



European  
Global Navigation  
Satellite Systems  
Agency



**EGNOS**

NAVIGATION SOLUTIONS  
POWERED BY EUROPE

# GNSS Downstream Markets

Martin Sunkevic, European GNSS Agency (GSA)

**Training on Global Navigation Satellite System (GNSS)  
Jointly Organized by GIC/AIT, CSIS/UT and ICG/UNOOSA**

15 January 2019, Bangkok

# Structure of the presentation

Introduction to  
EGNSS

GNSS industry

Market segments  
description

Emerging  
application  
areas

R&D funding  
opportunities

# The European GNSS Agency (GSA) is responsible for market development and operations of Galileo and EGNOS






- Staff: around **160**
- Nationalities: **22**
- Headquarters: **Prague, Czech Republic**
- Other Locations:
  - France
  - The Netherlands
  - Spain
  - Belgium
- in charge of managing operations and service provision of Galileo (2017) and EGNOS (2014)
- delivering safe and secure European satellite system
- ensuring that European companies are using Galileo and EGNOS
- making sure that European citizens are benefitting from EGNOS and Galileo

# EGNOS already available serving EU citizens and industry



- Satellite Based Augmentation System (SBAS)
- Improves GNSS performance
- European coverage (under extension in other regions, e.g. North Africa)
- Available free of charge and widely adopted in off-the-shelf receivers

<b>Open Service (OS)</b>	<b>Accuracy ~1m, free</b>	Available since October 2009	
<b>Safety of Life Service (SoL)</b>	<b>Accuracy ~1m, compliant to aviation standards and Integrity</b>	Available since March 2011	
<b>EGNOS Data Access Service (EDAS)</b>	<b>Accuracy &lt;1m, corrections provided by terrestrial networks</b>	Available since July 2012	

# Galileo is the European GNSS offering several services

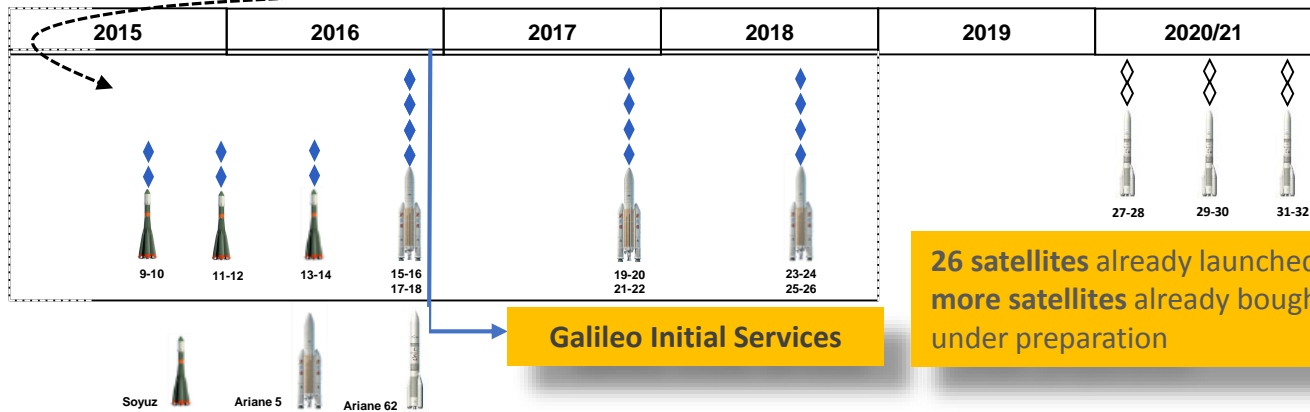
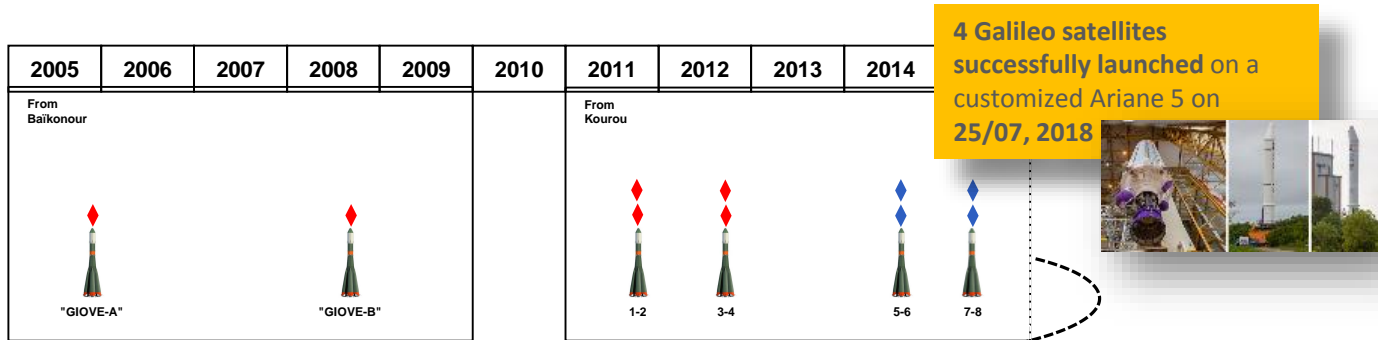


- Worldwide navigation system “made in EU”
- Fully compatible with GPS
- Open service free of charge, dual-frequency
- Signal authentication will provide trustability



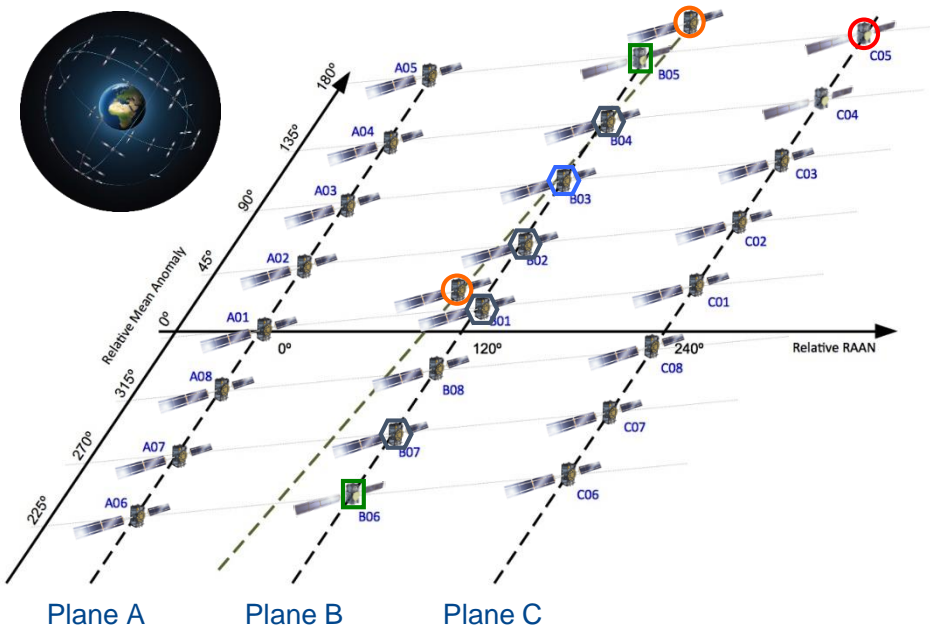
<b>Open Service (OS)</b>	Freely accessible service for positioning and timing	A man in a suit talking on a mobile phone.
<b>Public Regulated Service (PRS)</b>	Encrypted service designed for greater robustness and higher availability	A helicopter flying over water.
<b>Search and Rescue Service (SAR)</b>	Assists locating people in distress and confirms that help is on the way	A large ship at sea.
<b>High-Accuracy Service (HAS)</b>	To deliver high accuracy services for commercial applications	An offshore oil rig at sea.
<b>Signal Authentication Service (SAS)</b>	To deliver authentication commercial applications	A person holding a smartphone, likely using a navigation application.

# Galileo deployment is progressing



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

# Galileo Constellation Status



**Navigation Payload (18 Operational)**

- 26 satellites in orbit
- 4 under commissioning
- 2 in testing
- 1 spare
- 1 unavailable

**Search and Rescue Payload (19 Operational)**

- 2 out of 26 satellites with no SAR Transponder (by design)
- 4 under commissioning
- 1 spare

0 unoccupied reference slots

# Quarterly Performance Reports



- Following the declaration of [Initial Services](#) in December 2016, the Galileo Initial Open Service (OS) and the Galileo Search and Rescue (SAR) Service Public Performance Reports are published quarterly, to provide the public with information about the Galileo OS and the Galileo SAR Service measured performance statistics

## OS Performance Report - Q3 2018



## SAR Service Performance Report - Q3 2018





# Galileo will provide specific differentiators for a more robust and accurate positioning



## OTHER POSITIONING TECHNOLOGIES:

- WI-FI
- Inertial sensors
- Mobile network positioning

## GNSS POSITIONING

### MULTI-GNSS GALILEO VALUE ADDED

- INCREASED ACCURACY
- INCREASED AVAILABILITY
- REDUCED TIME TO FIRST FIX
- INCREASED RESILIENCY

### GALILEO DIFFERENTIATORS

#### HIGH PRECISION

- SIGNAL AUTHENTICATION
- RETURN LINK CAPABILITY
- INCREASED ROBUSTNESS



= OTHER GNSS

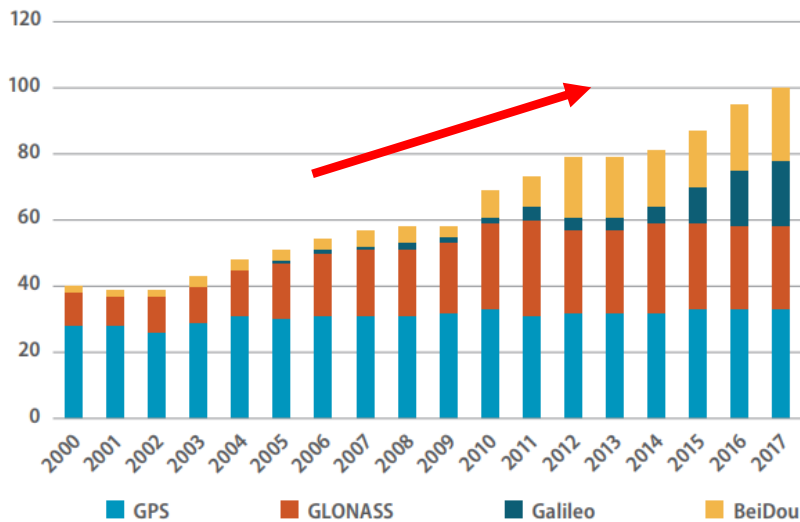


= GALILEO

# The evolution of GNSS infrastructure responds to the increasing user demand

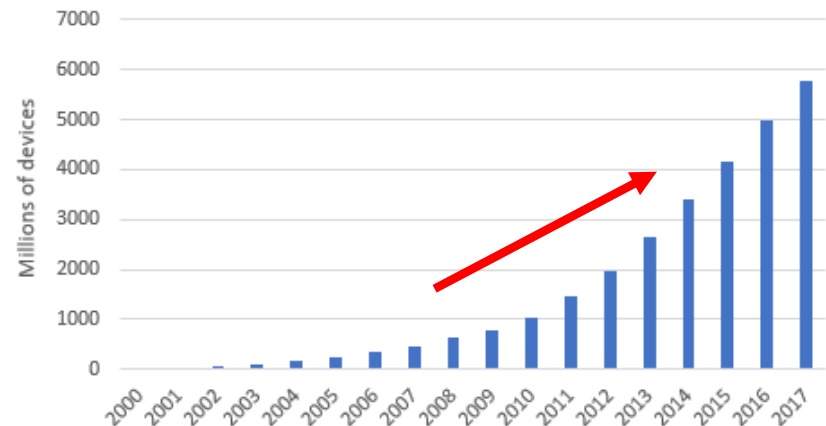


OPERATIONAL GNSS SATELLITES



All global and regional GNSS constellations are developing and modernising, with more than 100 GNSS satellites available today

Installed Base of GNSS devices



Introduction to  
EGNSS

**GNSS industry**

Market segments  
description

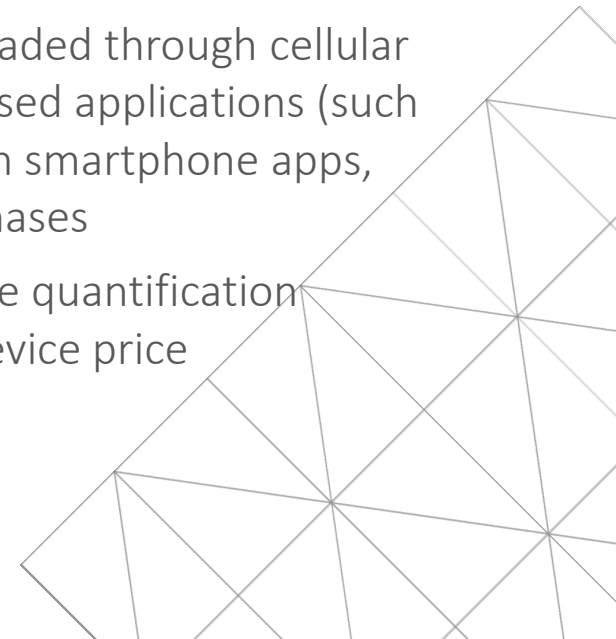
Emerging  
application  
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# GNSS Downstream market: the definitions



