will be dominated by the VFR sub-segment, with leisure flyers using GNSS as a supplementary information source.
- IFR sales will be dominated by new-build aircraft.
- Commercial and regional aviation account for more than 80% of the IFR movements within Europe. The increasing penetration of GNSS capabilities within these subsegments is crucial to realise GNSS benefits on a large scale. The implementation of PBN is expected to further increase these benefits.
- Commercial aviation GNSS shipments are predicted to increase as GNSS capabilities are deployed in response to regulatory changes, and the need for commercial operators to support routes to an increasing number of destinations. As a result, commercial aviation GNSS manufacturers are expected to capture approximately 30% of the Aviation market revenue by 2022 (see reference page).

Growing EGNOS use delivers real benefits to aviation

Benefits to aviation

Standalone GPS is neither accurate nor reliable enough for precision approaches. EGNOS guarantees the level of vertical accuracy required for PBN and offers safety and integrity for instrument approach procedures across Europe for fixed wing aircraft and helicopters (similar to WAAS in USA).

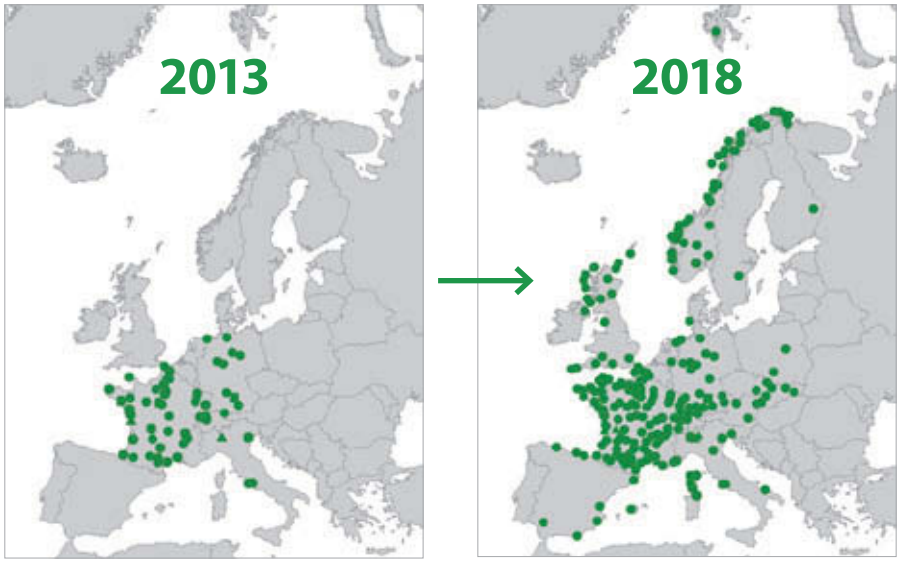
It improves the efficiency of aerodromes and allows smaller airports to remain accessible even in poor weather conditions.

No additional ground infrastructure is required for the use of EGNOS. EGNOS approach procedures have similar performance to ILS CAT I and give aerodromes with EGNOS procedures a competitive advantage over aerodromes only offering non-precision approach procedures.

By enabling more efficient routes, EGNOS reduces environmental impact and distortions of air traffic delivering operational benefits.

The EU activities in combination with countries' PBN implementation plans support the increasing demand from aviation users and build EGNOS implementation capacity. An increase in the number of procedures which use EGNOS operationally is expected to continue in the future.

Expected increase of EGNOS-enabled aerodromes



Source: Eurocontrol PBN Approach Map tool (August 2013)

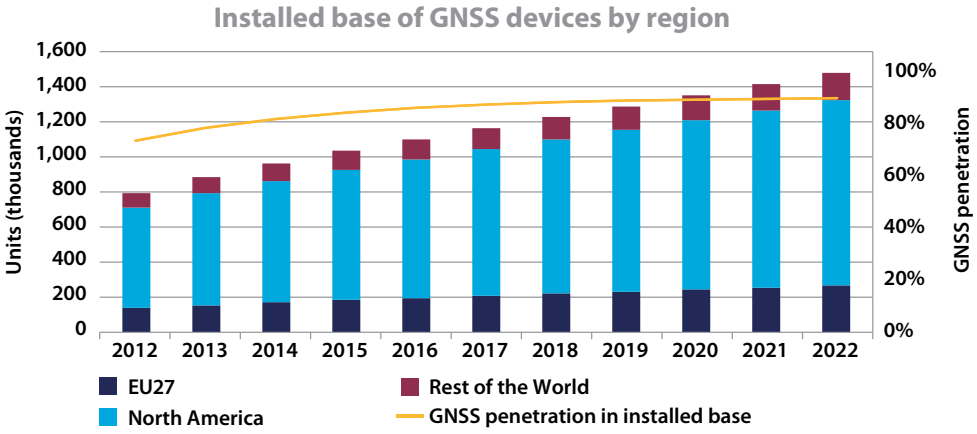
Example of R&D project: ACCEPTA

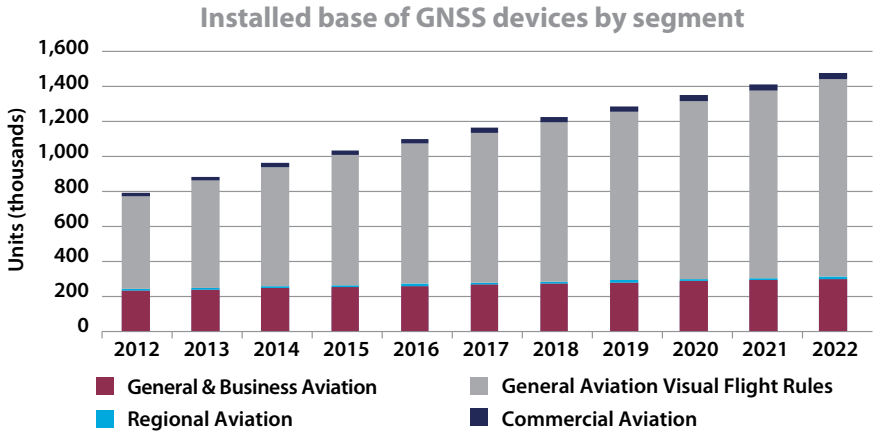
ACCEPTA's objective is to accelerate EGNOS adoption in Aviation, promoting wide-scale implementation of EGNOS-enabled LPV approaches throughout European airports, where the SBAS signal is available and certified, and the aircraft are operationally approved.

The project is successfully delivering EGNOS approaches to 74 runway ends in 11 countries and will result in 43 equipped aircraft being approved for LPV operations. The experience gained in these countries will lead to acceleration in the publication of EGNOS procedures and operators' adoption.

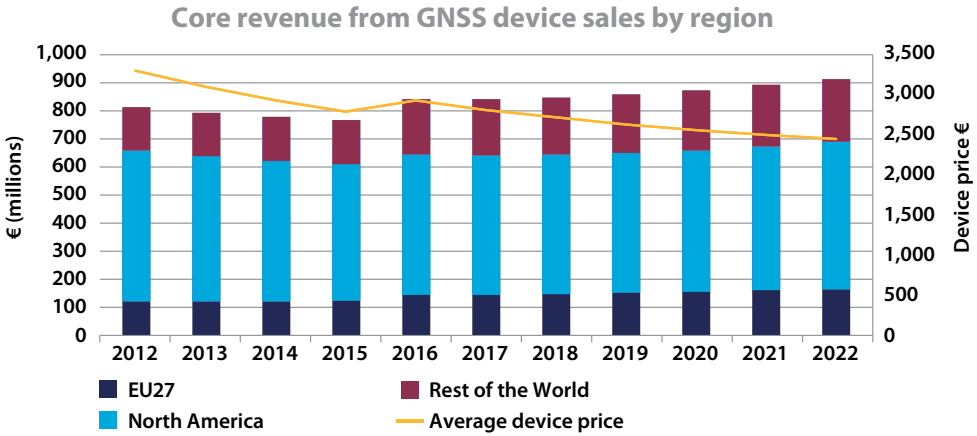
More information can be found at: http://accepta.ineco.es/acepta/html/main.html

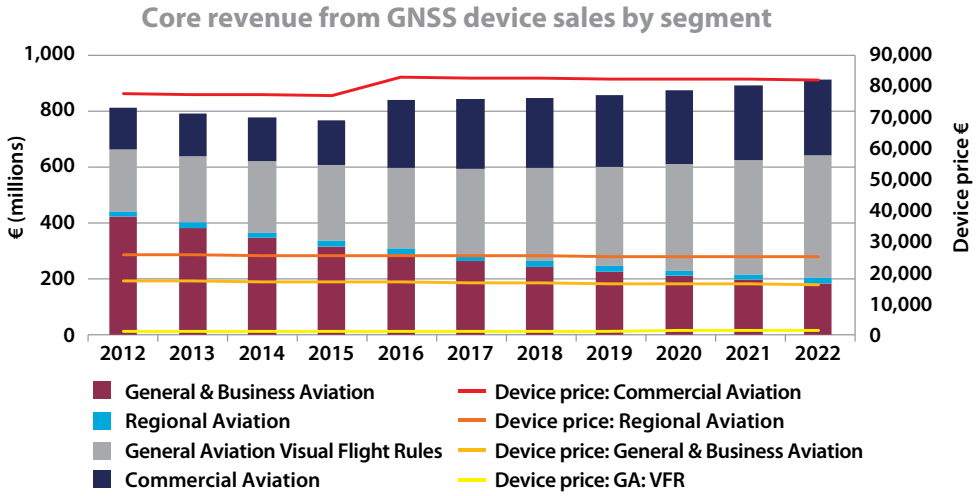
Aviation Reference Charts





The installed base of GNSS devices is expected to increase gradually, driven by the non-certified devices used in the general aviation VFR sub-segment.
The stock of devices in general & business aviation stabilises, dominated by forward fit. Commercial and regional aviation continue to increase their share of the market.





The use of IFR devices is expected to increase, driven by PBN implementation. Despite increasing GNSS shipments, revenue growth will slow down as the market becomes dominated by forward-fit aircraft (which have a lower cost). The increase of the average price of commercial aviation devices in 2016 is due to anticipated retrofits of SBAS capability.

Rail

Growing interest in GNSS use in Rail applications

Key market trends:

- **Growing interest in GNSS as a complementary technology for safety related functions.**
- **GNSS is becoming a standard feature in non-safety applications.**

Railways – a challenging environment

Railway lines are a challenge for GNSS because of high safety requirements comparable to aviation, combined with a challenging environment with the presence of tunnels, covered stations, deep cuttings, etc. where the signal is not available. However, integrated solutions combining GNSS with other technologies such as inertial navigation systems and traditional odometry can provide a good level of coverage. This is particularly the case for applications resistant to small periods of reduced accuracy.

A wide range of GNSS-assisted applications is considered:

- **High Density Command & Control Systems**, assisting train command and control on main lines referring primarily to the European Train Control System (ETCS) Level 3 (as part of the ERTMS standard) in Europe and some regions in Rest of the World, as well as Positive Train Control (PTC) in North America. GNSS is a source of additional input, e.g. for enhanced odometry in ETCS or Differential Global Navigation Satellite System (DGNSS) supporting PTC.
- **Low Density Line Command & Control Systems**, providing full signalling capabilities delivered by GNSS on lines with loose headway between trains. These lines are usually found in rural areas where cost savings can be vital for the viability of a service.
- **Asset Management**, including functions such as fleet management, need-based maintenance, infrastructure charges, and inter-modal transfers. GNSS is increasingly seen as a standard source of positioning and timing information in these systems.
- **Passenger Information** systems on-board trains showing the real-time location of the train along its route. Increasingly, the GNSS location of a train also is supporting platform and online passenger information services.

The revolution in mainline signalling

Traditionally, track-based systems have detected the presence of a train and fed this information back to a signalling system. This would then be relayed back to the driver in the form of line-side signals, providing the train with the authority to pass a particular point along the track.