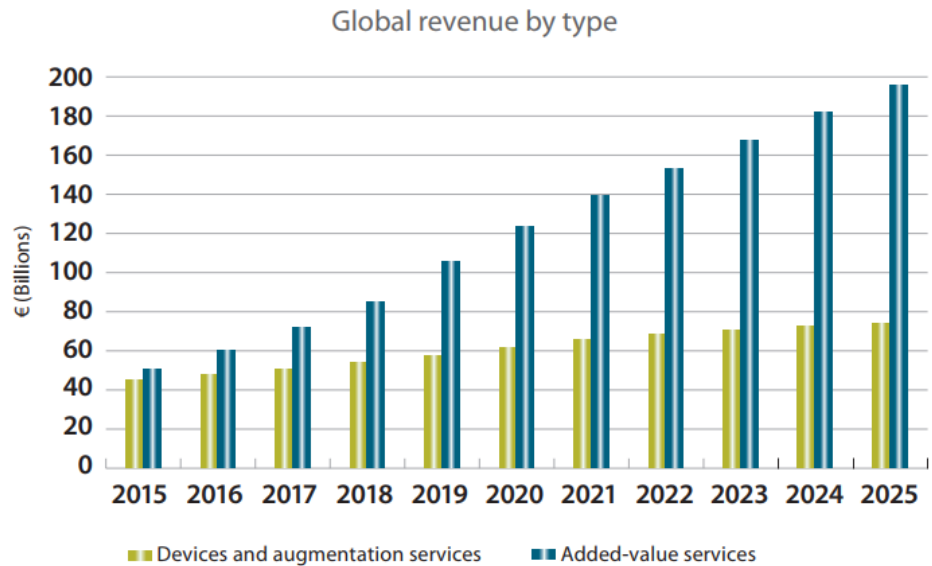
- GNSS Downstream Market defined as **activities where GNSS-based positioning, navigation and/or timing is a significant enabler or functionality**
  - Comprises **device revenues, revenues derived from GNSS augmentation services and other necessary software solutions and content (incl. digital maps); and added-value services directly attributable to GNSS**
  - Scope of ***added-value service revenues*** includes data downloaded through cellular networks specifically for the purpose of running location-based applications (such as navigation), as well as GNSS-attributable revenues of such smartphone apps, considering sales revenue, advertisements and in-app purchases
  - For ***multi-function devices***, such as smartphones, the revenue quantification includes ***only the value of GNSS functionality*** – not the full device price



# GNSS Downstream market: size



- The global **GNSS downstream market**, which comprises both **devices** (e.g. GNSS receivers) and **augmentation services**, is forecasted to grow by 6.4% annually between 2015 and 2020 before slightly decelerating to 3.8% towards 2025
- These downstream markets enable the development of **added-value services**, which are set to witness skyrocketing growth between 2015 and 2020 at 20% annually, gradually slowing to an average annual growth of 9.6% through 2025



# The use of GNSS is key for eight different market segments



LBS



ROAD



AVIATION



RAIL



MARITIME



AGRICULTURE



SURVEYING

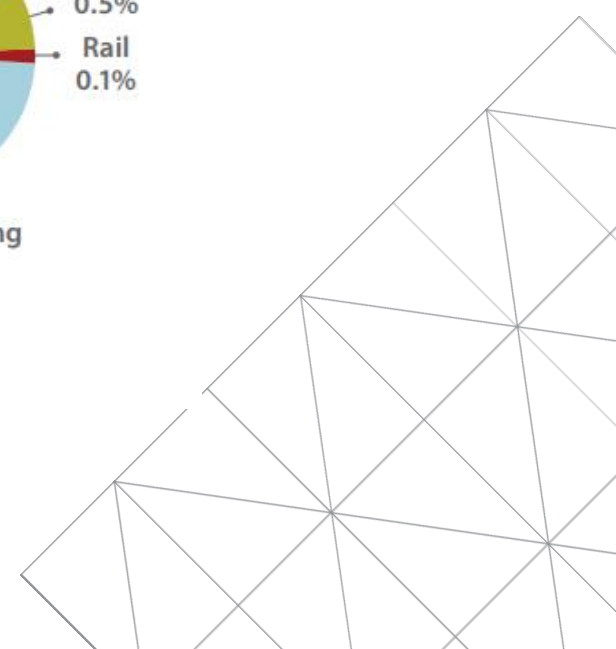
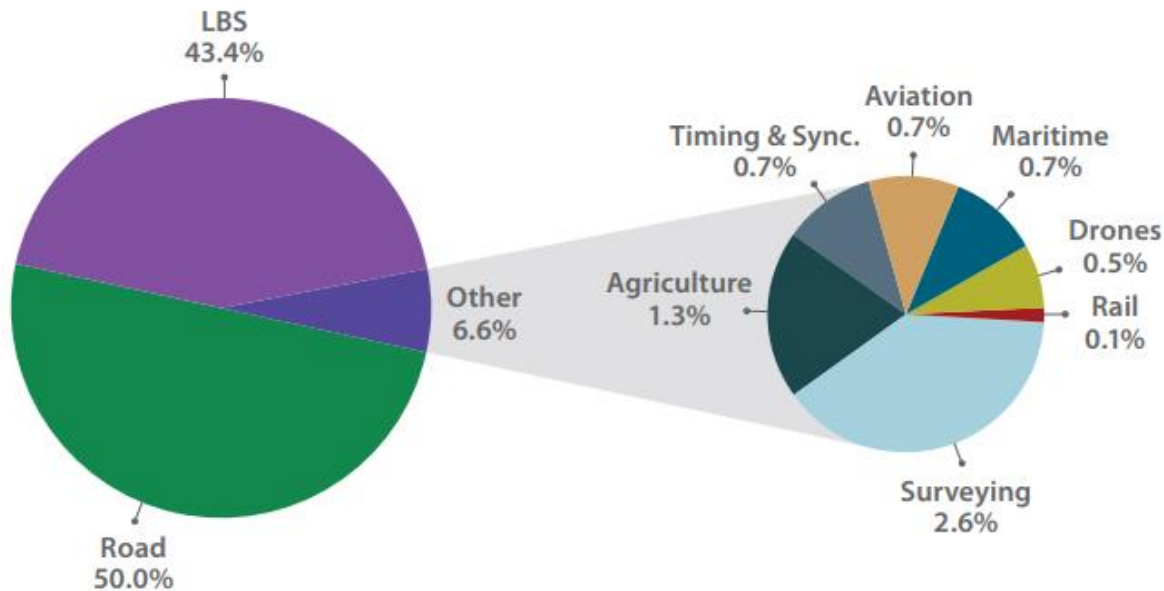


TIMING &  
SYNCHRONIZATION

# GNSS Downstream market: LBS and Road dominates the total revenues



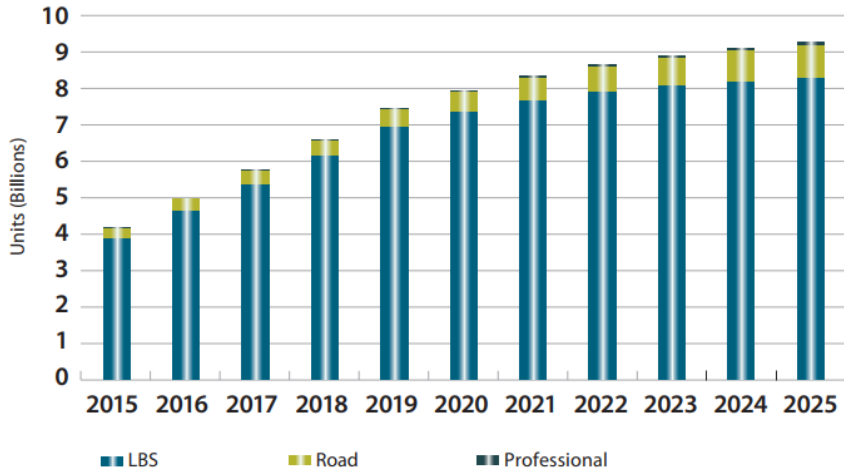
Cumulative Revenue 2015-2025 by segment



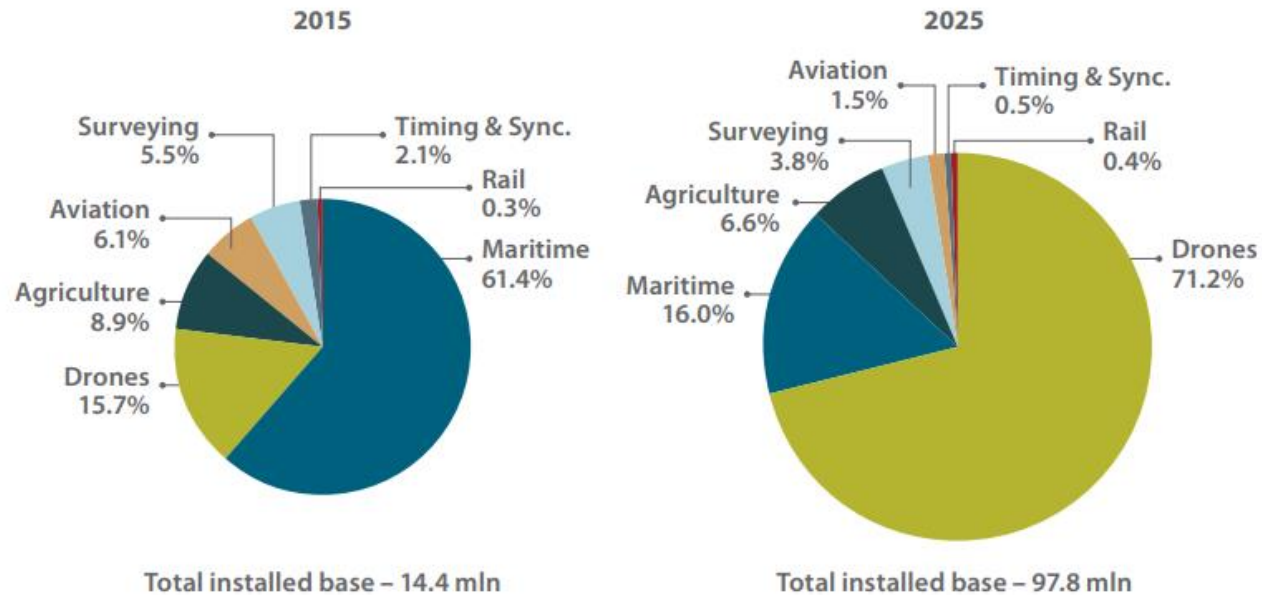
# GNSS Downstream market: Installed base



Global installed base by segment



Installed base of 'Professional' segments

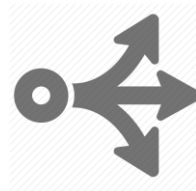
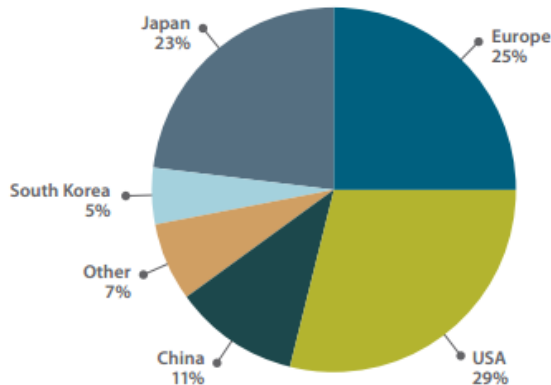




# GNSS downstream industry: consolidation at the top, opportunities for new players at the bottom



Revenue generation in the GNSS industry by key countries (% split of revenues 2015)



Top 10 companies across the value chain based on 2015 revenues

Component manufacturers		System integrators		Added-value service providers		GNSS applications users
Qualcomm	USA	Toyota	JP	Google	USA	Mass Market Users, Professional Users, Users With Special Needs, Retailers
Broadcom	USA	General Motors	USA	Here Global	DE	
Mediatek	CN	Garmin	USA	Pioneer	JP	
Trimble Navigation	USA	Ford	USA	Denso	JP	
Hexagon	SE	China First	CN	Microsoft	USA	
u-blox	CH	Volkswagen	DE	Boeing	USA	
STM	CH	Samsung Elec.	KR	Ericsson	SE	
Cobham	UK	Apple	USA	Garmin	USA	
Furuno Electric	JP	Nissan	JP	Clarion	JP	
Topcon	JP	Honda	JP	Tomtom	NL	

● New Entrants in the Top 10

Component manufacturers are becoming increasingly consolidated, underpinned by a number of recent Mergers and Acquisitions

System integrators primarily comprise car manufacturers and smartphone vendors, for which GNSS represents only a small part

Within value-added service category, GNSS currently offers an increasingly large potential for app development

# Regional market shares



Regional Market shares for component manufacturers and system integrators in 2015

	Component manufacturers (Europe: 20%)			System integrators (Europe: 27%)		
	Europe*	North America	Asia+Russia	Europe*	North America	Asia+Russia
	6%	61%	33%	4%	36%	60%
	<b>51%</b>	23%	27%	30%	21%	48%
	25%	65%	10%	23%	76%	1%
	31%	46%	23%	33%	14%	53%
	<b>43%</b>	9%	47%	<b>37%</b>	37%	26%
	6%	63%	31%	<b>42%</b>	39%	19%
	36%	40%	24%	<b>37%</b>	34%	29%