In the future, a train is expected to detect its own position, through different technologies such as balises, RFID and GNSS. This position will then be reported to the signaller and movement authority will be displayed on in-cab signals, removing the need for costly lineside signalling infrastructure.

In Europe and in some parts of the Rest of the World the signalling system will gradually migrate to ETCS. GNSS will support this programme by providing an additional source of positioning information, especially in the evolution of the signalling system.

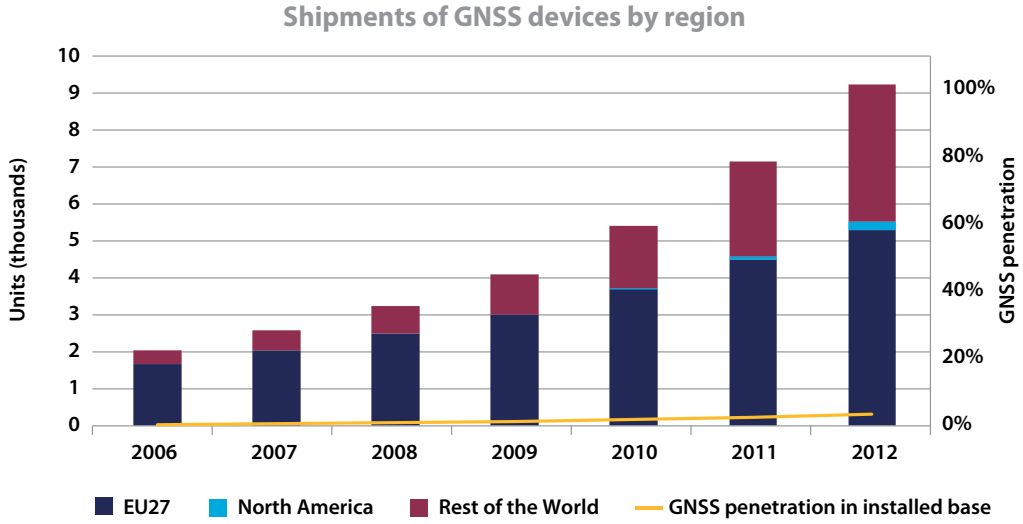
In some cases (such as PTC in the USA) GNSS will form the core of the signalling system, whereas in others it will more likely be a fall-back capability.

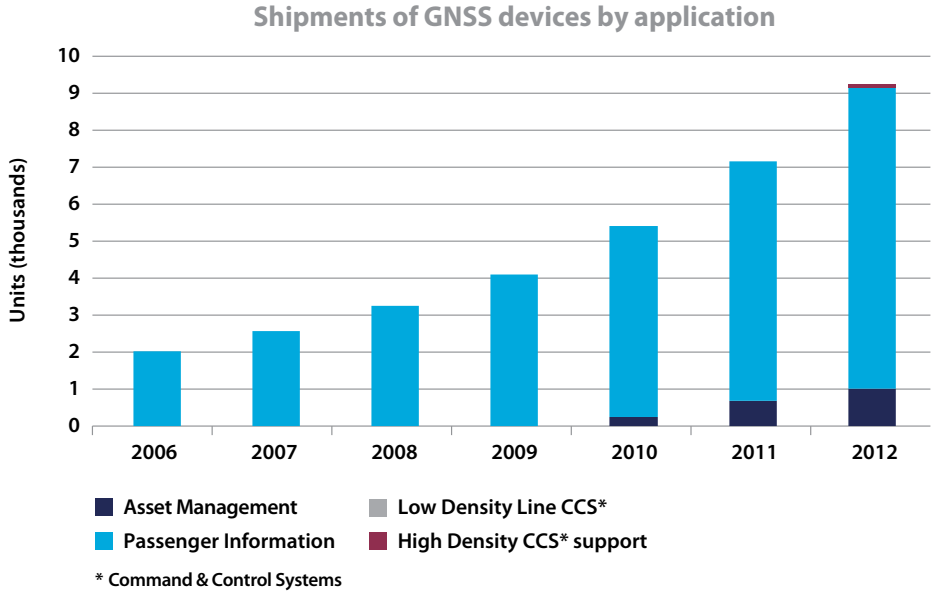
Rail Value Chain

	Receiver Manufacturers	System Integrators	Train Manufacturers	Train owners/ operators	Infrastructure Managers
Examples of key players	**Safety related:** ‣ Furuno ‣ Leica ‣ Omnicom ‣ Trimble **Non-safety:** ‣ CSR-SiRF ‣ Japan Radio Co. ‣ U-Blox ‣ Septentrio	‣ Alstom ‣ Ansaldo STS ‣ Bombardier ‣ Siemens ‣ Thales	‣ Alstom (EU) ‣ Bombardier (NA) ‣ Hitachi (Japan) ‣ Siemens (EU)	**TOCs & FOCs*:** ‣ e.g. SNCF, DB, Stagecoach, Arriva, RENFE, Trenitalia, Veolia, Colas **ROSCOs*:** ‣ Investment Banks ‣ Consortia e.g. Angel trains, Porterbrook ‣ National companies e.g.SNCF, DB	‣ ADIF (Spain) ‣ DB (Germany) ‣ Network Rail (UK) ‣ RFI (Italy) ‣ SNCF (France)
Market Trends	‣ For safety related applications, professional recievers are expected to be used. Mass-market recievers are generally used in non-safety applications and are therefore not designed specifically for Rail.	‣ An increasing number of systems on trains make use of GNSS position and time data. Some equipment manufacturers already supply fully functional GNSS signalling systems.	‣ GNSS-based passenger information and asset management is increasingly provided as standard. ‣ In a number of cases train manufacturers operate proprietary systems and send this data on to their customers e.g. train operating companies.	‣ Driver advisory systems, which improve comfort and safety, and optimise the overall performance, are being fitted to many trains. ‣ Interest in future developments to reduce signalling costs so that train operators can save on track access charges.	‣ Main focus is on signalling systems, concerned with implementation of ETCS on mainlines. ‣ More financially constrained infrastructure managers are interested in GNSS signalling for some low density lines. ‣ Use of GNSS as a back-up signalling system for mainlines is being investigated.

** TOC: Train Operating Company, FOC: Freight Operating Company, ROSCO: Rolling Stock Operating Company*

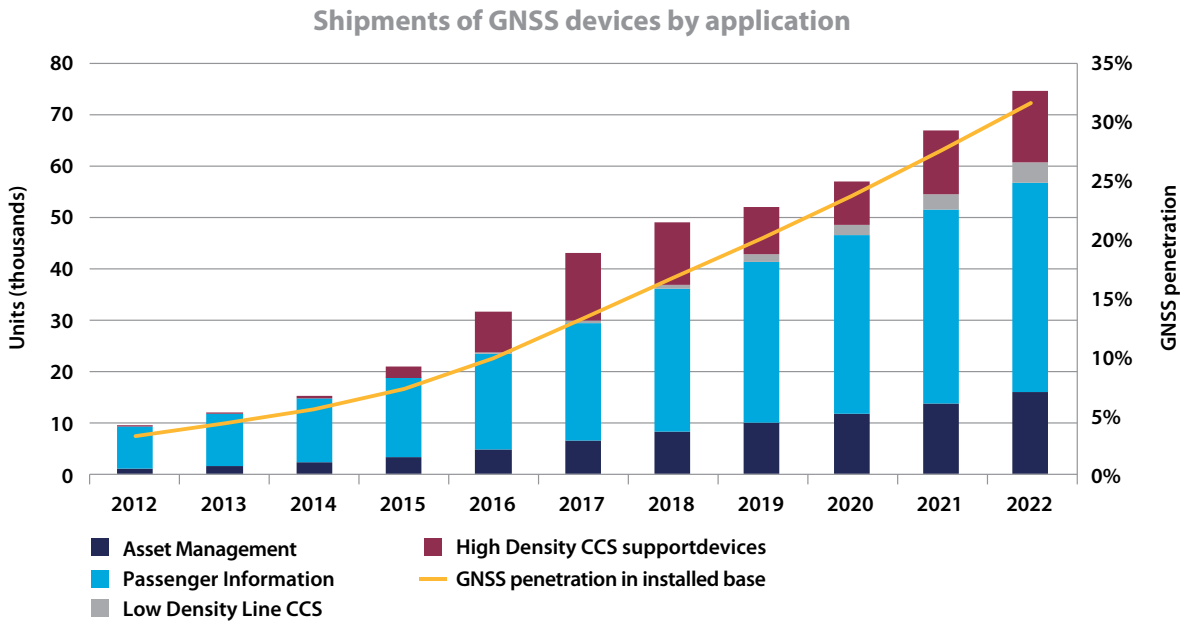
GNSS systems are predominantly used for non-safety related applications





- Europe, which has a very well developed passenger train network, has historically been the main market for GNSS devices, as sales have been dominated by passenger information systems. However, as many regions invest heavily in rail infrastructure, particularly in China, the Rest of the World market has grown to become highly significant, representing roughly 40% of GNSS shipments in 2012.
- Compared to other industries, the railways have been slow to adopt GNSS technology, this is in part due to the perceived challenges of using space technology on the railways and safety considerations.
- The main current use of GNSS in Rail is in passenger information systems, however other non-safety critical applications, such as asset management, are becoming significant, with sales of approximately 1000 devices in 2012. The majority of new trains include GNSS systems for non-safety related functions.
- Major train manufacturers use GNSS devices as standard equipment to track, in real time, all of the trains they have produced. This positioning information is routinely fed back to train operators to provide them with inputs to operations management. Most manufacturers use proprietary systems, however, interfaces between these are provided where needed.

Safety related GNSS systems are expected to complement traditional rail technologies



- Over the coming decade, GNSS use in Rail is expected to increase substantially.
- It is forecast that 30% of trains in use worldwide will be equipped with GNSS for some purpose by 2022. Most devices are likely to be non-safety critical in the short to medium term, however, GNSS devices will increasingly support safety critical functions.
- The regulatory requirements for Positive Train Control (PTC) in the USA drive the sales of high density train control devices between 2015 and 2019. The roll-out programme was originally intended to be completed for Class-1 railroads by 2015, though there have been some delays to this timescale.
- European roll-out of ETCS Level 3 is expected to occur gradually towards the end of the decade. Low density line CCS (offering significant cost savings by removing large parts of the trackside infrastructure) is expected to see cautious introduction, particularly on passenger lines.

European GNSS will enhance the GNSS offering to the rail industry

EGNOS provides ionosphere and system corrections, that improve GPS (and in the future Galileo) accuracy and deliver information about its integrity. Designed for aviation, EGNOS can also enhance train positioning in terms of accuracy and integrity, and together with other augmentation systems, contribute to meet the highly demanding requirements of safety-related applications.

Multi-constellation GNSS systems offer the opportunity to overcome some, but not all, of the inherent difficulties of GNSS in the rail environment. For example, the increased number of satellites available to a multi-constellation system offers improved availability when in deep cuttings, forests or urban canyons. The dual-frequency solution of Galileo will significantly enhance the accuracy which is achievable from GNSS systems – and go some way towards meeting railway requirements for accuracy, for example, by enabling track discrimination.

Example of R&D project: GaLoROI

New solutions are required today to reach an enduring strengthening of railways. The GaLoROI project aims to develop a certified, safety relevant, satellite-based on-board train localisation unit to be used on low density railway lines. Galileo will be used as a base for migration from conventional railway localisation equipment towards European GNSS, in order to provide cost benefits for low density lines.