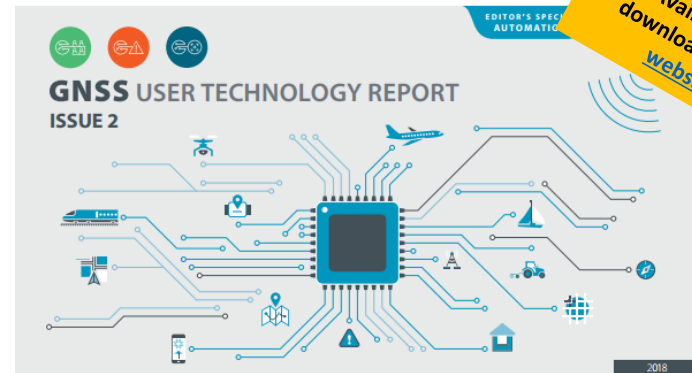
- Added-value service providers cannot be linked directly to market segments
  - Aggregated values amount to: Europe 26%; North America 50%; Asia+Russia: 24%

# The information sources



## 2<sup>nd</sup> edition of GSA's GNSS User Technology Report (Sept 2018)

- General overview of the latest GNSS receiver technology common to all application areas
- An in-depth analysis of GNSS user technology as it pertains to three key macrosegments:
  - ✓ Mass market solutions
  - ✓ Transport safety and liability-critical solutions
  - ✓ High precision, timing and asset management solutions
- Editor's special on Automation and increasingly important role of GNSS



## 5<sup>th</sup> edition of GSA's GNSS Market report (May 2017)

- GNSS market overview
- Macrotrends impacting GNSS across market segments
- For each of eight segments:
  - ✓ market segment updates, opportunities and trends
- Editor's special on Drones



# Internal GSA tool: Market Monitoring and Forecasting Tool



- **GSA's Market Monitoring and Forecasting Process MMFP** has been implemented to monitor the development of the growing market for GNSS and its evolution and to provide information in support of market development

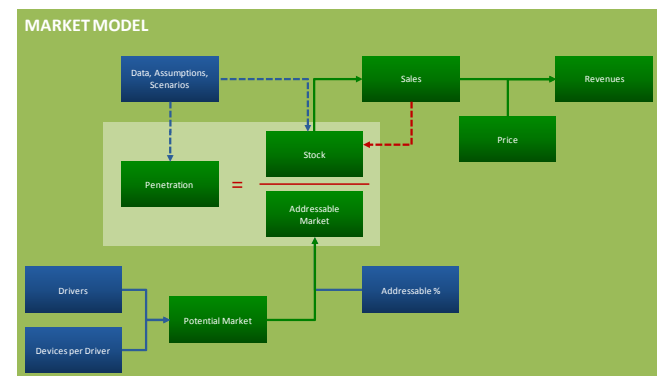
**MMFT is device-based model**

- Its objectives are to:
  - provide a solid source of market intelligence on GNSS in Europe, notably to **establish the real size of the main downstream market segments**;
  - **measure the impact of the GNSS programmes** and action plans in terms of **economic, social and public benefits**;
  - provide a tool to support policy decisions by responding to requests of **market estimation and scenario analysis**;
  - **forecast market developments** based on present knowledge and be able to compare alternative scenarios that represent different visions on how the market will evolve

The MMFP contains three econometric models:

- **Market** and two public benefits models
- **Socio-economic** and
- **Public utility models**

There are **three methodologies** used in the **Market Model** depending on data available



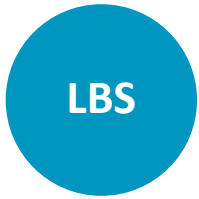
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# LBS applications/markets

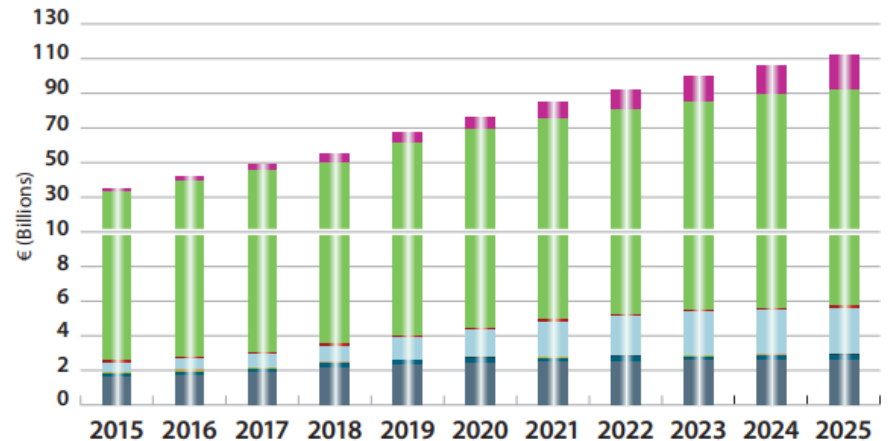


## GNSS applications

- **Navigation:** Route planning and turn-by-turn instructions based on GNSS support for both pedestrian and road navigation.
- **Mapping&GIS:** Smartphones enable users to become map creators thanks to the democratisation of digital mapping.
- **Geo marketing and advertising:** Consumer preferences are combined with positioning data to provide personalised offers to potential customers.
- **Safety and emergency:** GNSS in combination with network based methods provides accurate emergency caller location.
- **Enterprise applications:** Mobile workforce management and tracking solutions help companies to improve productivity.
- **Sports:** GNSS enables monitoring of users' performance through a variety of fitness applications.
- **Games/Augmented reality:** GNSS enables a wide range of location-based games on smartphones and tablets. In augmented reality games, positioning and virtual information are combined to entertain the user.
- **mHealth:** In combination with other technologies, GNSS enables a vast array of applications from patient monitoring to guidance systems for the visually impaired.
- **Personal Tracking:** GNSS facilitates innovative tracking solutions, including the deployment of local geofences that trigger an alarm when a user leaves the perimeter.
- **Social networking:** Friend locators embedded in social networks use GNSS to help keeping in touch and sharing travel information.

VS

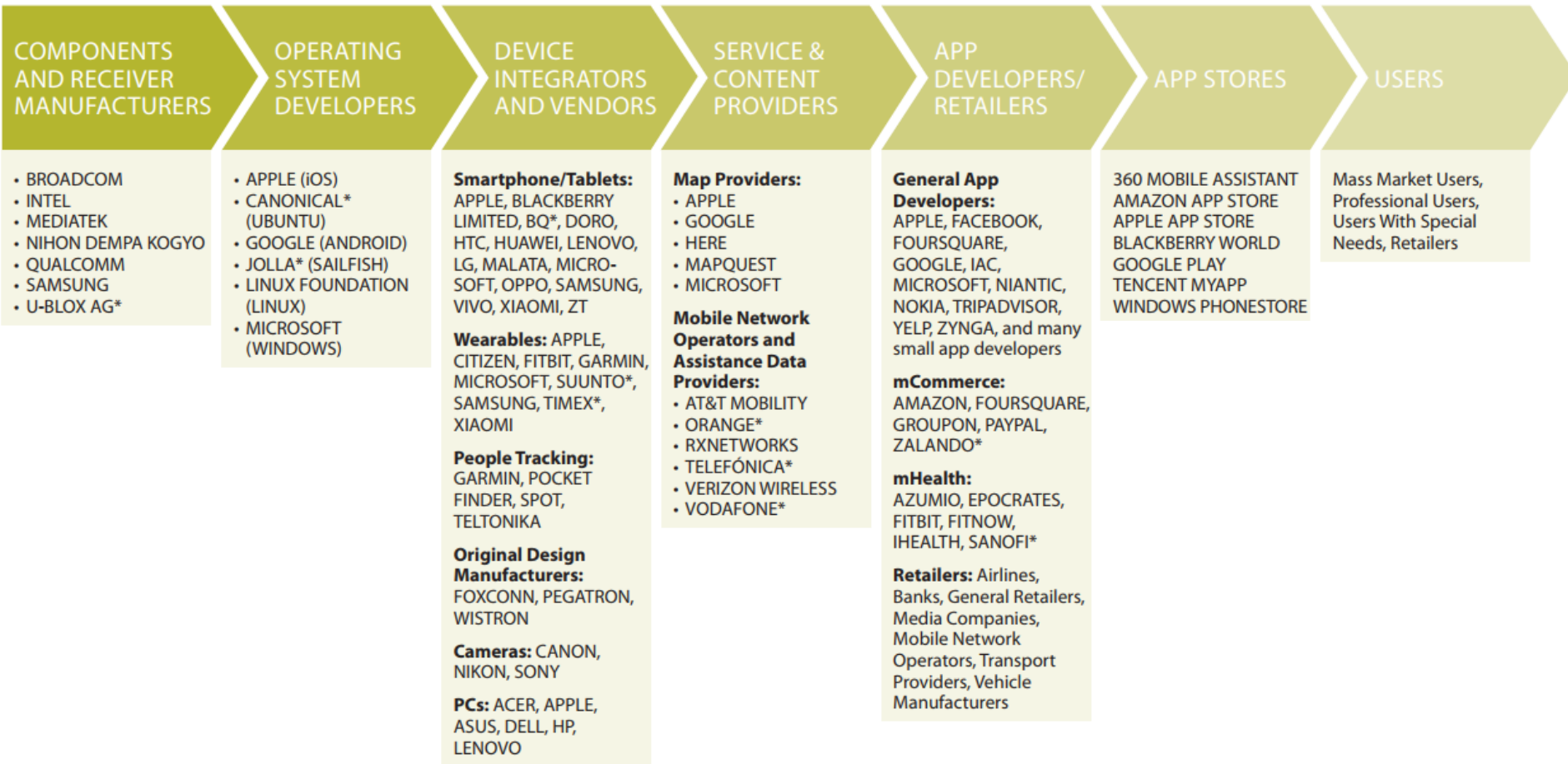
### Revenue of GNSS device sales and services by type



- Smartphones, Moblies and PDAs
- Digital cameras
- Sport & Wearables
- Search and Rescue (PLB)
- Software (apps) - GNSS share\*\*
- Tablets
- Portable computers
- Personal tracking devices
- Data revenue (smartphones and tablets)\*

\* Only data revenue arising from the use of Location-based services considered

\*\* Pay-to-download, In-app-purchases and ad revenue from social, tracking, search and gaming apps



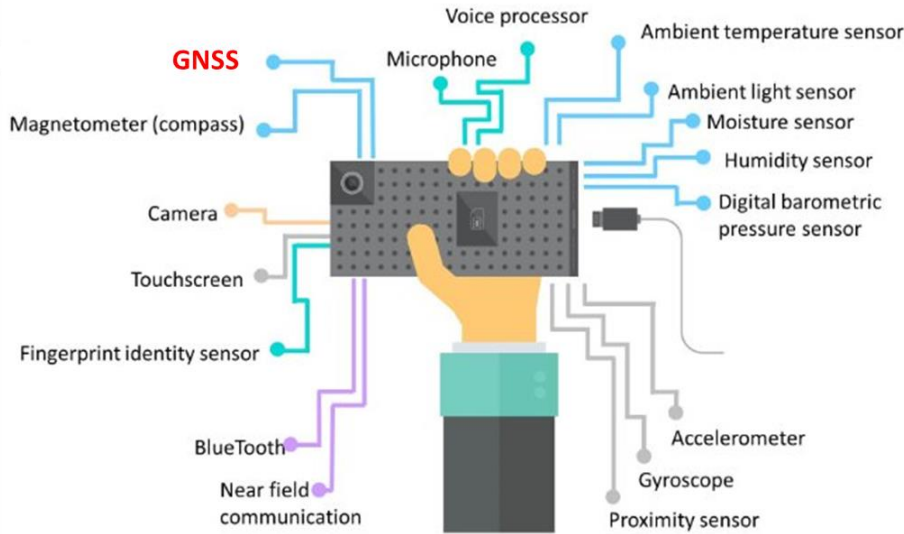
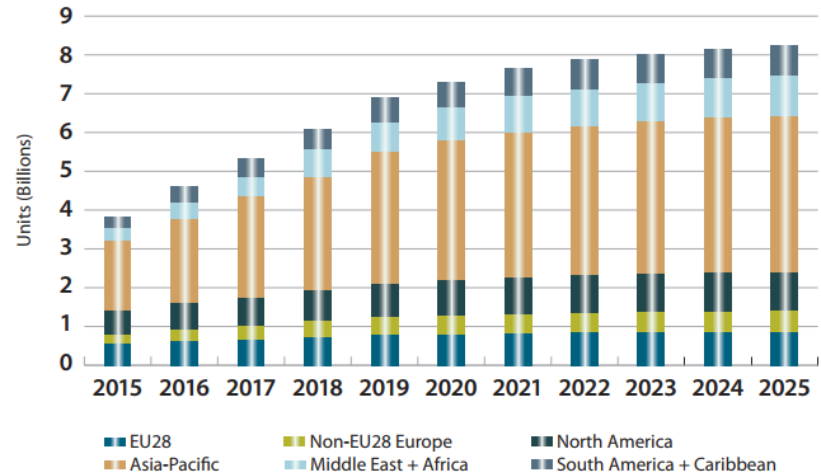


GNSS is considered a commodity inside smartphones with little room for innovation...



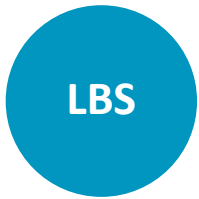
**GNSS sensors are included in many devices, 6 billion units of installed base in 2018**

Installed base of GNSS devices by region



**GNSS is today included in all new smartphones**

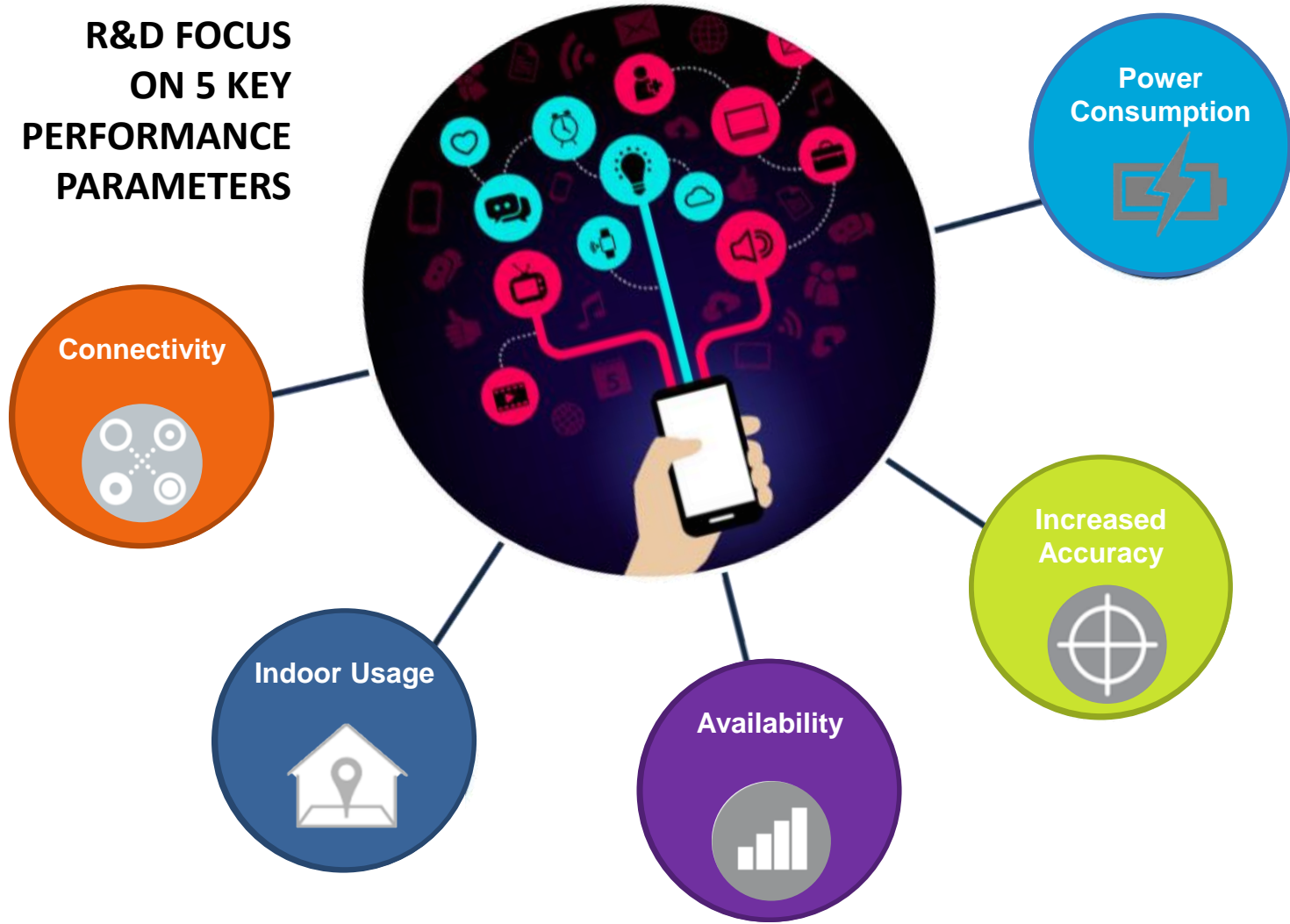


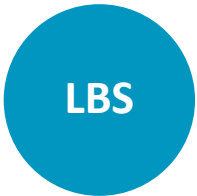


... however GNSS plays a role in all technological developments towards LBS of the future

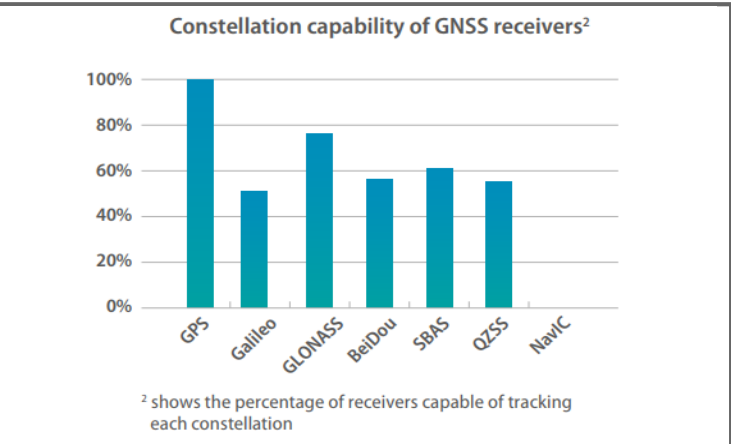


**R&D FOCUS  
ON 5 KEY  
PERFORMANCE  
PARAMETERS**

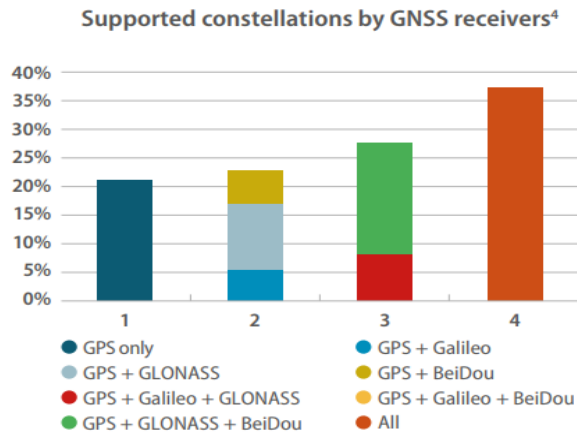




# Multi-constellation improves availability in urban environments



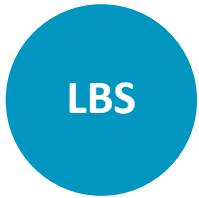
The need to provide enhanced geolocation capabilities in deep urban environment drives the uptake of multi-constellation receivers



<sup>4</sup> shows the percentage of receivers capable of tracking 1, 2, 3 or all the 4 GNSS constellations

**Galileo is already adopted by all global leaders in chipset manufacturing:**





# Access to raw measurements opens new possibilities for app developers and users



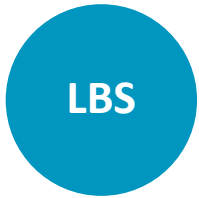
Google made GNSS raw measurements available on Android Nougat and higher in 2016 opening the door for the use of advanced GNSS processing techniques

Four main areas of innovation enabled by GNSS android raw measurements :

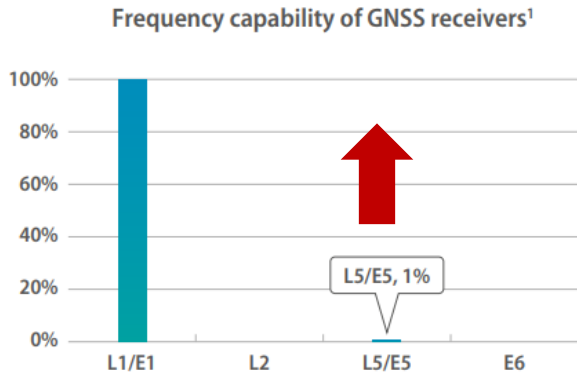
- ✓ Scientific use and R&D
- ✓ Increased accuracy
- ✓ Integrity and Robustness
- ✓ Testing, performance monitoring and education



The white paper on “Using GNSS Raw Measurements on Android devices” is available at GSA website



# The demand for further accuracy will support the uptake of dual frequency in mass market



<sup>1</sup> shows the percentage of receivers supporting each frequency band

- Historically, GNSS chipsets for a mass market use are **single frequency** ones
- However the **interest for dual frequency** increased:
  - Enabled by semiconductor's industry development
  - Pushed by the use of applications more and more demanding in terms of location
- Broadcom already in the smartphones, Qualcomm and Intel has recently announced dual-frequency chipsets

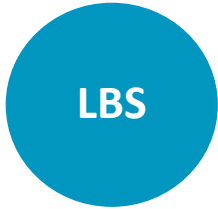


# Dual-frequency phones

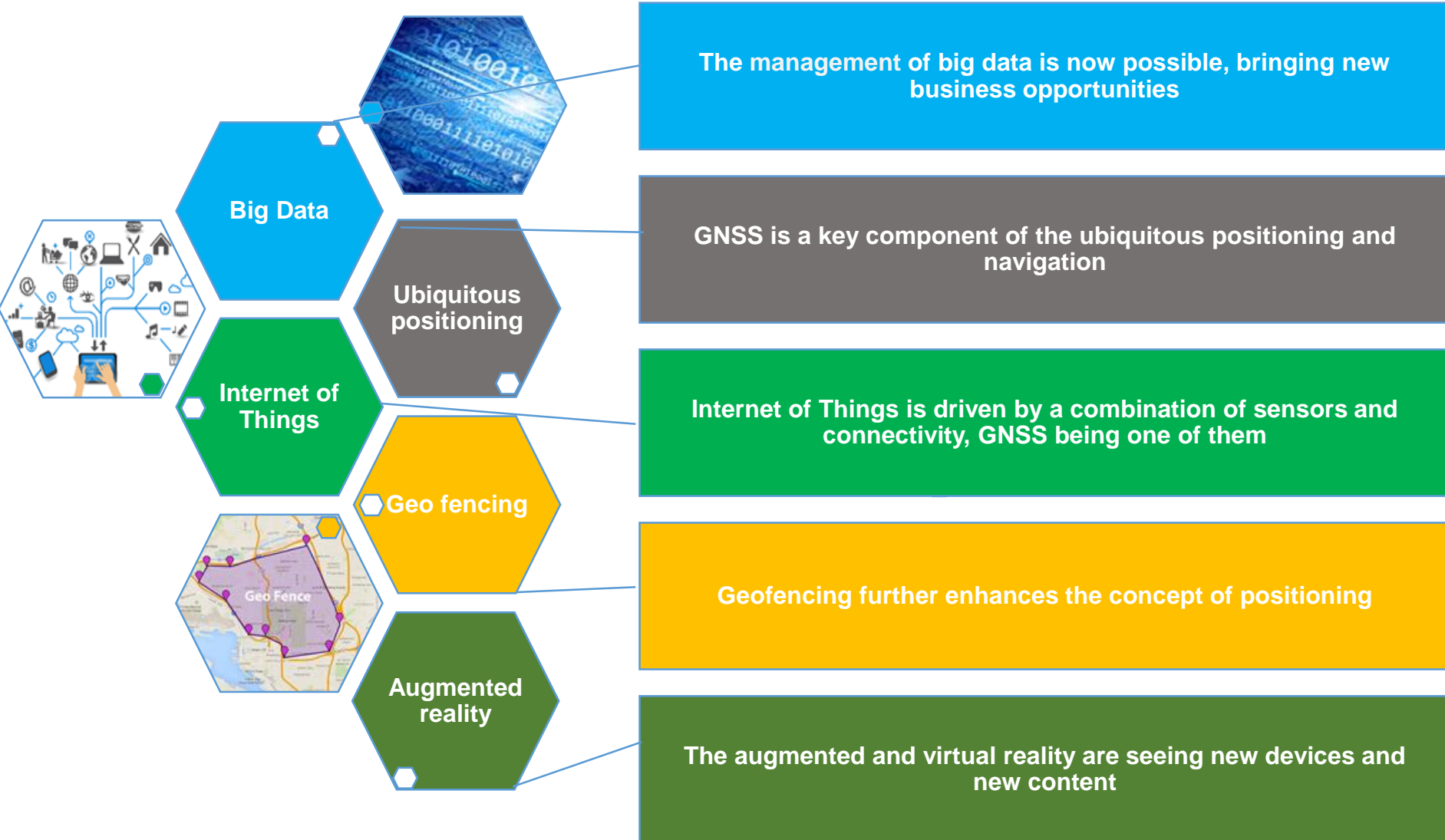


- Xiaomi`s world`s first dual-frequency GNSS smartphone Mi8
  - Fitted with a [Broadcom BCM47755 chip](#)
  - launched on May 31 2018
  - the world`s first smartphone providing below meter accuracy for location-based services and vehicle navigation
  - Raw measurements can help to provide even higher accuracy
  - Use L1/E1 and L5/E5 frequencies
- 
- Huawei`s first dual frequency GNSS smartphone Mate 20 Pro
  - Fitted with the [Broadcom BCM47755 chip](#) too
  - launched on November 2018





# Technology developments/features benefiting from GNSS



The management of big data is now possible, bringing new business opportunities

GNSS is a key component of the ubiquitous positioning and navigation

Internet of Things is driven by a combination of sensors and connectivity, GNSS being one of them

Geofencing further enhances the concept of positioning

The augmented and virtual reality are seeing new devices and new content

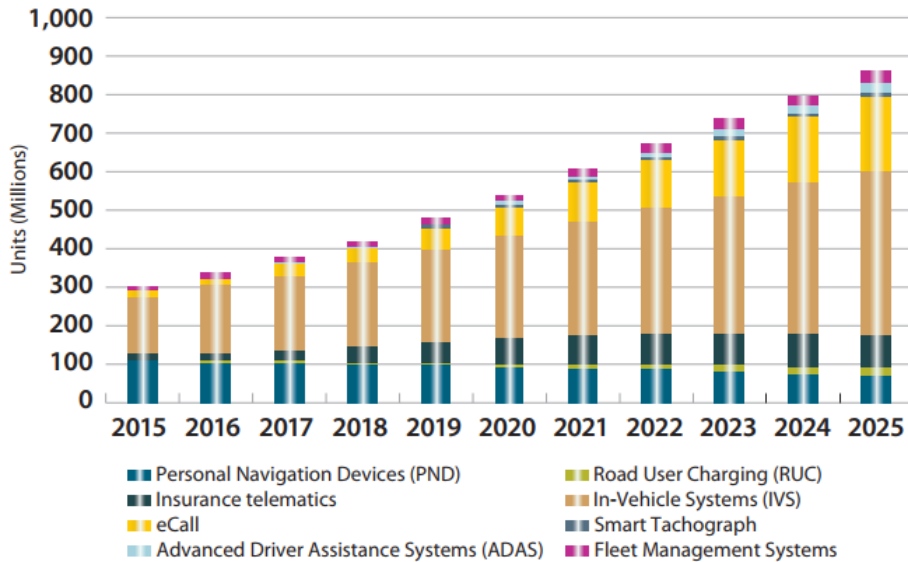
- **Smart mobility applications** improving efficiency, effectiveness and comfort of road transportation:
  - **Navigation** is the most widespread application, providing turn-by-turn indications to drivers through portable navigation devices (PNDs) and In-Vehicle Systems (IVS) built in cars.
  - **Fleet management** on-board units (OBUs) transmit GNSS positioning information through telematics to support transport operators in monitoring the performance of logistics activities.
  - **Satellite road traffic monitoring** services collect floating car location data from vehicles through PNDs, IVS and mobile devices, then process traffic information to be distributed to users and other interested parties.
  