More information can be found at: http://www.galoroi.eu/

Example of R&D project: Satloc

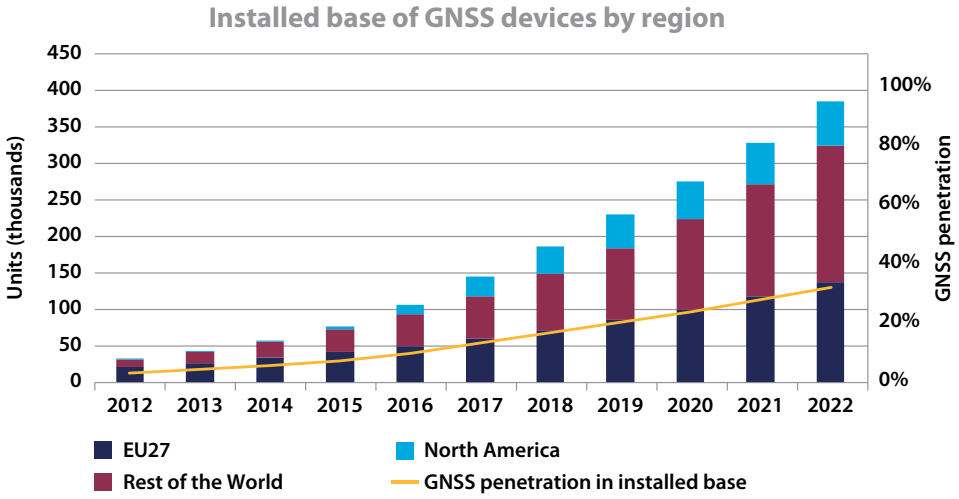
The project aims at the development and demonstration of an innovative GNSS safety-of-life rail application for train control, speed supervision, traffic control, and traffic management of UIC-E lines (low density lines).

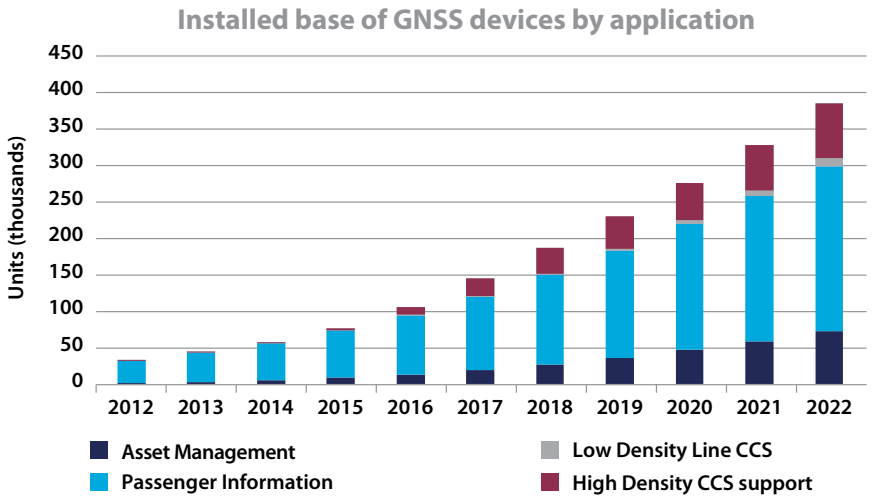
The application contributes primarily to the safe adoption of EGNOS in Rail and paves the way for the introduction of Galileo in the rail safety domain.

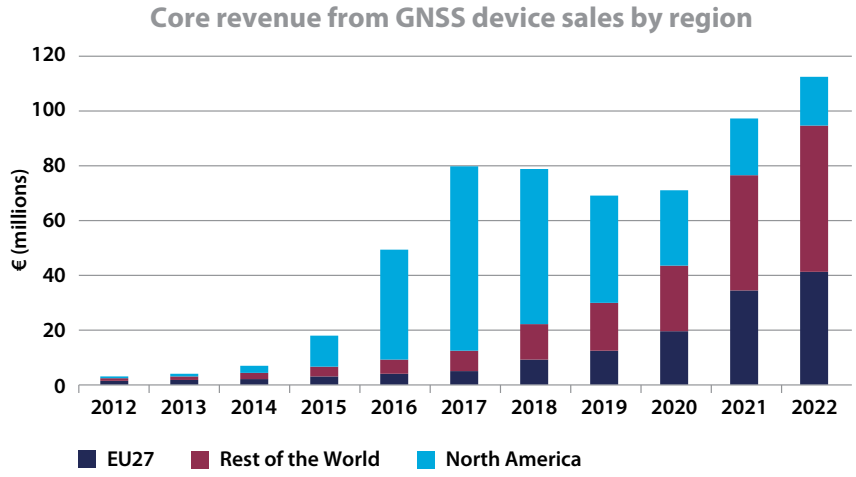
It develops a new rail integrated operational concept, software, hardware, services and datasets compatible with the current evolution of the rail signalling and standards.

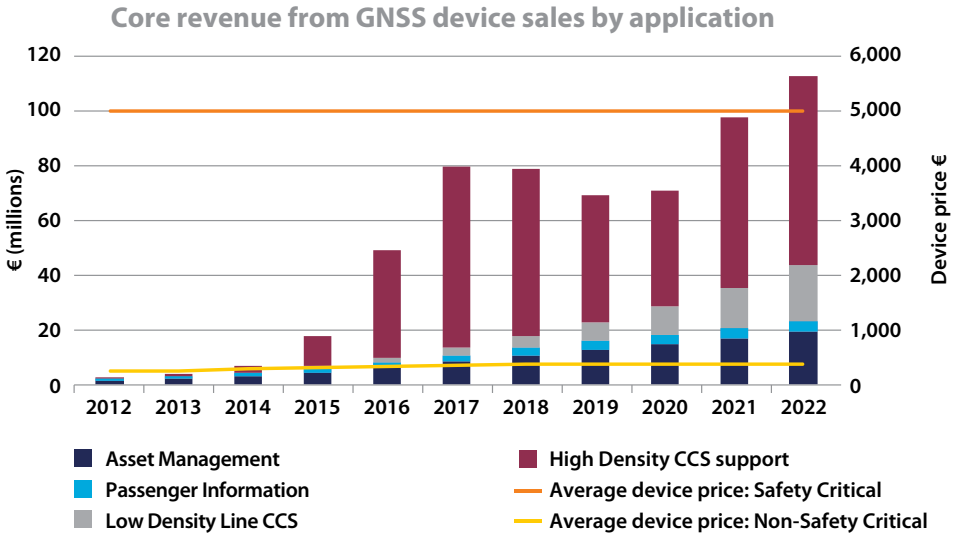
More information can be found at: http://satloc.uic.org/Project-summary

Rail Reference Charts









Maritime

E-navigation and GNSS-enabled SAR (MEOSAR) operations open new horizons to mariners

Key market trends:

- **Multi-constellation GNSS receivers at the centre of the proposed IMO* e-navigation concept.**
- **COSPAS-SARSAT enhancing the infrastructure with GNSS to reduce reaction time in emergency response.**

Background

Maritime general navigation was an early adopter of GPS and remains an extensive user. This issue of the market report covers the following maritime applications:

- General navigation
- Traffic management
- Marine engineering
- Homeland security
- Search and rescue
- Ports**
- Inland waterways**

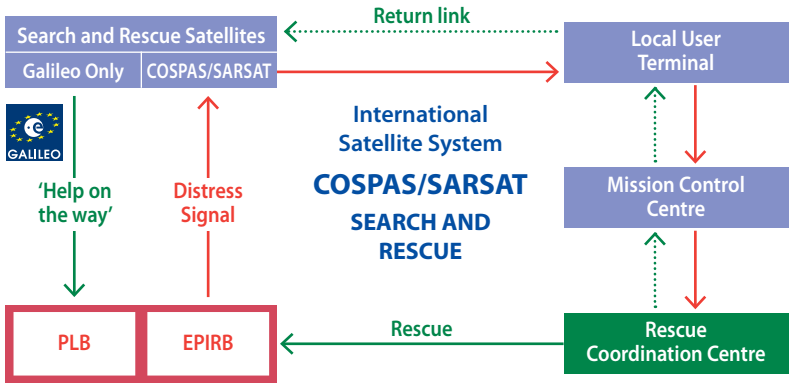
Recent developments

E-navigation: This is an initiative of IMO designed to reduce the complexity of on-board systems by integrating bridge systems with all data inputs. It could be a driver for multi-constellation uptake within the maritime community. It is being implemented by the IMO's e-NAV Committee involving maritime authorities.

Fisheries policy: There is an increasing interest in proving where fishing vessels are to comply with the regulatory requirements of the EU Common Fisheries Policy. GNSS is playing an increasingly significant role in providing positioning information to authorities.

Search and Rescue services

The COSPAS-SARSAT system, comprising low and high orbit satellites, is used for Search and Rescue (SAR) emergency response operations. GNSS will enhance the current system, providing the MEOSAR capability which will increase the number of satellites available. Uniquely, Galileo will provide a return link that informs the casualty that help is on the way.



Personal Locator Beacons (PLBs) and Emergency Position Indicating Radio Beacons (EPIRBs) are used by regulated vessels. PLBs are also becoming increasingly common for leisure craft.

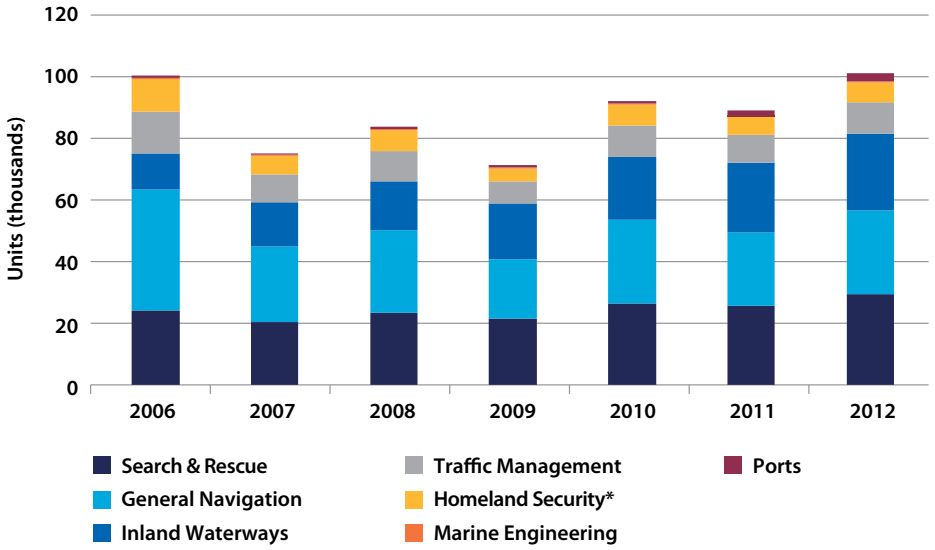
** International Maritime Organisation*
*** Both ports and inland waterways are included for the first time in this report as separete applications, which are not covered in general navigation for the need of this report. Leisure vessels (which increasingly use LBS devices such as tablets) are not included.*

Maritime Value Chain

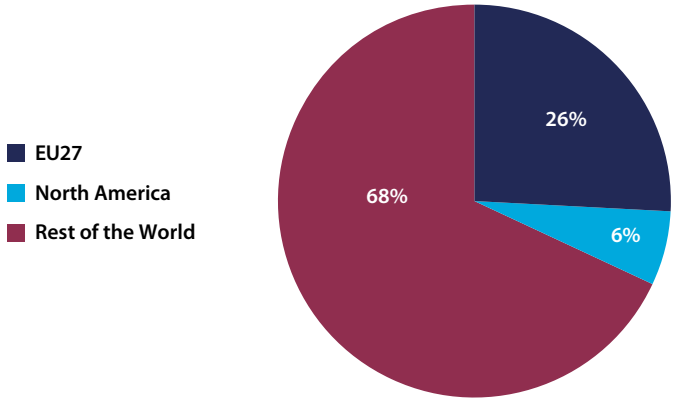
	Maritime Authorities and regulators	Components and Receivers	Bridge integrators	Ship owners/ operators	Ports operators
Examples of key players	• International Maritime Organisation (IMO) sets international standards for merchant shipping • IALA is an industry body harmonising aids to navigation	• Furuno • Japan Radio • Laird • Leica Geosystems • Novatel • Pulse • Trimble	• Cobra • Furuno • Kongsberg • Mitsubishi • Safran	• APL • CMA CGM Group • Evergreen • Maersk Line • MSC	**Main Categories:** • Cruise & Ferry Terminals • Large container ports • Specialist coastwise ports
Market Trends	• Growing awareness of the increased reliance on GNSS for navigation and as an input to other bridge systems. • Integrity remains a key priority. • Continued provision of national DGNSS infrastructure for maritime users pending future technology developments in multi-constellation and multi-frequency solutions.	• Increasing use of SBAS in navigation products aimed at the leisure market. • Increasing SBAS penetration in navigation products aimed at regulated market. • Increasing use of GNSS in search and rescue products.	• GNSS is now an essential input for navigation and to other bridge systems. • Larger modern vessels being constructed with high performance integrated bridge systems.	• Operators becoming gradually aware of the issues of dependence upon GNSS. • Increasing use of vessel position for safety, commercial, and homeland security applications. • Increasing levels of automation on the bridge in an attempt to reduce the workload of the mariner.	• Growing use of accurate DGNSS solutions for harbour navigation and precision berthing particularly of new large vessels. • Use of precision survey systems to reduce cost and improve efficiency of harbour dredging.