- **Safety-critical applications** leveraging on accurate and secure positioning to scenarios of potential harm to humans or damage to a system/environment:
  - In **Cooperative ITS**, GNSS positioning information feeds technologies allowing road vehicles to communicate with other vehicles, traffic signals, roadside infrastructure and other road users.
  - **Advanced Driver Assistance Systems (ADAS)** support the driver during the driving process and act as a first stepping stone towards **Autonomous Vehicles**.
  - **Dangerous goods tracking** can be done by transmitting GNSS-based positioning data on the vehicles carrying them, together with other information about the status of the cargo.
  
- **Liability-critical applications** can generate significant legal or economic consequences based on positioning data:
  - In **Road User Charging (RUC)** GNSS-OBUs support toll operators in charging levies for the use of roads and for congestion control.
  - **Insurance telematics** black boxes rely on GNSS data to increase the fairness of motor insurance for both insurers and subscribers.
  
- **Regulated applications** apply the transport policies introduced by national or international legislations:
  - **eCall**: the pan-European GNSS-enabled in-vehicle systems (IVS) support system, such as the ERA-GLONASS in Russia, which sends an emergency call to 112 in case of accident, accelerating assistance to drivers.
  - **Smart tachographs** leverage on GNSS positioning to support road enforcers, by recording the position of the vehicle at different points during the working day.



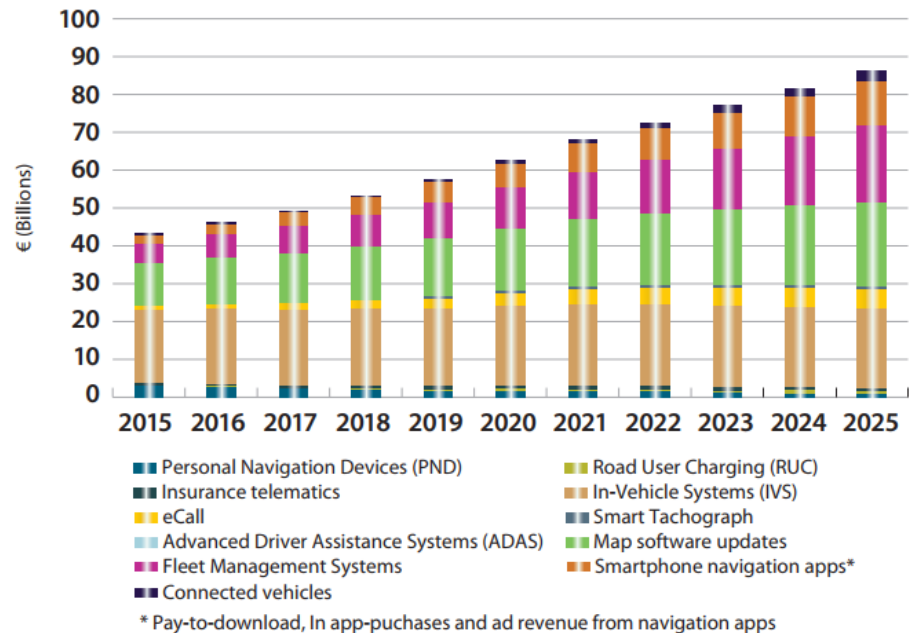
# Installed base and total revenues



Installed base of GNSS devices by type



Total revenue of GNSS device sales and services by type



\* Pay-to-download, In app-purchases and ad revenue from navigation apps



# The uptake of in-built GNSS could reshape the role of aftermarket players



GNSS-enabled IVS is set to become a platform for safety and infotainment applications: **move towards GNSS-enabled telematics platform, aftermarket to focus on service provision element**



# GNSS will play an important role in the vehicles of the future



**Autonomous driving is high on the agenda of many converging sectors**

- ✓ All major car groups worldwide are working on their own Autonomous Driving technology
- ✓ In-vehicle sensors are of key importance
- ✓ Together with other technologies (LiDAR, radar and cameras), GNSS is an enabler of autonomous driving concept



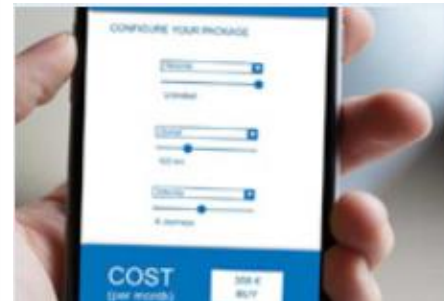
GNSS is already in use to assist the semi-autonomous vehicles during navigation using digital maps

# Mobility as a Service: The importance of GNSS



**Definition: *Mobility-as-a-Service (MaaS)*** describes a shift away from personally-owned modes of transportation and towards mobility solutions that are consumed as a service. This is enabled by combining transportation services from public and private transportation providers through a unified gateway that creates and manages the trip, which users can pay for with a single account

- MaaS identifies the best transport option for users
- Smart combination of public transport and vehicle rental or sharing
- Accuracy and availability in urban areas are important



## Key role of GNSS



# eCall is being introduced in cars, providing location to the rescue centres in case of emergency



11 eCall models were tested by GSA/EC



- **July 2018:** Volvo was the world-first car-maker to announce equipping its vehicles (V60 first) with the regulated pan-European eCall

- And since then until now.....



# GNSS applications in aviation



Regulated application

**Performance Based Navigation (PBN):** applications used when an aircraft follows a specific procedure or route within a prescribed error margin (e.g. airport approach).

Different applications for fixed wing (e.g. LPV, SBAS Cat-I) and rotorcraft (PinS, SNI, RNP0.3)

**GBAS:** Galileo as an enabler for GBAS CAT II/III



**Navigation aid:** systems designed as additional aid to GA pilots flying according to (Visual Flight Rules). They are also used to alert when they get too close to restricted airspace



Regulated application

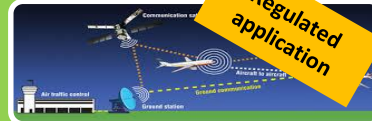
**Emergency Locator Transmitters (ELTs):** equipment helping Search & Rescue operations. Many ELTs utilize GNSS to report their position when triggered.

ELT is mandatory in all EU aircraft with more than 6 seats



**Personal Locator Beacons (PLBs):** portable devices which are almost always equipped with GNSS, that support localization in case of emergency.

PLB (or ELT) is mandatory in aircraft/helicopters of six or less seats.



Regulated application

**Automatic Depended Surveillance – Broadcast (ADS-B):** surveillance technique whereby an aircraft automatically provide, via a data link, data derived from on-board navigation and position-fixing systems.



**Unmanned Vehicles Systems:** growing market, demanding robust positioning and navigation

Regulated application use certified equipment to achieve safe and efficient operations

Regulated application



# GNSS Adoption in aviation is growing



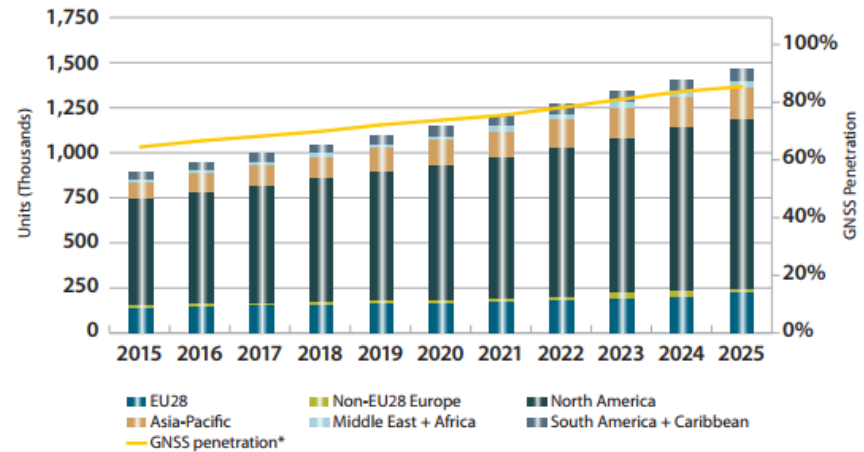
Aviation market grows worldwide

Rotorcraft operations are expanding their use of SBAS

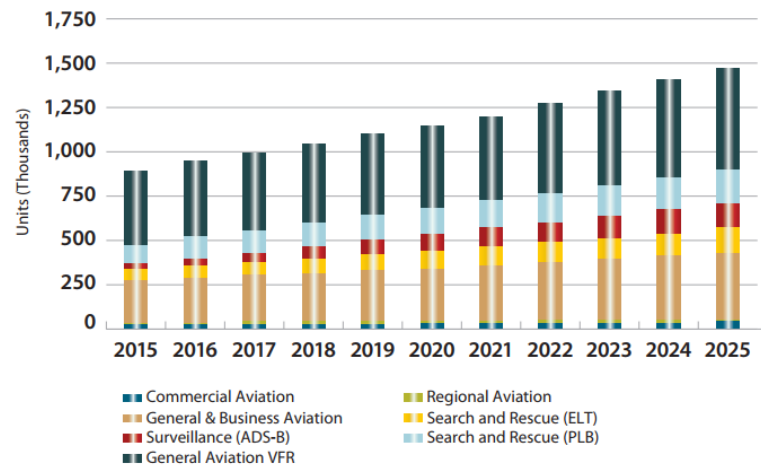
Regulators support expansion of PBN, foreseeing the future use of Multi-Constellation / Multi-Frequency

ELT increases sales and enhanced by Autonomous Distress Tracking (ADT) capabilities

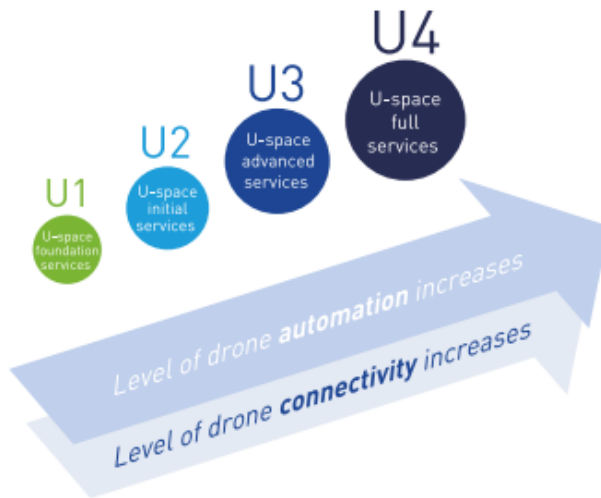
Installed base of GNSS devices by region



Installed base of GNSS devices by application



# The increasing use of drones demands Aviation's regulations



U-Space: Europe's initiative to enable drone service market while ensuring the safe and secure integration of drone operations



## Safe Navigation in challenging environments requires:

- Increased availability
- Increased accuracy for geo-fencing
- Signal authentication

## Need of GNSS:

- Positioning solution for drones involve GNSS and SBAS
- High integrity geo-fencing
- High accuracy
- MC/MF and SBAS as technical enablers for drone's requirements

# GNSS multi-constellation is becoming a solution for a lot of maritime applications in navigation...



- GNSS is the primary means of obtaining PNT information at sea

## Sea

**SOLAS Vessels: GNSS to support navigation activities**

**Non-SOLAS Vessels: GNSS for maritime navigation in commercial and recreational vessels**

## NAVIGATION



## Inland Waterways (IWW)

**GNSS for navigation in rivers, canals, lakes and estuaries**

SOLAS: All passenger ships, cargo ships larger than 500 gross tonnage or larger than 300 tons if engaged on international voyages



## Traffic management and surveillance

GNSS-based systems including Automatic Identification System (AIS) and Long-Range Identification and Tracking (LRIT)

## Fishing vessel control

GNSS to locate fishing vessels

## *POSITIONING*



## Marine Engineering

GNSS to support marine construction activities

## Search and Rescue

Provision of aid to people in distress or danger. Second Generation devices (EPIRBs and PLB) make use of GNSS.