General navigation, inland waterways and SAR represent the largest share in shipments

Shipments of GNSS devices by segment



Shipments of GNSS devices by region (2012)

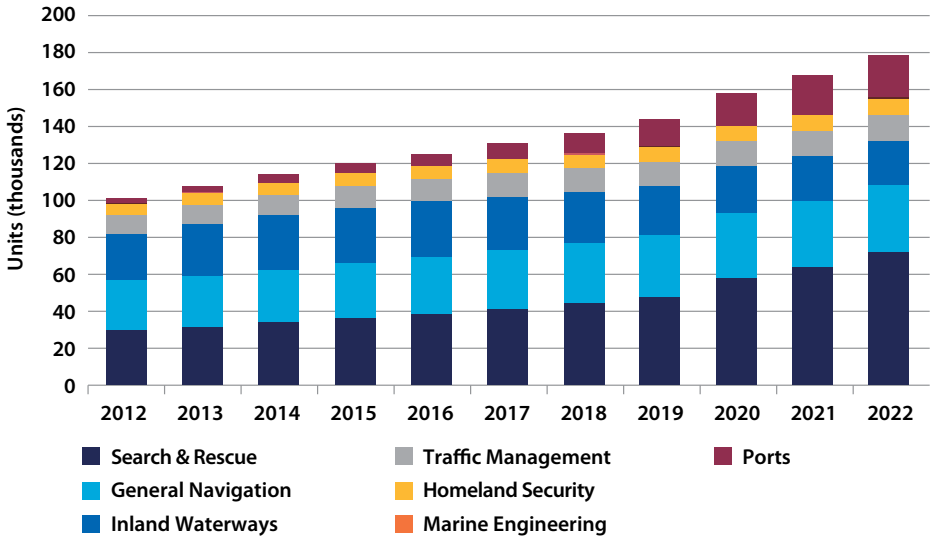


- General navigation and inland waterways represent a large proportion of the market.
- Many of the regulated applications of GNSS in the Maritime segment already have high, if not total, GNSS penetration.
- For these applications, equipment replacement and new vessel construction are the drivers for equipment sales, as systems reach the end of their lifecycle or become outdated or obsolete.
- With over 50,000 regulated vessels globally and large ships using several receivers, this represents a very established, yet stable market.
- The Rest of the World dominates Maritime device shipments. The regional breakdown of device shipments is expected to remain roughly constant over the next decade.
- The region a ship is assigned to is dictated by where the true controlling interest of the fleet is located, which is determined by the United Nations Conference on Trade and Development (UNCTAD).

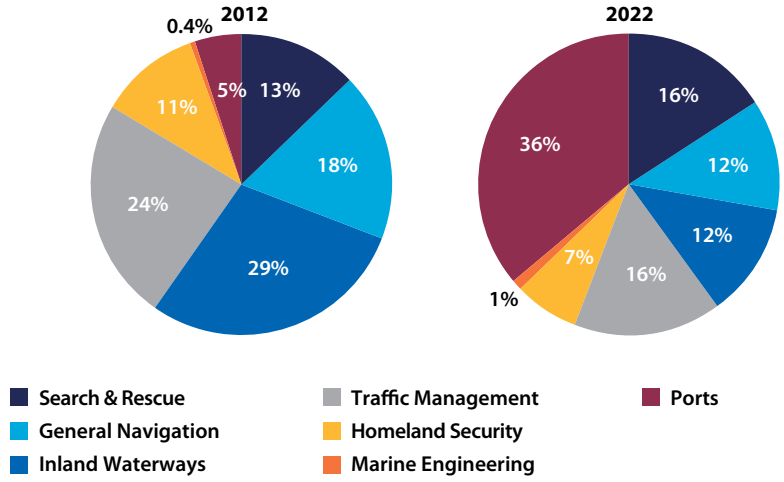
** Homeland Security includes Long Range Identification and Tracking (LRIT) devices*

Safety related applications will drive the growth

Shipments of GNSS devices by application



Core revenue of GNSS device sales by application



- Sales of devices are forecast to be led by GNSS-equipped SAR beacons for which a number of devices may be installed on each vessel (e.g. on lifeboats). In addition, the lifecycle of a SAR beacon tends to be shorter than for a standard navigation receiver.
- Second-generation SAR beacons, which are foreseen to have the return link feature, are likely to further stimulate the market in the next decade. The regulatory requirements for such beacons are currently being developed by COSPAS-SARSAT.
- The use of GNSS in ports is forecast to grow rapidly due to the increasing congestion of the waters in and around ports, combined with the ever increasing size of vessels.
- Two significant applications are: Portable Pilot Units (PPUs), GNSS-enabled specialist navigation aids used to enter ports, and port automation, such as the tracking of shipping containers and other goods. For these applications, GNSS is used to improve the efficiency of large ports.
- Ports are set to grow into the largest application by revenue by 2022.

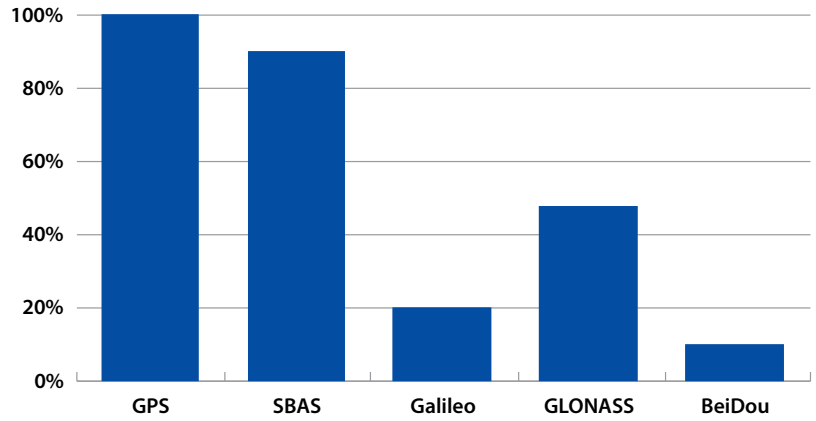
Maritime is ready to benefit from European GNSS

Galileo enters into multi-constellation mainstream

Multi-constellation devices are increasingly common in the Maritime domain, with around half of devices offering GPS and an additional constellation. SBAS and GLONASS adoption is quite significant whilst Galileo and BeiDou uptake will likely increase rapidly once IMO recognition is achieved. Acceptance into the Worldwile Radio-navigation System (WWRNS) confirms that the system is capable of providing adequate position information within its coverage area and that the carriage of receiving equipment for use with the system satisfies the relevant requirements of the SOLAS Convention.

Galileo will contribute to multi-constellation receivers by providing better position performances thanks to improved signal accuracy and availability.

GNSS capability of Maritime devices*



EGNOS proves its value in Maritime

Trials assessing the performance of EGNOS in the maritime and inland waterway environments were conducted by the European Commission.

These trials demonstrated that the use of EGNOS capabilities provides improved integrity and accuracy, enhancing the user experience and improving safety. Private craft owners with less expensive receivers saw a particularly marked benefit.

The trials confirmed that EGNOS can meet the following IMO performance requirements:

- Accuracy for coastal navigation.
- Horizontal alert limit for navigation zones outside ports.

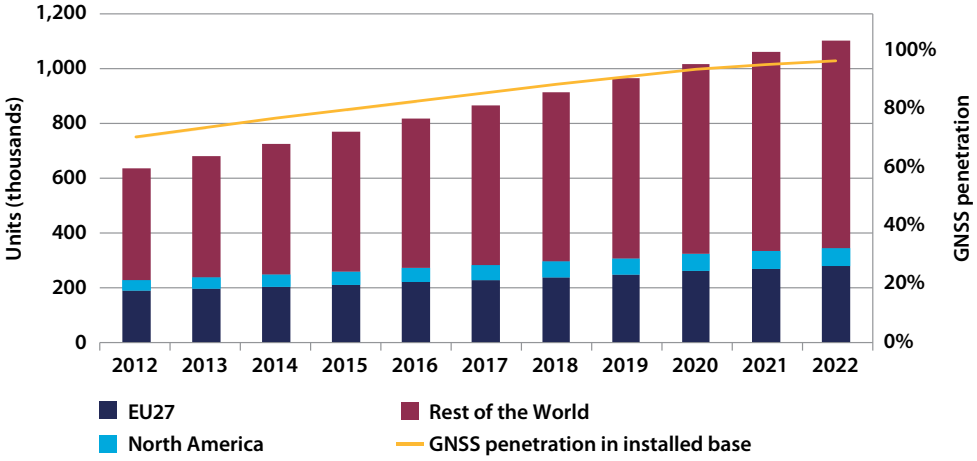
Even port navigation requirements were met in some cases, showing future potential to rationalise DGNSS network infrastructure.

The availability of the EGNOS signal can be achieved even in very difficult environments by transmitting the correction over the Automatic Identification System (AIS), with which all large vessels are equipped for collision avoidance purposes.