## Port Operations

Several ports activities are performed with the help of GNSS



# GNSS substantially improves SAR Response



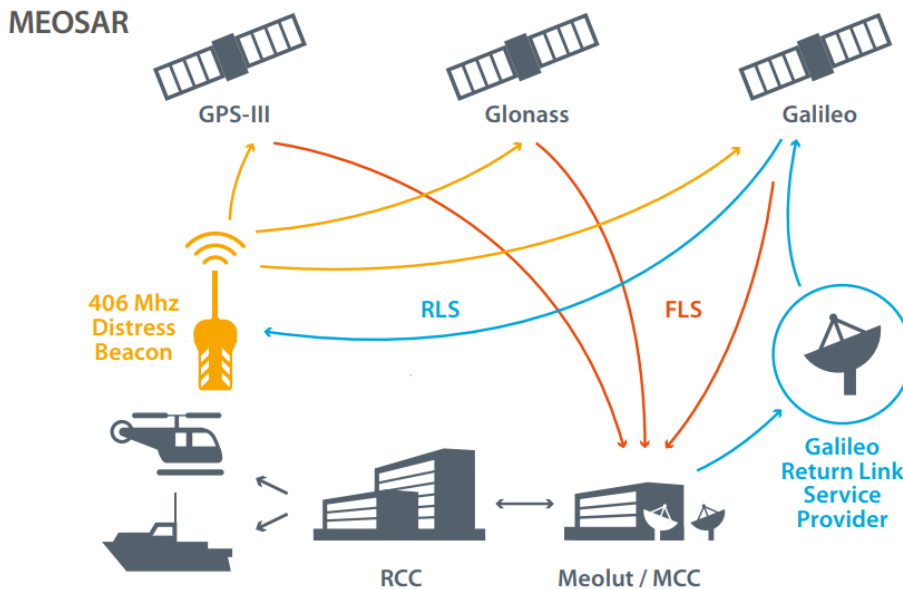
- Galileo soon to provide Return Link Service (acknowledge of receipt of a distress call)

GNSS is a significant differentiator for SAR activities

When an emergency is launched, GNSS information is used simultaneously with the independent COSPAS-SARSAT process to localise the person or vessel in distress

Reduces the time needed to reach the people in distress

Helps to save lives

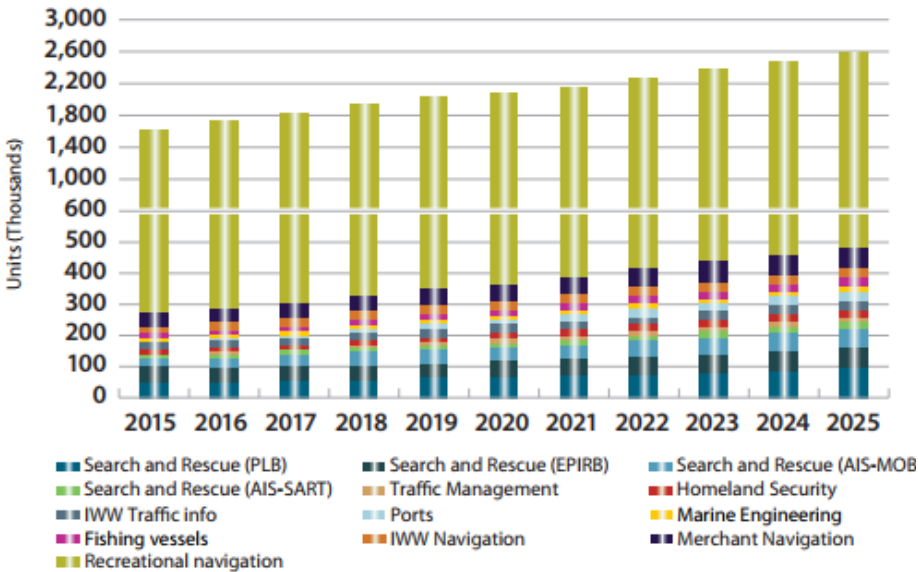




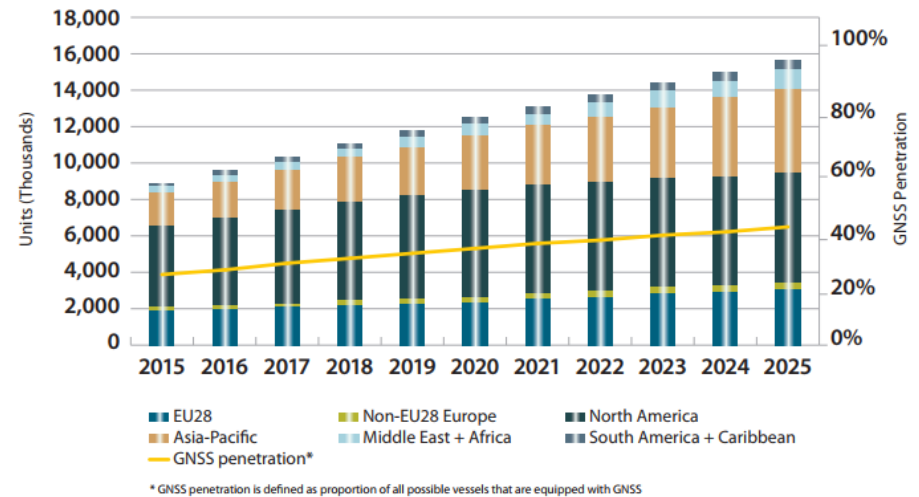
# GNSS penetration steadily growing within the maritime segment



GNSS unit shipments by application



Installed base of GNSS devices by region



\* GNSS penetration is defined as proportion of all possible vessels that are equipped with GNSS

# GNSS applications are wide extended



## Main Line Command & Control Systems

Train assistance and control with high traffic density

GNSS as source of additional inputs

## Low Density Line Command & Control Systems

GNSS support signalling on lines with low to medium traffic

Lines located in rural areas where cost saving is vital

## Asset management

Fleet management, need-based maintenance, infrastructure charges, inter-modal transfer

GNSS as a source for positioning and timing information

## Passenger Information

System on-board trains show real-time train location

GNSS is a source for positioning

## Driver Advisory System (DAS)

Real-time geo-location help train drivers to operate

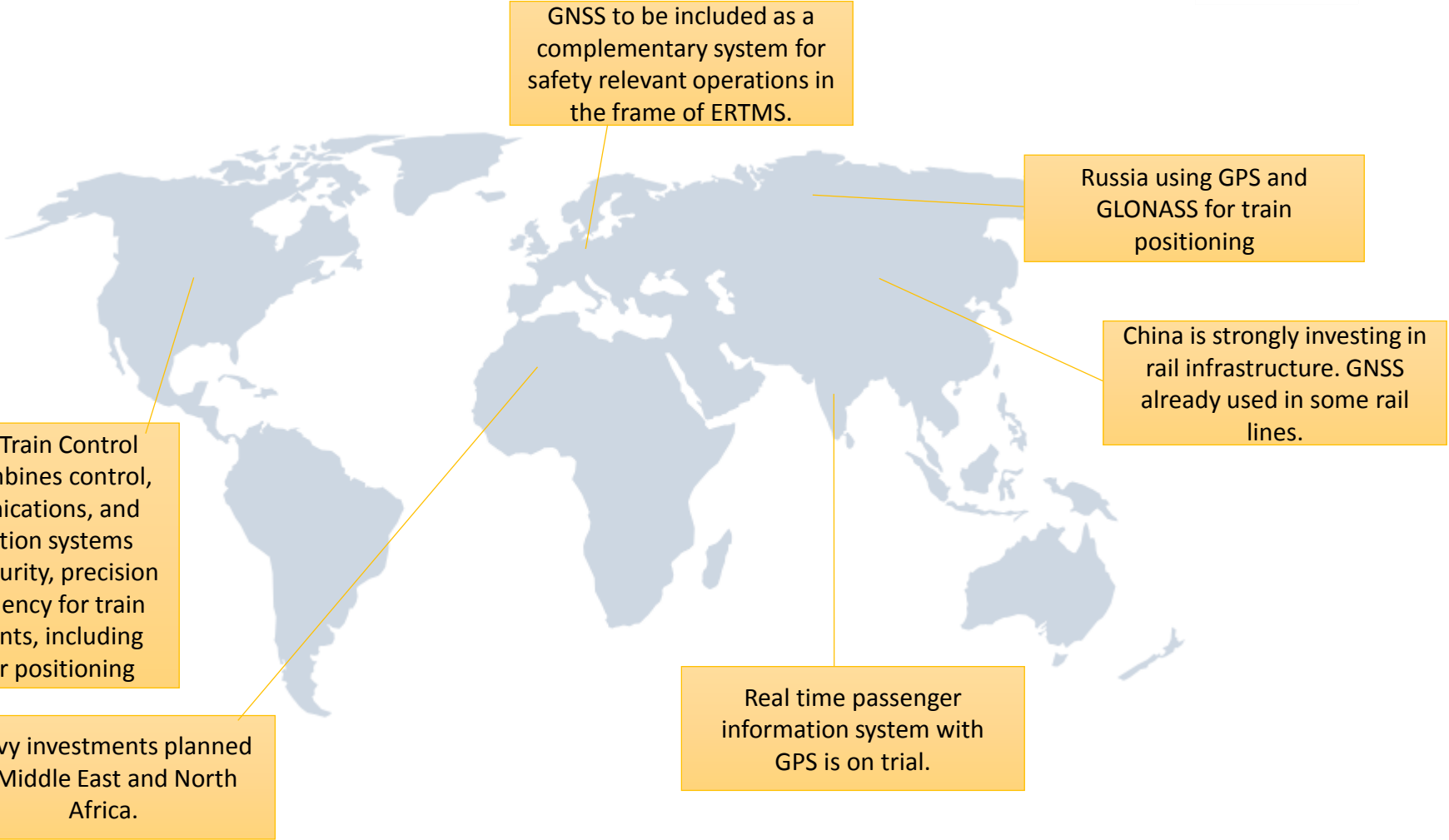
Operation optimisation of train traffic





Rail

# GNSS use in rail depends on the region

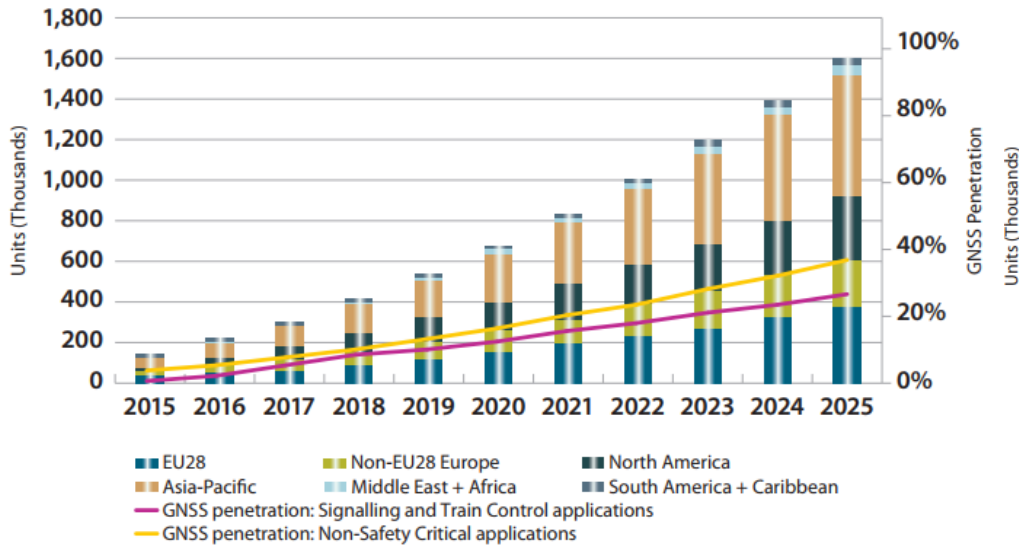




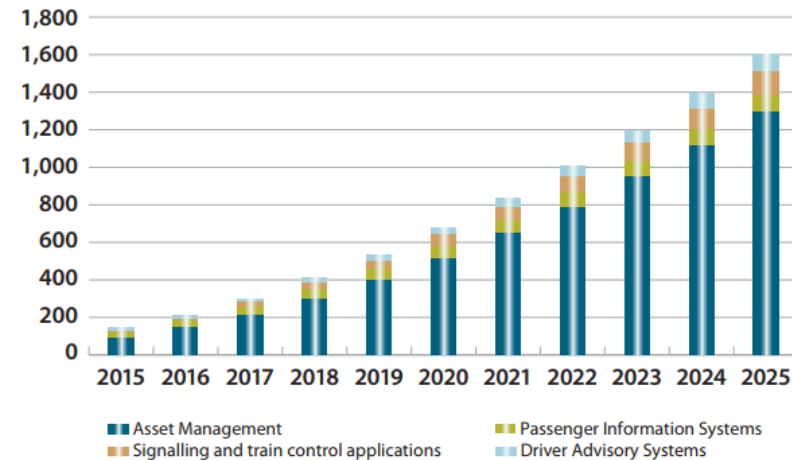
# GNSS will become a standard equipment within a decade



Installed base of GNSS devices by region



Installed base of GNSS devices by application



- Safety relevant applications based on GNSS will be increasingly developed
- High level of performance required
- GNSS could reduce infrastructure costs

# Agriculture applications/markets



**Precision agriculture** is the application of different technologies and solutions to manage the variability of agricultural production, in order to improve crop yield and reduce environmental impact. Key GNSS enabled applications include:

- **Farm machinery guidance** uses GNSS positioning to assist drivers in following the optimal path thanks to a digital display, thus minimising risks of overlaps.
- **Automatic steering** completely takes over steering of the farm equipment from the driver allowing the operator to engage in core agricultural tasks.
- **Variable rate application** combines GNSS positioning with information from other sensors and digital maps to distribute the right amount of agrichemicals.
- **Yield monitoring** enables site-specific monitoring of harvest, combining the output of a yield sensor with GNSS positioning of the harvester.
- **Biomass monitoring** enables site-specific monitoring of biomass in an agricultural field, providing up-to-date information on crop development.
- **Soil condition monitoring** enables updates of soil moisture levels, fertility or diseases to optimise their management. GNSS positioning and software applications identify the exact position of the soil samples sent to laboratories. Data from soil sampling is used in VRT application maps.
- **Livestock tracking and virtual fencing** use a GNSS-enabled portable equipment to track animals behaviour, leveraging tracking and virtual fencing.
- **Forest management** makes use of GNSS positioning for different forestry tasks such as identification and mapping of damage and areas under stress, location of clear-cut areas, sample plots and roads.

**Agri-logistic** applications help farmers to increase efficiency and to comply with number of regulations and new standards:

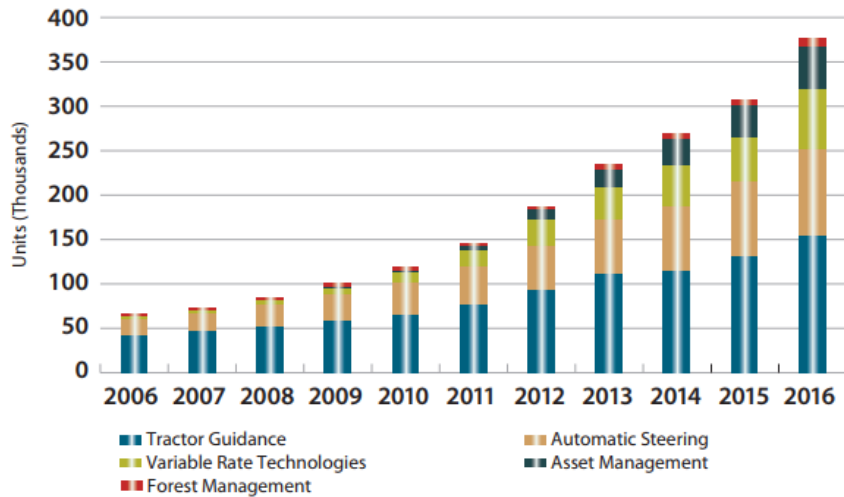
- **Farm machinery monitoring and asset management** use real-time GNSS information for monitoring the location and mechanical status of equipment and to manage work flows efficiently.
- **Geo-traceability** enhances the effectiveness of food, animal and product traceability by using transponders on animals and vehicle GNSS trackers, as well as by geo-referencing location and size of land parcels.
- **Field definition** is the activity of measuring precisely the boundaries and the size of agricultural fields. In the EU, GNSS-based operations using EGNOS and Galileo support a system of area-based subsidies for farmers within the Common Agricultural Policy (CAP).



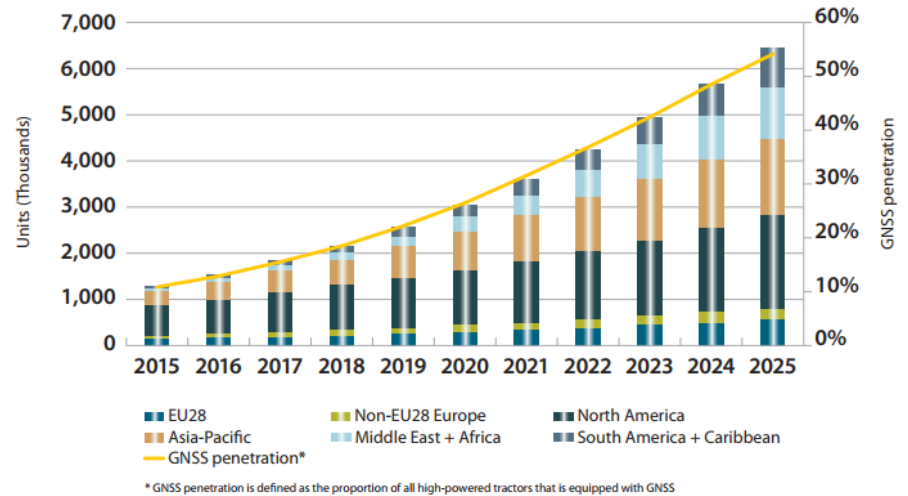
# Growth of emerging markets will further push adoption of GNSS



Shipments of GNSS devices by application



Installed base of GNSS devices by region



- Most of the applications require high accuracy services (not only SBAS, but DGNS and RTK and PPP)



# Agriculture likely to be one of the largest users of drone technology



## Benefits of use of drones in agriculture:

- ✓ Spotting yield-limiting problems
- ✓ Savings in time by covering the entire field faster
- ✓ Easy to use
- ✓ Human eye error removed
- ✓ Operational with clouds



## Applications in Land Surveying:

- **Cadastral surveying** aims at establishing property boundaries. Fiscal policies such as land taxation rely widely on cadastral surveying.
- **Construction surveying** covers the different construction stages of a building or civil engineering work, whereas machine control applications automate construction activities:
  - **Machine control** applications use GNSS positioning, for example to automatically control the blades and buckets of construction equipment based on information provided by 3D digital design.
  - **Person-based** applications involve topographic surveys for construction sites, checking levels, performing “as-built” checks or stake out reference points and markers.
- **Mapping:** GNSS is used to define specific location points of interest for cartographic, environmental and urban planning purposes.
- **Mine Surveying:** mine surveying involves measurements and calculations at each stage of mine exploitation, including safety check.
- **Infrastructure Monitoring:** GNSS is used to monitor critical infrastructure and the natural environment to prevent major disaster and promptly intervene in case of emergency.

## Applications in Marine Surveying:

- **Marine surveying:** encompasses a wide range of activities (seabed exploration, tide and current estimation, offshore surveying, etc.), and their outcomes are important for maritime navigation.

# New and emerging GNSS applications and market trends



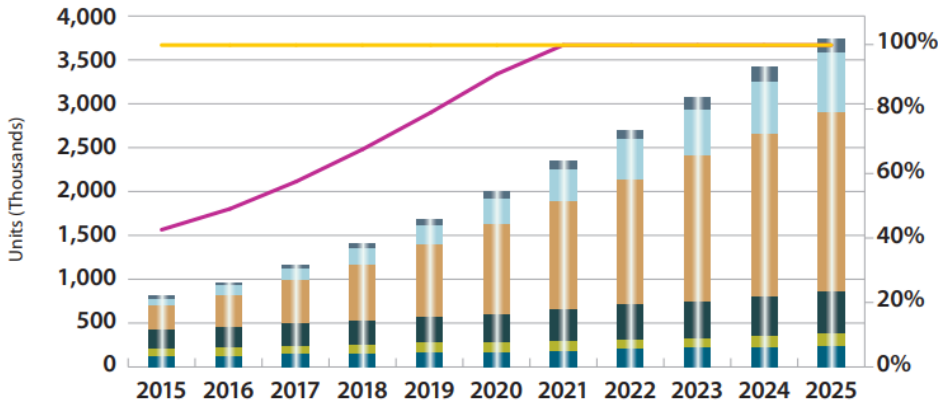
<p><b>Democratisation of mapping GNSS devices</b></p>	<p>The reduction of GNSS receiver prices and the increase in the level of accuracy are transforming mapping into a more accessible activity. In particular, making accurate measurements easier to perform leads the market of positioning devices to the multiplication of integrated, highly performing and easy-to-use tools for an increasing range of positioning applications. Today GNSS receivers are more compact, reliable, highly performant and yet affordable thanks to modularisation. This trend is also prompting the collection of crowdsourcing data.</p>
<p><b>Crowdsourcing data</b></p>	<p>Simply using smartphones or any GNSS portable devices, combined with simultaneous localisation and mapping (SLAM) technologies, users become data collectors for mapping activities, especially in urban areas. Crowdsourcing data allows for the mapping of places rather than spaces. Moreover, the crowdsourced satellite signal-to-noise ratio (SNR) measurements can improve GNSS accuracy in urban environments. This massive data collection is expected to change the paradigm of the mapping profession and is enhanced by the democratisation of GNSS mapping devices.</p>
<p><b>Smart cities</b></p>	<p>A Smart City is an urban development meant to improve quality of life increasing the efficiency of services and better meeting residents' needs. Different techniques such as EO images combined with EGNSS positioning data, integrated by crowdsourced data and augmented reality can serve this purpose. EGNSS plays a key role also in tracking citizens' mobility, mapping infrastructures, improving waste management, optimising public transport flows or implementing smart port management system.</p>
<p><b>Uptake of PPP</b></p>	<p>Users are increasingly seeking high-accuracy and easy to use GNSS solutions with good coverage, and therefore the Precise Point Positioning (PPP) is gaining more surveying users. Major players are offering affordable and user-friendly PPP solutions, providing centimetre level accuracy worldwide, covering also oceans, with no distance limit from the reference stations, with a minimal network infrastructure. These advantages are boosting the uptake of PPP in land and marine construction and mapping.</p>



# Construction activities in Asia-Pacific and North America will drive GNSS growth



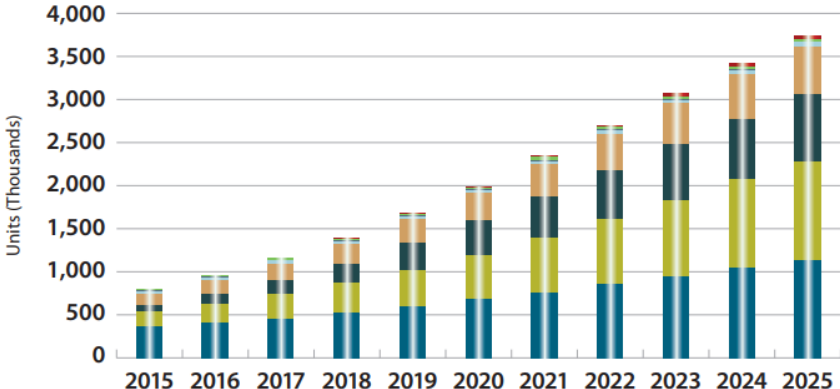
Installed base of GNSS devices by region



- EU28
- Asia-Pacific
- Non-EU28 Europe
- Middle East + Africa
- North America
- South America + Caribbean
- GNSS penetration: Land surveying
- GNSS penetration: Marine surveying

\* GNSS penetration is defined as the proportion of all potential users that use GNSS

Installed base of GNSS devices by application



- Cadastral Surveying
- Construction Surveying: Machine control
- Construction Surveying: Person based
- Mapping
- Mine Surveying
- Marine Surveying
- Infrastructure monitoring
- RTK Networks

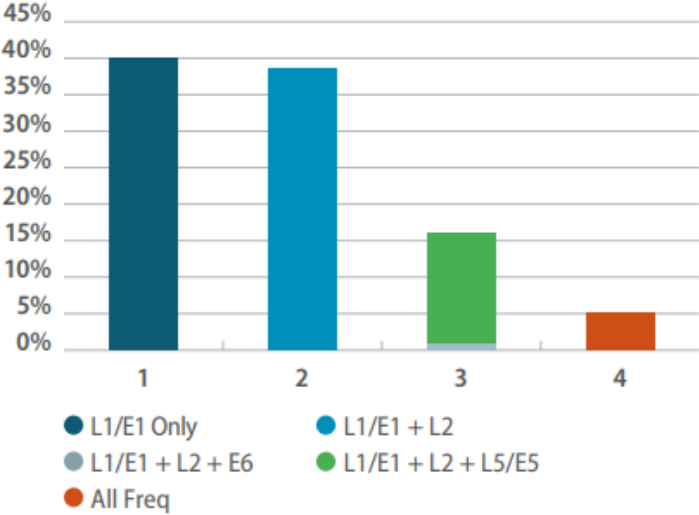
- Together with Agriculture, Surveying is the main adopter of the new techniques and high accuracy as possible



# Multi-constellation and multi-frequency a common feature

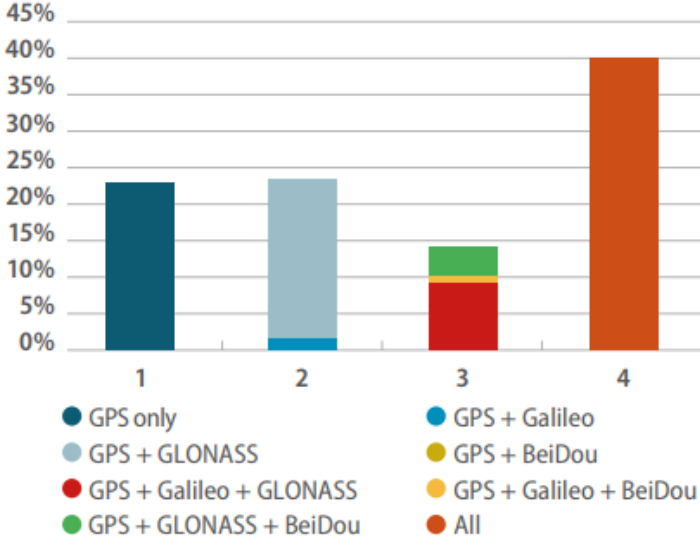


Supported frequencies by GNSS receivers<sup>3</sup>



<sup>3</sup> shows the percentage of receivers capable of tracking 1, 2, 3 or all the 4 frequencies

Supported constellations by GNSS receivers<sup>4</sup>



<sup>4</sup> shows the percentage of receivers capable of tracking 1, 2, 3 or all the 4 GNSS constellations