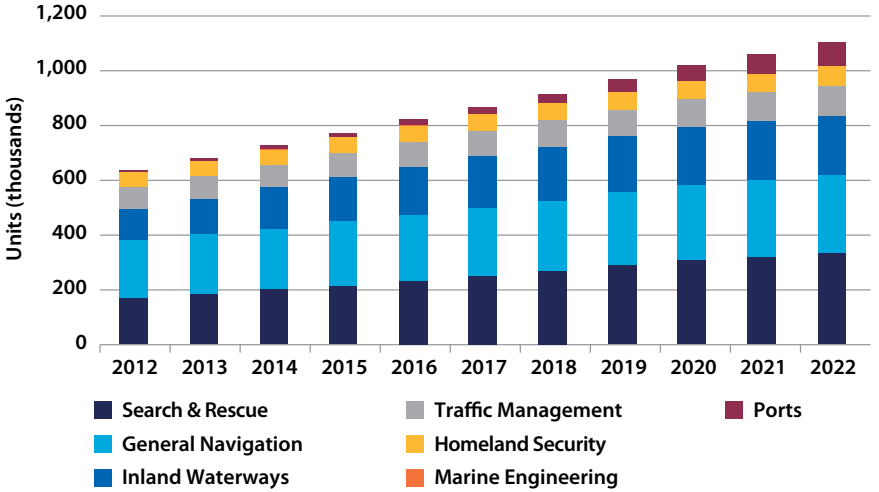
** Source: GSA analysis based on GPS World Survey 2013. Percentages based on number of models available, not sales.*

Maritime Reference Charts

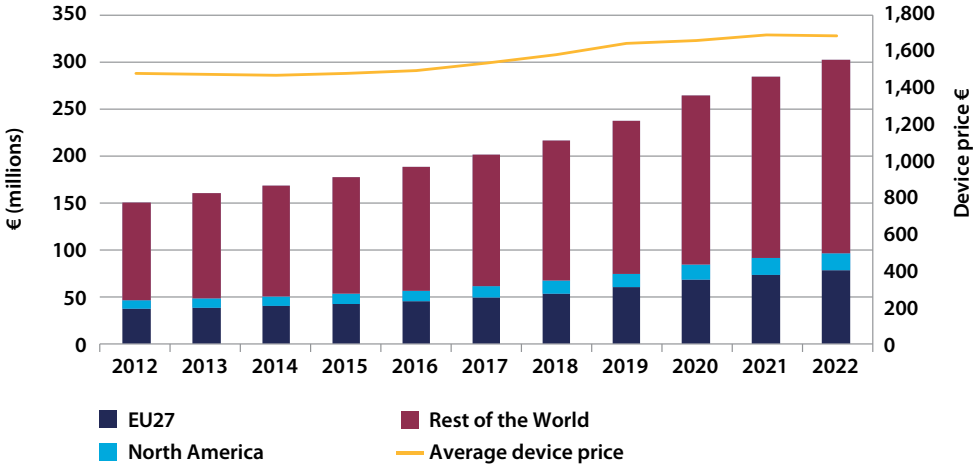
Installed base of GNSS devices by region



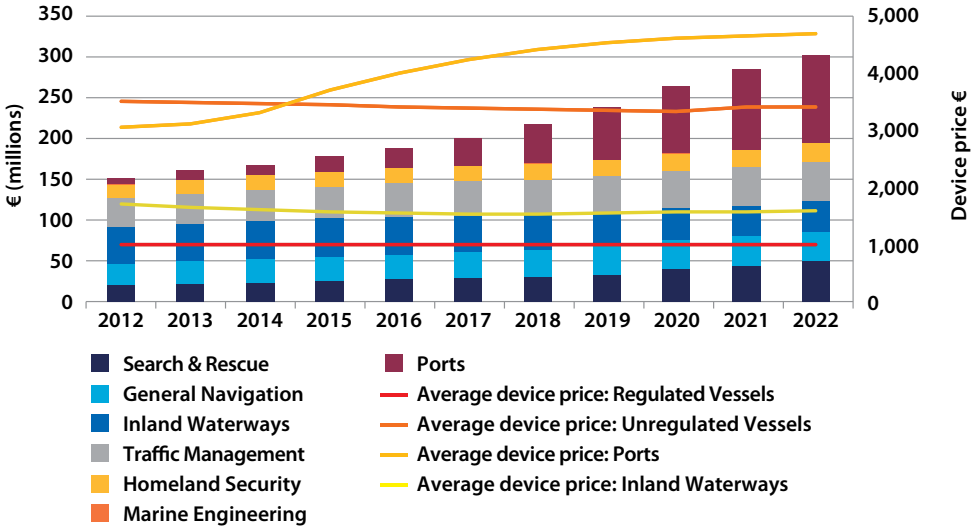
Installed base of GNSS devices by application



Core revenue from GNSS device sales by region



Core revenue from GNSS device sales by application



Agriculture

Precision agriculture for increased productivity

Key market trends:

- **Increased use of precision agriculture in developed countries, in larger farms and mostly for crop production.**
- **Uptake of GNSS precision agriculture in less industrialised regions set to accelerate, supported by consolidation of farms.**
- **Adoption of integrated applications combining Earth observation and GNSS.**

Precision agriculture responds to the need to improve yields and efficiency, while controlling costs. GNSS adoption is facilitated by the growing average farm size, machine-intensive methods of farming, and the increased awareness of GNSS systems amongst farmers.

Key applications in precision agriculture:

- **Tractor Guidance**, making use of a digital display which assists drivers to follow a predetermined path, minimising risks of overlap/gaps. This is often the first GNSS application a farmer adopts.
- **Automatic Steering**, the most advanced form of tractor guidance, used mainly on large farms, allowing farm vehicles to be automatically steered along a predetermined path. The operator can concentrate solely on monitoring the overall process.
- **VRT (Variable Rate Technology)**, leveraging local conditions on the field for precise control over farming inputs (e.g. fertilisers, nutrients). It identifies areas with similar levels of yield-limiting characteristics in a field and enables site-specific treatment.
- **Asset Management***, involving the use of real-time information for monitoring the location and status of farm equipment.

The use of GNSS together with Earth observation data (e.g. coming from Copernicus, the European Earth Observation Programme) enables a new range of applications in agriculture (e.g. assessment of land use and the impact on biodiversity and landscapes, crop conditions and yield forecasts or management of irrigation).

** New application, added in this issue of the market report*

Different levels of accuracy are required for farming operations:

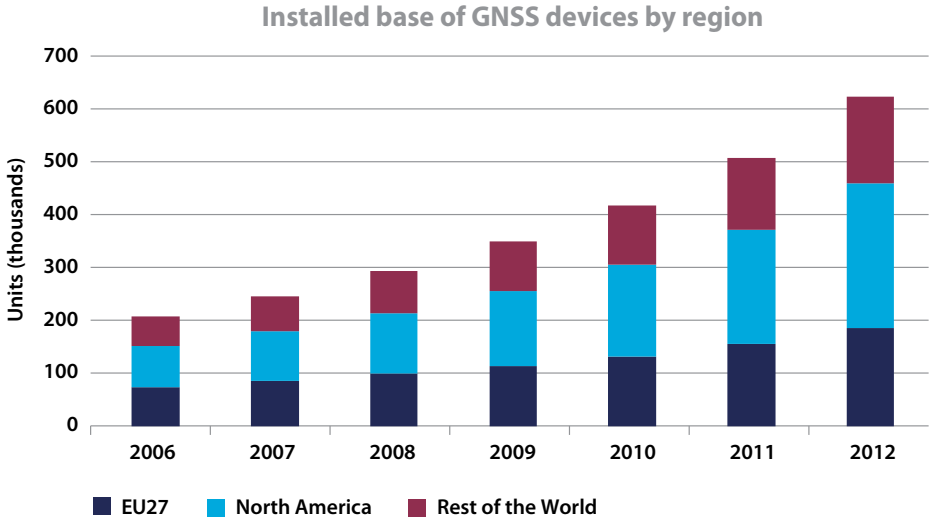
Solution	Accuracy	Application
Low accuracy standalone GNSS	c. 2.5 m accuracy	Asset management, tracking and tracing
Medium accuracy SBAS (e.g. EGNOS, WAAS)	10-30 cm pass to pass accuracy	Tractor guidance, lower accuracy operations (e.g. spraying, spreading, harvesting bulk crops), area measurement, field mapping
High accuracy RTK/DGPS	2-10 cm pass to pass accuracy	Auto-steering, precision operations, (e.g. planting, weeding, sowing)

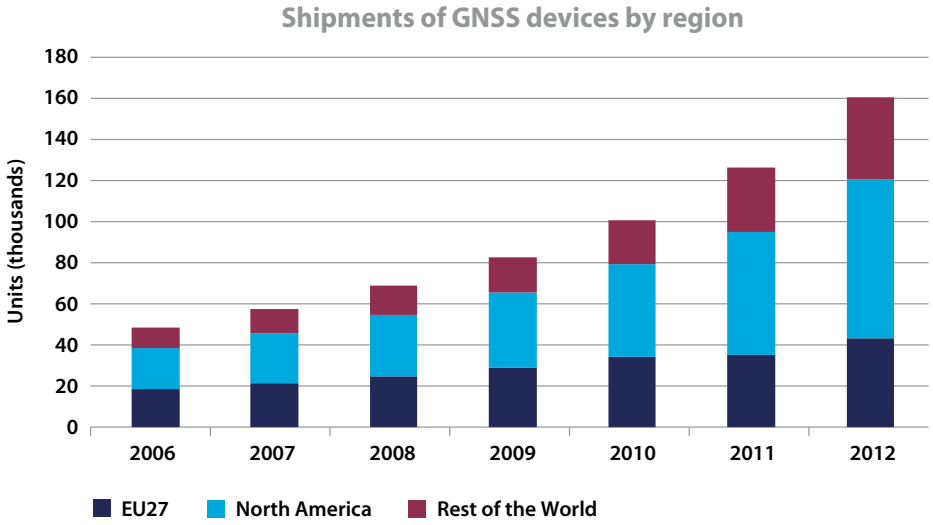
GNSS is used together with augmentation systems like RTK, and SBAS to increase the accuracy. Solutions based on SBAS initiated the diffusion of precision agriculture into smaller farms thanks to more affordable equipment and a medium level of accuracy.

Agriculture Value Chain

	Service Providers	Device Vendors	Application Providers	Tractor Manufacturers
Examples of key players	**SAPOS (DE)** is the satellite positioning service of the Official German Surveying and Mapping Authority. The service is available throughout Germany and is based on reference stations processing GNSS signals and providing observation and correction data via data communication media.	**Hexagon (SE)**, a measurement technologies group with c. €2.5 billion sales worldwide in 2012, is active in the precision agriculture market via its two subsidiaries Leica Geosystems and NovAtel. **Topcon Precision Agriculture (JP)** is a subsidiary of Topcon Positioning Systems (TPS Inc.), providing tractor guidance and auto-steering, VRT, water management, and planning/ documentation solutions.		
		AGCO Corporation is focused on the design, manufacture and distribution of agricultural machinery with c. $10 billion sales worldwide in 2012. AGCO's Advanced Technology Solutions incorporates precision farming technologies distributed by AGCO. The group provides solutions for satellite-based steering, data collection and management, yield-mapping and other purposes.		
	Trimble (US) is a major GNSS systems and solutions vendor in the precision market and generated a total turnover of over $2 billion in 2012 (c. 25% of which in field solutions, including agriculture). Omnistar acquired by Trimble in March 2011, is provider of satellite-based augmentation services and also broadcasts to users that work with third-party GNSS equipment (e.g. NovAtel).			
	NavCom, a subsidiary of John Deere (US) is the main competitor of Omnistar in the precision agriculture market. NavCom provides both global satellite–based augmentation services (StarFire Network) and core technology hardware, such as RTK systems and geodetic quality multi-frequency GNSS receivers. Its services require proprietary receivers.	**John Deere (US)** is a leader in agriculture vehicles and machineries with a turnover of over $36 billion in 2012. Its subsidiary, John Deere Ag Management Solutions, develops applications for GNSS guidance and machine control based on core receivers developed by NavCom.		
	CLAAS (DE) is present in the GPS reference stations network industry via acquisition of a 34% stake in **SAT-INFO (FR)** in 2009.	**CLAAS (DE)** is a major agricultural machinery manufacturer with a turnover of approximately €3.5 billion in 2012. Through its Agrosystems division, it provides guidance and automatic steering solutions with accuracies up to 2-3 cm.		
Market trends	Service providers offer an augmentation service that enhances the performance of GNSS. SBAS corrections are provided for free, while services offering a higher level of accuracy are paid. The two leading players in commercial services adopt different strategies: NavCom exploits John Deere's sales channels while Omnistar cooperates with major device vendors. With the recent acquisition of Omnistar by Trimble, the market is strongly consolidated.	Device and application vendors usually provide both the hardware and the software required to perform precision agriculture operations. Players include manufacturers of multi-frequency and multi-constellation receivers, equipment manufacturers (e.g. guidance systems), system integrators, and applications providers. Machine/tractor manufacturers establish agreements and partnerships with device vendors. They can also be service providers (e.g. John Deere provides the StarFire service via NavCom).		

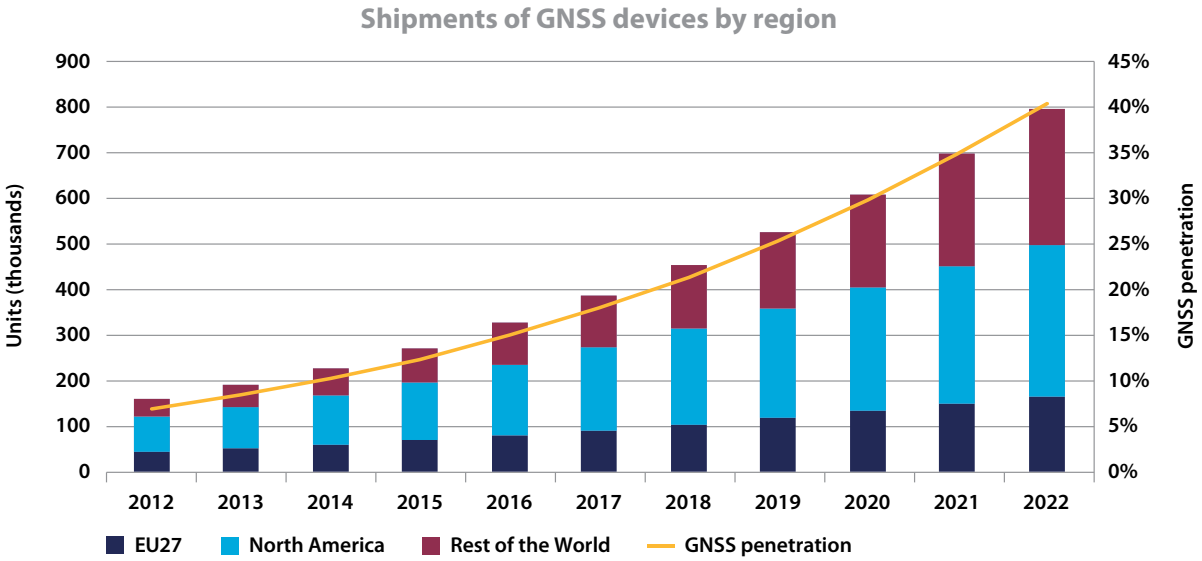
GNSS use is progressing in all regions





- Between 2006 and 2012, global shipments and the installed base of GNSS devices more than tripled.
- North America, representing the highest share in shipments and installed base, is the most technologically advanced region with respect to precision agriculture. Major crop productions are related to corn, soybeans and wheat which are ideal for GNSS-based applications.
- The Rest of the World comprises countries with markedly different levels of technological development, varying from Japan and Australia, with extensive adoption of precision agriculture, to nascent markets such as China and India.
- In Europe, growth in shipments and installed base is the result of GNSS adoption in Western European countries where more favourable conditions exist, such as larger average farm size and greater access to capital.

Automatic steering and VRT common in future farms



- Technological progress and consolidation of farms are the key drivers for growth in shipments of GNSS devices in all regions.
- Farmers in developed countries will opt for more advanced solutions (e.g. Automatic steering and VRT) to further increase productivity.
- Developing countries will modernise their means of agricultural production in order to face the major challenges of rising input costs, resource scarcity, and food demand.
- In Europe, future growth is expected to be increasingly driven by uptake of GNSS technologies in Central and Eastern Europe, currently representing lower GNSS penetration.
- Falling prices will be an important driver for the uptake of precision agriculture over the next decade.
- Revenues will be generated mainly by automatic steering and VRT, growing much faster than previously estimated. Together, these two applications will provide nearly 80% of revenues in 2022 (see reference page).

European GNSS to bring benefits beyond the industry

The main system of choice for tractor guidance

EGNOS delivers various benefits to farmers:

- Minimal investment.
- Optimisation of yields.
- Increased labour productivity and profit margins.
- Reduced driver fatigue.

… and to society:

- Increased productivity to better feed increasing population.

EGNOS is used within the **Common Agriculture Policy (CAP)** for on-the-spot checks to verify subsidy claims. Tests have shown positive results with an improvement in accuracy and reliability in comparison with GPS only. Thus, using EGNOS, which is free of charge, reduces the need for second measurements.

Galileo will bring additional benefits

- Dual-frequency capability to offer enhanced real-time positioning accuracy to sub-metre range.
- RTK receivers with multi-constellation service will further increase performance.
- Improved availability and continuity derived from multi-constellation environment.
- Reduced dependence on ground-based augmentation systems.
- No subscription fee for Galileo Open Service.

The Farming by Satellite prize

The aim of this competition is to promote the benefits generated by GNSS in agriculture among farmers. Participating teams propose innovative ideas for satellite service usage in agriculture, food production, or land management.

The winning ideas for 2012 were:

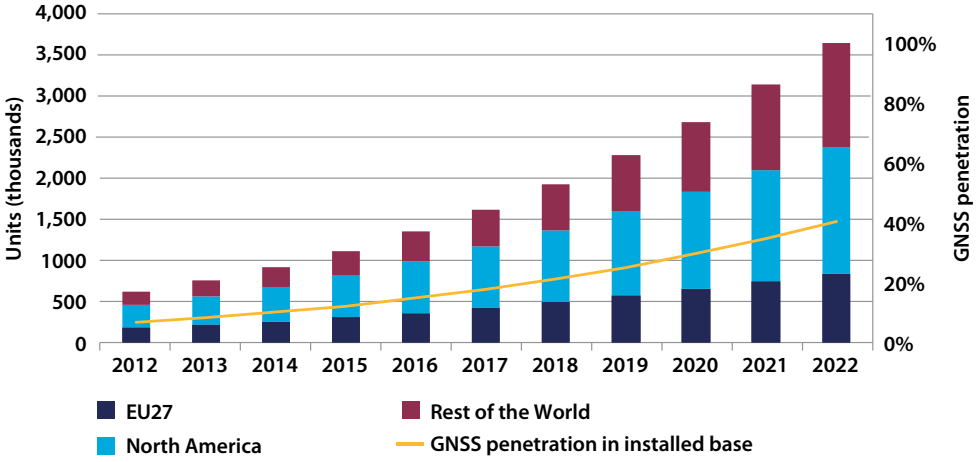
- 1st prize: Geo-referenced online data sharing platform with information services for farmers across Europe.
- 2nd prize: Hay bale collection optimisation solution using less fuel and saving time.
- 3rd prize: Using satellite positioning in combination with camera-based recognition of biomass for small and medium sized vineyards.

For more information and to be ready for the new edition of the Farming by Satellite prize: www.farmingbysatellite.eu

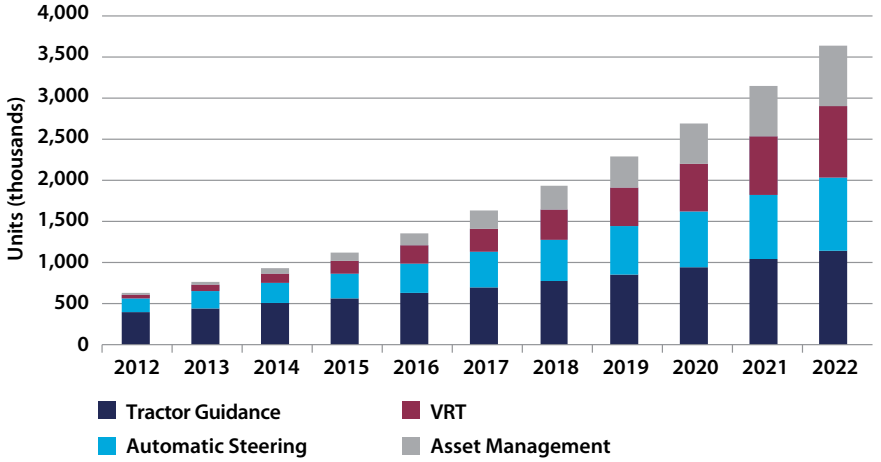
2012 Farming by Satellite prize

Agriculture Reference Charts

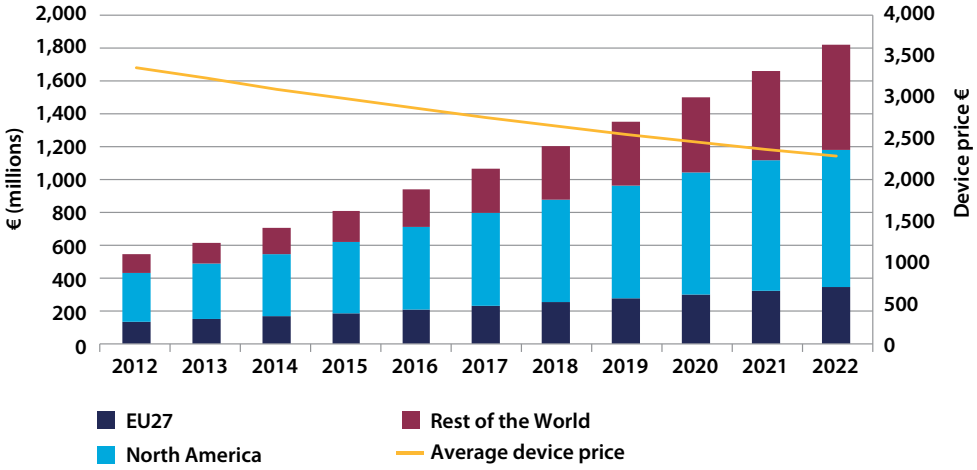
Installed base of GNSS devices by region



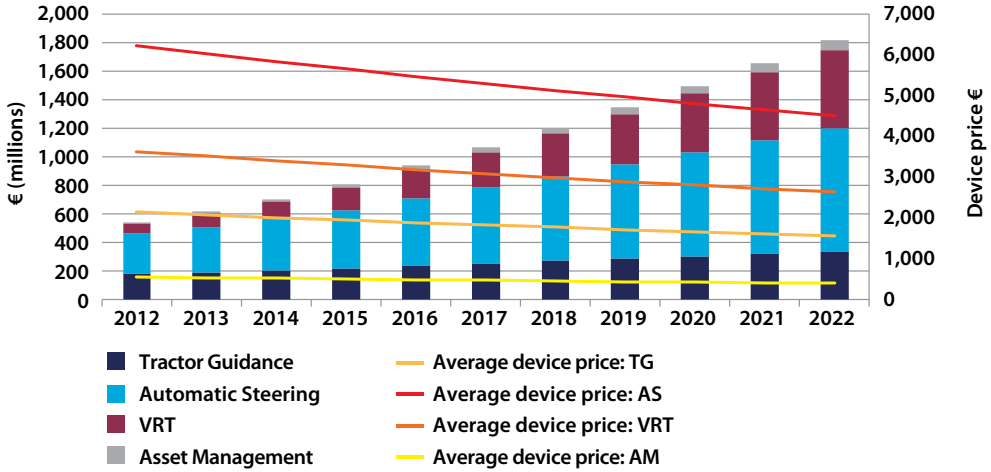
Installed base of GNSS devices by application



Core revenue from GNSS device sales by region



Core revenue from GNSS device sales by application



Surveying

GNSS in the centre of surveying applications

Key market trends:

- **Major growth in surveying depends heavily on economic conditions in high growth economies. Cadastral and construction segments are the largest applications of GNSS in surveying.**
- **New professional users in environmental and engineering disciplines together with mapping communities are fostering the use of geoinformation and the development of new applications.**

GNSS and surveying

Surveying is an early adopter of new location technologies such as GNSS. Currently, professional surveying receivers are already using all available GNSS signals (multi-constellation and multi-frequency) and other differential correction techniques (e.g. SBAS, RTK, DGPS).

The role of GNSS receivers in the surveying equipment market has demonstrated the added value of satellite positioning to optimise survey operations and fruitful co-existence with other land measurement technologies, such as laser scanners and photogrammetric/LIDAR cameras.

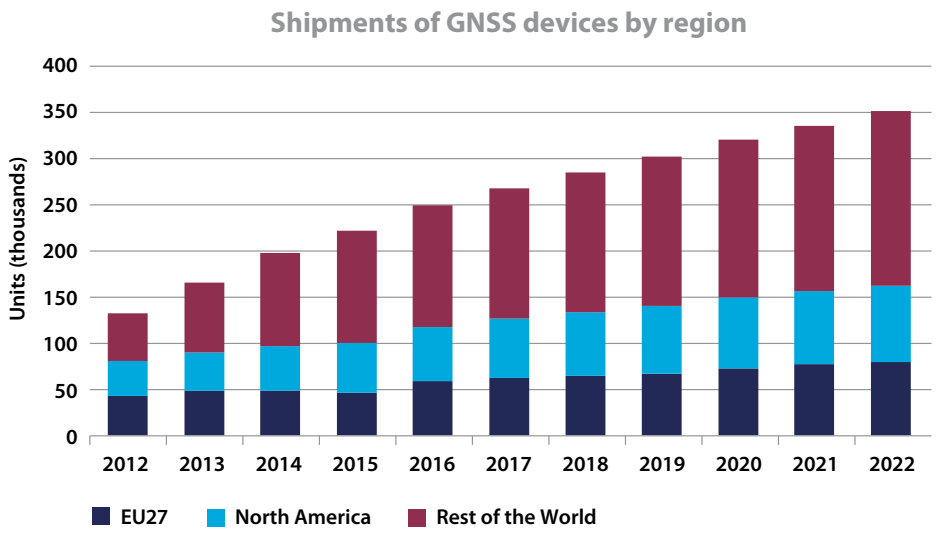
The main GNSS-enabled applications include:

	Discipline	Overview
Land	**Cadastral surveying**	Cadastral surveying involves the physical delineation of property boundaries in parcels and the determination of dimensions, areas and certain rights associated with properties. Land taxes are frequently paid according to this determination of parcels. Frequently, cadastral surveying is performed to subdivide parcels, to re-establish physical boundaries, or to facilitate the transfer of the property title in accordance with the national land laws. This work is normally performed by Licensed Surveyors.
	Construction surveying	In addition to GNSS, other surveying equipment (e.g. levels, total stations, laser scanners) are used for accurate measurement in areas with poor satellite coverage, such as indoor structures, tunnels, and other extreme environments. Traditional operations in construction surveying are related to the precise drawing of the future work site for buildings and infrastructure; as well as the stake-out of reference points that will guide the construction of new structures.
	Mapping	Mapping is the use of GNSS to plot maps and charts that contain locations of points of interest. Specific applications include road mapping, pipeline mapping, planning of public works and forestry management.
	Mine surveying	Mine surveying includes all measurements, calculations and mapping which serve the purpose of ascertaining and documenting information at all stages from prospecting to exploitation and utilising mineral deposits both by surface and underground working.
Marine	**Hydrographic Surveys**	Hydrographic surveying is the science of measurement and description of features which affect maritime navigation, marine construction, dredging, offshore oil exploration, and related activities.
	Offshore surveys	Offshore vessels that utilise surveying include: Anchor Handling Tug Supply (AHTS) vessels (mainly built to handle anchors for oil rigs, tow them to location and anchor them up) and salvage vessels.

Surveying Value Chain

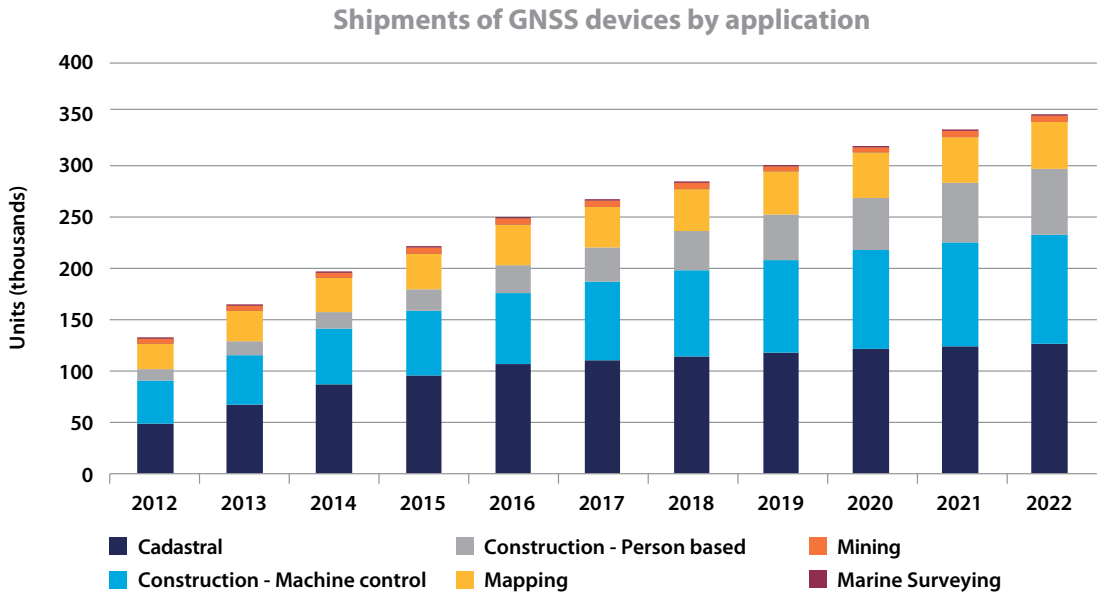
	Complementary Infrastructure (Commercial augmentations)	Receiver & Firmware	Professional Users	Customers
Examples of key players	• Fugro • Leica Geosystems • Navcom • Omnistar • Orpheon • SAPOS • TERIA • Veripos	• Ashtech • Deere & Co • Hemisphere • Javad • Laird • Leica Geosystems • North Surveying • Novatel • Pentax • Pulse Electronics • Septentrio • Topcon/Sokkia • Trimble • Yageo Corporation	• Constructors • Educators • Engineers • Environmentalists • Professional Organisations • Scientists • Surveyors	• Public organisations • Private companies • Individuals • Natural resource management firms • Hydrographic offices, chart publishers • Offshore wind farms underwater cable & pipeline installers
Market Trends	• Augmentation services provided by complementary infrastructures are essential for precise positioning. • These infrastructures are particularly useful for the fast collection of accurate coordinates. • The use of complementary infrastructure is expected to grow.	• The market for receiver manufacturers is very consolidated and the top 3, Trimble, Leica and TopCon, are dominating, particularly within the land surveying sector. • Many commercial grade receivers will be able to take advantage of the Galileo signal, sometimes after a simple firmware update.	• Following the recession, the construction market is recovering, especially in Central & Eastern Europe and the Middle East. • The production of topographical maps for official purposes require accredited professionals in some countries. • The number of professional users coming from transversal disciplines is increasing, e.g. from environmental and spatial planning applications.	• Demand for certified positioning is expected to increase over the short term. • Users may also contribute to the creation of maps through mapping communities. Several crowdsourcing initiatives exist already e.g. Open Street Map.

Use of GNSS in surveying spreads around the globe



- The surveying market in the Rest of the World is expected to experience major growth and develop much faster than in Europe or North America. This is due to a high level of construction activity in this region. In addition, GNSS is expanding faster in the Rest of the World region because often there are no alternative legacy systems and dense geodetic ground networks to support surveys frequently do not exist.
- Surveying equipment is still expensive compared to other segments, however price erosion can be observed in the last few years supported by increased competition and demand, and lower production costs (see reference page).
- Leading manufacturers have introduced low cost devices sometimes under other brand names to satisfy the increasing demand in emerging economies, which are more eager to buy less expensive devices. These systems are usually less technically advanced so as not to undermine sales in more developed markets.

Growth in surveying depends on general economic conditions



- Due to increasing GDP and population in the Rest of the World, cadastral surveys will increase in importance and frequency. In growing economies, land boundaries and their measurement are likely to become a far more important issue due to the regulations associated with the ownership of property. Cadastral surveys are also important for restoration work after natural disasters.
- Mapping applications will support further market growth by enabling new applications, requiring lower levels of accuracy. Volunteered Geographical Information (VGI) initiatives are fostering the use of GNSS devices to share instant updates of geo-information within mapping communities.

The professional market is ready for Galileo

The trend in surveying is to adopt all new signals in one device, maximising accuracy of measurements and improving availability in places with poor aerial exposure (e.g. urban canyons and forests).

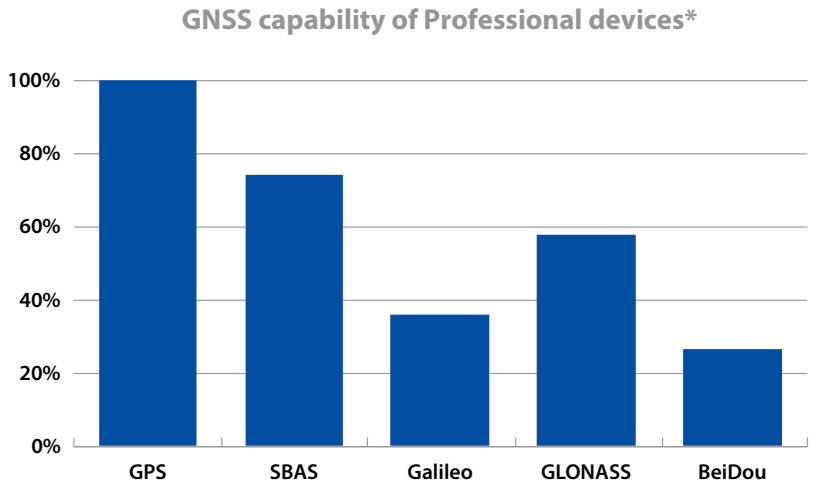
Galileo will enable enhanced performance compared to previous combinations of GPS and GLONASS by providing signals on dual frequencies. GLONASS has achieved high market penetration due to its early availability and the associated performance improvements that multi-constellation offers.

Galileo is already present in many receivers, some of them still require firmware update.

Galileo Commercial Service (CS) will deliver high accuracy and robustness even for very demanding applications.

EGNOS provides metre level accuracy, responding well to the needs for enhanced GPS positioning by municipalities, forestry authorities, etc.

It is widely adopted in all levels of devices, providing added value free of charge. Using EDAS, it can also be received by alternative communication channels in areas with poor satellite coverage.



Example of R&D project: ASPHALT

ASPHALT is the Advanced Galileo Navigation System For Asphalt fleet machines. The objective of the project is to develop a system for machine control and fleet management on a construction site, which enables roads of better quality and durability to be built.

More information can be found at: http://www.asphalt-fp7.eu/

Example of R&D project: WalkEGNOS

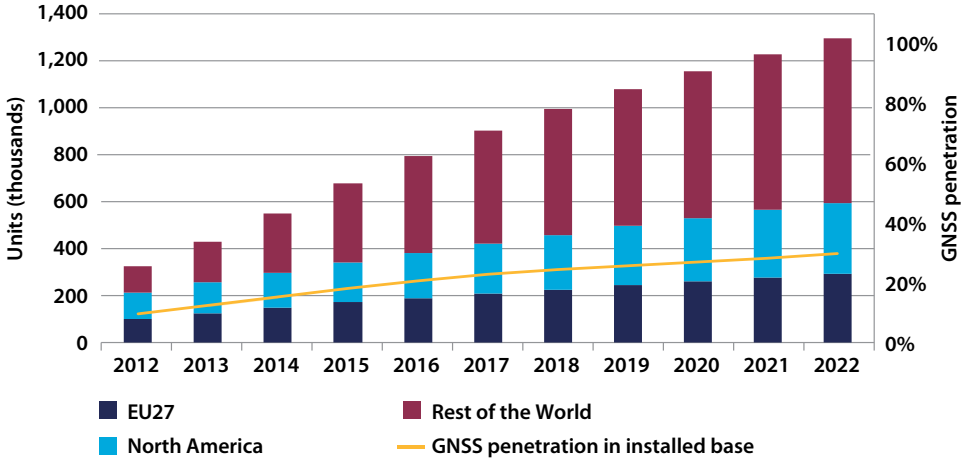
The project allows users to record their walks/mountain bike routes on their GNSS-enabled smartphone. The GNSS data gathered by the user in their journey is uploaded and corrected by post-processing EGNOS corrections, allowing the route to be accurately plotted on a map or satellite image.

More information can be found at: http://walkegnos.net/

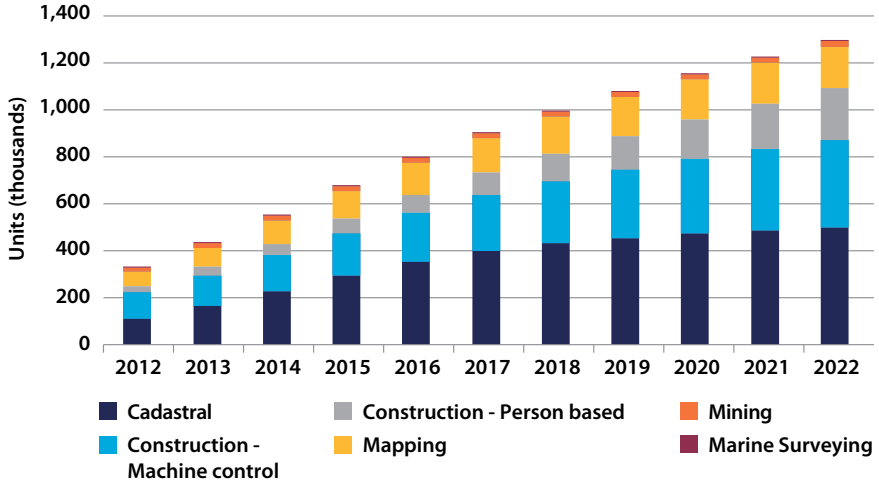
** Source: GSA analysis based on GPS World Survey 2013. Percentages based on number of models available in Agriculture and Surveying combined, not sales.*

Surveying Reference Charts

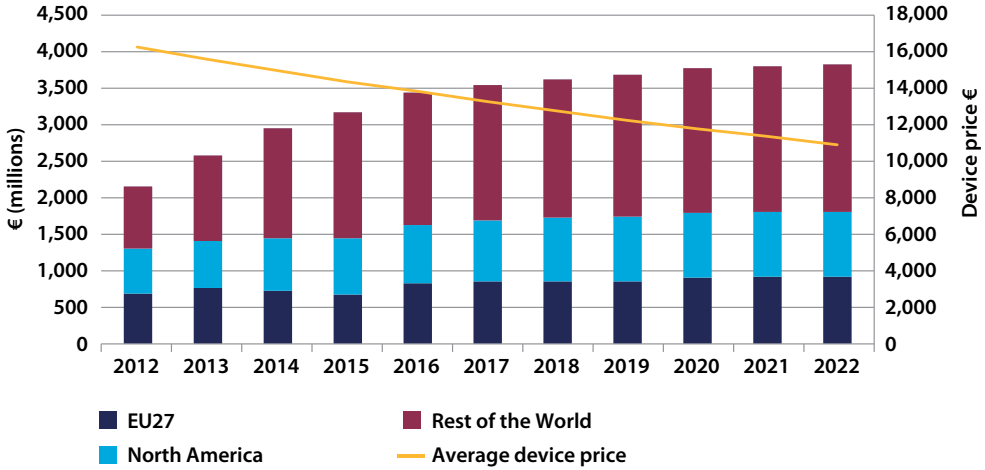
Installed base of GNSS devices by region



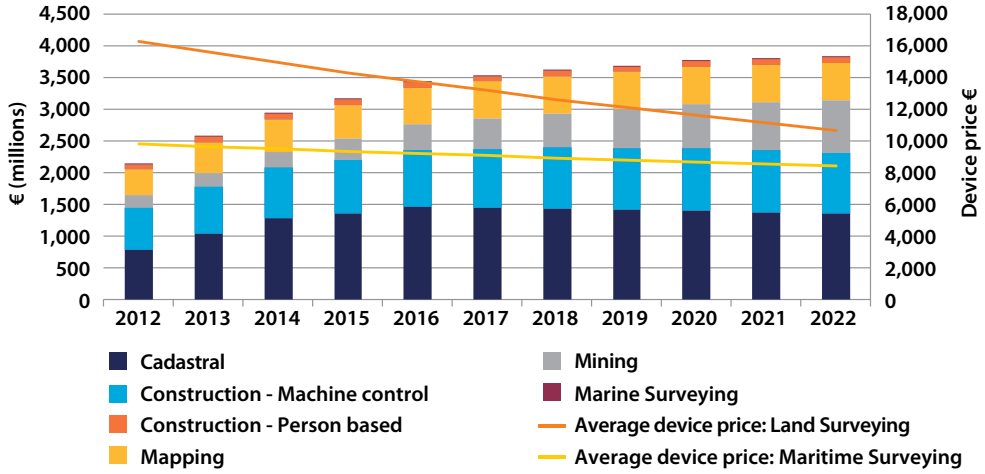
Installed base of GNSS devices by application



Core revenue from GNSS device sales and services by region



Core revenue from GNSS device sales and service by application



Methodology and sources of information

The present market report has been produced by applying the GSA's* market monitoring and forecasting process.

Employing the same general methodology as previous issues, the underlying market model** utilises advanced forecasting techniques applied to a wide range of input data, assumptions, and scenarios to forecast the size of the Global Navigation Satellite System (GNSS) market in terms of shipments, revenue, and installed base of receivers.

Historical values are anchored to actual data, where possible, in order to ensure a high level of accuracy. Assumptions are informed by expert opinions and model results are cross-checked against the most recent market research reports from independent sources, before being validated through an iterative consultation process with sector experts and stakeholders.

The model makes use of publicly available information including the following sources: Eurostat, United Nations Conference on Trade and Development (UNCTAD), United Nations public information, US National Transportation Statistics, US Bureau of Labor Statistics, International Road Assessment Programme (IRAP), International Telecommunication Union (ITU), Nations Online, GSM Association, Boeing, Airbus, Federal Aviation Administration, General Aviation Manufacturers Association (GAMA), World Shipping Council, Equasis, Eurocontrol, Infomines Food and Agriculture Organisation (FAO), and FP7 project websites. Additional data and reports were purchased from: ABI Research, Berg Insight, Bureau van Dijk (ORBIS), Clarkson Research Ltd, Farstad Shipping, UIC International Railway Statistics and the Council of European Geodetic Surveyors (CLGE).

Disclaimer

The information provided in this report is based on the Agency's best estimates and forecasts at the time of publication*. Although the Agency has taken utmost care in checking the reasonableness of assumptions and results with the support of industry experts, the Agency accepts no responsibility for the further use made of the content of this report.**

* *About the GSA: The European GNSS Agency (GSA) is an agency of the European Union. One of its missions is to support the European Commission in promoting the use of European GNSS (EGNOS and Galileo), keeping Europe at the forefront of the satellite navigation sector.*

** *The market monitoring and forecasting process is supported by London Economics (www.londecon.co.uk/aerospace) and Helios (www.askhelios.com).*

*** *Previous reports: In the past, the Agency communicated various market forecasts through different channels including its own website and conference presentations. The current publication is based on the latest and most comprehensive analyses, and the most recent trends and information with respect to the Galileo deployment.*

List of acronyms

ACCEPTA	ACCelerating EGNOS adoPTion in Aviation
ADAS	Advanced Driver Assistance System
AIS	Automatic Identification System
ANSP	Air Navigation Service Provider
AOPA	Aircraft Owners and Pilots Association
APV	Approach Procedure with Vertical guidance
BA	Business Aviation
BRIC	Refers to: Brazil, Russia, India, China
CA	Commercial Aviation
CAGR	Compounded Annual Growth Rate
CANSO	Civil Air Navigation Services Organisation
CAT I, II, III	ILS Categories for precision instrument approach and landing
CCS	Command and Control System
COSPAS-SARSAT	Russian Cosmicheskaya Sistyema Poiska Avariynich Sudow - Search and Rescue Satellite-Aided Tracking (International Satellite System For Search and Rescue)
CS	(Galileo) Commercial Service
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DT	Digital Tachograph
EDAS	EGNOS Data Access Service
EGNOS	European Geostationary Navigation Overlay Service
ESA	European Space Agency
ETCS	European Train Control System
EU	European Union
FAA	Federal Aviation Administration
FAO	Food and Agriculture Organisation
FOC	Full Operational Capabilities
FOC	Freight Operating Company
GA	General Aviation
GAGAN	GPS Aided Geo Augmented Navigation
GAMA	General Aviation Manufacturers Association
GBAS	Ground Based Augmentation System
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	European GNSS Agency
GSM	Global System for Mobile Communications
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMES	Indoor Messaging System
IMO	International Maritime Organisation
INS	Inertial Navigation System
IOC	Initial Operational Capabilities
IOV	In-Orbit Validation
IRAP	International Road Assessment Programme
ITS	Intelligent Transport System
ITU	International Telecommunication Union
IVS	In-Vehicle System
LBS	Location Based Service
LPV	Localizer Performance with Vertical guidance
MEOSAR	Medium Earth Orbit Search and Rescue satellites
MSAS	Multi-functional Satellite Augmentation System
OBU	On-Board Unit
OS	(Galileo) Open Service
PBN	Performance Based Navigation
PERNASVIP	PERsonal NAvigation System for Visually disabled People
PND	Portable Navigation Device
PPP	Precise Poing Positioning
PPUI	Pay Per Use Insurance
PRS	Public Regulated Service
PTC	Positive Train Control
PVT	Position, Velocity, Timing
RA	Regional Aviation
RFID	Radio-Frequency IDentification
RIMS	Ranging and Integrity Monitoring Stations
ROSCO	Rolling Stock Operating Company
RTK	Real Time Kinematic
RUC	Road User Charging
SAR	Search and Rescue
SBAS	Space Based Augmentation System
SIS	Signal In Space
SMS	Short Message Service
SOLAS	International Convention for the Safety of Life at Sea
TACOT	Trusted multi-application receiver for trucks
TOC	Train Operating Company
TTFF	Time To First Fix
UNCTAD	United Nations Conference on Trade and Development
VFR	Visual Flight Rules
VGI	Volunteered Geographical Information
VRT	Variable Rate Technology
WAAS	Wide Area Augmentation System
WWRNS	World-Wide Radio Navigation System

The European Commission

The European Commission is responsible for management of the European satellite navigation programmes, Galileo and EGNOS, including:

- management of funds allocated to the programmes,
- supervising the implementation of all activities related to the programmes,
- ensuring clear division of responsibilities and tasks in particular between the European GNSS Agency and European Space Agency,
- ensuring proper reporting on the programme to the Member States of the EU, to the European Parliament and to the Council of European Union.

The Galileo and EGNOS programmes are entirely financed by the European Union.

The European GNSS Agency (GSA)

The GSA is the European Union Community Agency formed to accomplish specific tasks related to European GNSS programmes.

The GSA's current mission is to:

- contribute to the preparation of the commercialisation and the exploitation of the systems, laying the foundations for their economic sustainability and maximising the economic, social and public benefits;
- ensure the security accreditation of the systems and the operation of the Galileo security centre;
- accomplish other tasks entrusted to it by the Commission, such as the promotion of applications and services and managing R&D programmes on satellite navigation.

European Commission

European GNSS Agency

European Global Navigation Satellite Systems Agency

market@gsa.europa.eu
www.gsa.europa.eu
www.egnos-portal.eu