## Timing & Sync.

# GNSS is used in Time and Synchronization applications



- **Timing:** GNSS provides direct and accurate access to Coordinated Universal Time (UTC)
- **Synchronisation:** Synchronisation between receivers at different locations can be established and maintained using GNSS reference time. In addition, a master clock synchronises itself using the time provided by GNSS, redistributing this time to the slave clocks disseminated within the systems

Precise T&S is crucial for **Critical Infrastructure (CI)**, an asset essential for maintaining vital societal functions related to health, safety, security and social well-being of people in the following domains:



**Telecommunication** uses the GNSS timing function for handover between base stations in wireless communications, time slot management purposes and event logging. The main applications are: **Satellite Communication (SATCOM)**, **Professional Mobile Radio (PMR)**, **Digital Cellular Network**, **Public Switched Telephone Network (PSTN)** and **Small Cells**



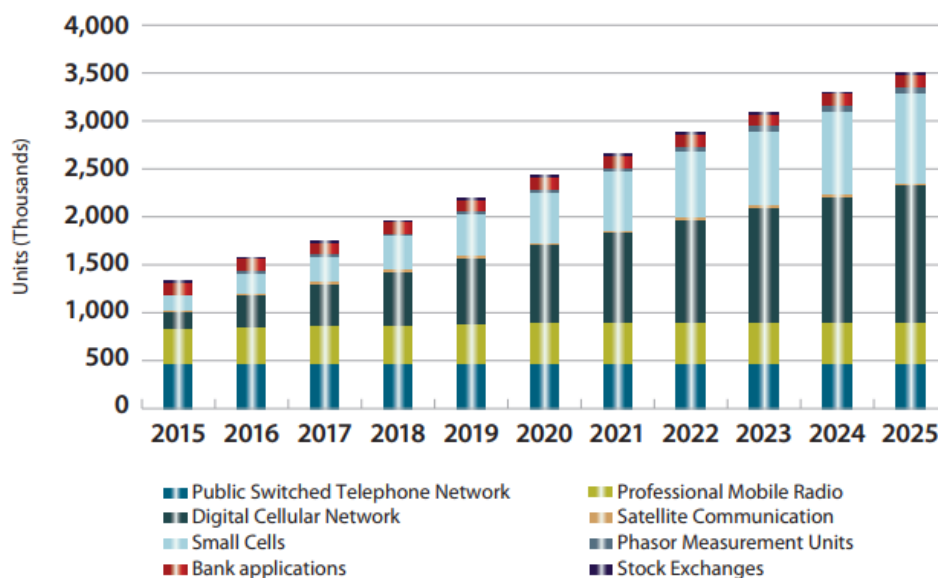
**Energy** including power transmission, uses GNSS timing in systems providing frequent measurements relevant to the network status and to determine the location of faults along a transmission line by means of a **Phasor Measurement Unit (PMU)**



**Finance** (i.e. Banks and Stock Exchanges) uses GNSS to **timestamp financial transactions**, allowing tracing of causal relationships and synchronizing financial computer systems. The main applications are financial transaction timestamps

- The Timing capability offered by satellite navigation systems is at the core of most vital infrastructures: telecom networks operation, energy distribution, financial transactions, TV broadcast are some examples of areas where GNSS is used for timing or synchronisation purposes.
- GNSS provides a unique offering to the T&S user communities by delivering a free, stable and very accurate time and frequency source available worldwide.
- Expansion of telecom networks (e.g. Small Cells, 4G) makes GNSS more and more essential, driving future shipments.
- The T&S community is facing many challenges linked to an increased need for resilience, reliability and security, supported by an evolution of the regulation.

Installed base of GNSS devices by application



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R&D funding  
opportunities



# GNSS support innovation across major technology developments



<b>Internet of Things (IoT)</b>		<p>A major development in the role of the internet, the IoT allows physical devices, vehicles, buildings and other objects to be <b>interconnected</b> and <b>controlled remotely</b> across network infrastructures.</p> <p>IoT is relying on a wide range of <b>different sensors</b> and technologies, one of them being <b>GNSS</b> which provides <b>localisation</b> and <b>timing information</b>.</p>
<b>Big Data</b>		<p>With traditional data processing unable to deal with the skyrocketing volumes of data that are produced every single day, <b>complex systems</b> are being created to allow for <b>big data processing</b>.</p> <p>GNSS is a major data source providing <b>location</b> and <b>timing information</b> to the world of Big Data. The proliferation of GNSS devices is boosting the quantity of location and timing data.</p>
<b>mHealth</b>		<p><b>Mobile Health (mHealth)</b> is a sub-segment of eHealth and covers medical and public health practice supported by mobile devices.</p> <p>Key mHealth application categories include <b>disability assistance</b>, <b>preventive medicine</b> and <b>emergency</b>, and leverage fusion of big data with GNSS.</p>
<b>Augmented Reality (AR)</b>		<p><b>AR</b> integrates <b>digital information</b> with the user's <b>environment</b>. Unlike virtual reality, which creates a totally artificial environment, AR uses the existing environment and overlays new information on top.</p> <p><b>GNSS</b> provides a globally available source of georeferenced information that <b>brings augmented reality into the open</b>. GNSS allows the creation of a direct link between the surrounding reality and digital objects.</p>
<b>Smart Cities</b>		<p><b>Smart Cities</b> feature an integrated system for collecting, measuring, collating and broadcasting city data and for making it easily <b>accessible</b> to citizens, municipalities and city planners.</p> <p>GNSS is one of the key technologies used within <b>infrastructure design</b> and <b>mobility</b> of smart cities, offering numerous opportunities to <b>citizens</b>, <b>local governments</b> and <b>city planners</b> alike.</p>
<b>Multimodal Logistics</b>		<p>Multimodal logistics refers to the transport of goods by at least two different modes of transport in the framework of a single multimodal transport contract.</p> <p>Logistics service providers draw on GNSS for <b>efficiency</b>, <b>security</b> and <b>safety</b>. GNSS contributes to the monitoring of <b>cargo</b> along the entire supply chain and enables pivotal <b>asset management</b> applications.</p>

© All images Getty Images

# Application areas driving the PNT requirements: Autonomous vehicles



Audi and Italdesign presenting Pop.Up in 2018



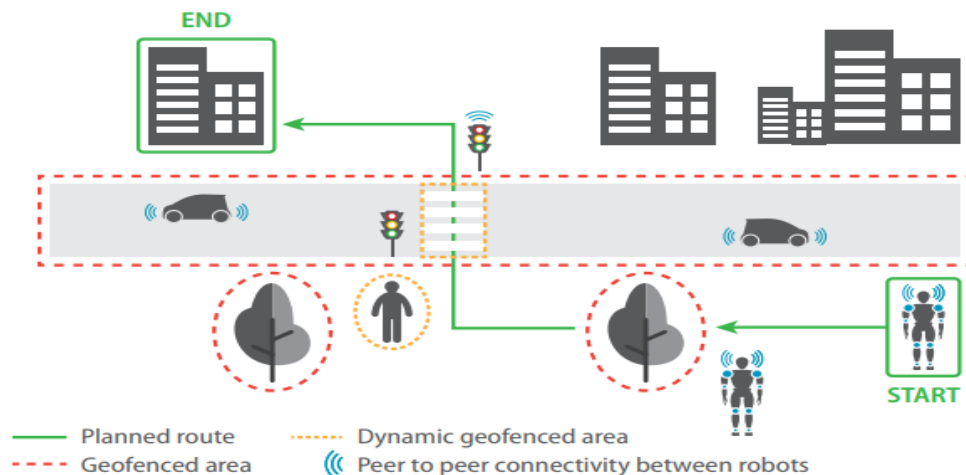
NEXT self-driving pods – live tested in Dubai 2018

Above innovations are not possible without high precision positioning and navigation:

- management of autonomous fleet
- navigation to customer and to destination
- precise “docking” of drones on the vehicles and merging of pods

# Application areas driving the PNT requirements: Autonomous robots

- ✓ Real world objects and their position in relation to the robot need to be understood with a high degree of precision
- ✓ To mitigate the risk of a robot entering an area it should not, GNSS-based geofencing is being increasingly utilised thanks to its accuracy and availability



# Application areas driving the PNT requirements: Drones/UAVs



Challenges for the drone market:

- ✓ Precise and reliable tracking information
- ✓ Diverse connectivity requirements
- ✓ Hybridisation of various data sources
- ✓ Harmonisation of regulation

## Urban environment

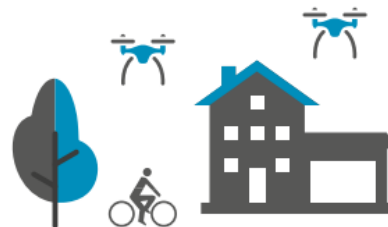


**GNSS:** Centimetre level accuracy, high update rate  
**Connectivity:** High bandwidth important, range might be compromised

Example technology requirements:

Dual-frequency GNSS, differential GNSS, 5G

## Suburban environment



Dual-frequency GNSS, 5G, Satcom

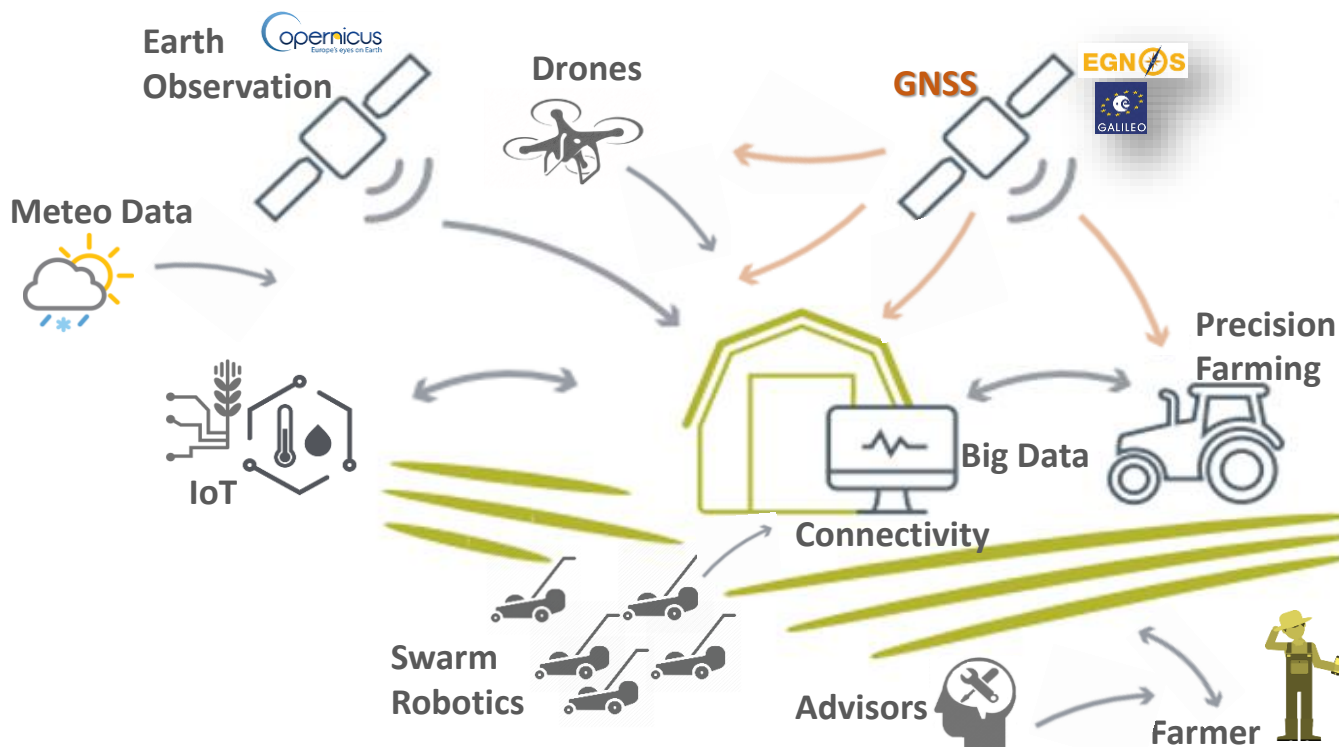
## Rural environment



**GNSS:** Metre level accuracy, update rate can be compromised  
**Connectivity:** Long range connectivity, bandwidth might be compromised

Low cost GNSS, Satcom, ADS-B

# Application areas driving the PNT requirements: Farming of the future - The autonomous Farm



## GNSS is used for:

- Navigating autonomous tractors/harvesters
- Positioning of drones
- Navigation of swarm robots
- Geotagging of earth observation data
- Positioning of assets on the farm
- Geotraceability of agriculture products

# Application areas driving the PNT requirements: Augmented Reality (AR)



## The use of AR in high precision market includes:

### City Planning:

- ✓ In-situ design

### Construction:

- ✓ Showcase projects
- ✓ Control progress of work and anticipate problems

### Mining:

- ✓ Definition of mining area
- ✓ Assessment of environmental licensing scenarios

## In mass market AR is used by a large number of applications for:

- ✓ Image recognition
- ✓ Overlay basic information on outdoor locations



GNSS receivers already meet the key performance parameters required to enable AR: Accuracy and Availability

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# Funding programme available to support innovation around GNSS



Opening:  
16 October 2018

Deadline:  
05 March 2019

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

**20 €mln is the budget dedicated to EGNSS applications and products in the 4<sup>th</sup> H2020 call**

The call is divided into four topics :

- ✓ Green, safe and smart mobility
- ✓ Digitisation
- ✓ Societal resilience and environment
- ✓ Awareness raising and capacity building

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

Check eligibility for funding at:

[http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-a-countries-rules\\_en.pdf](http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-a-countries-rules_en.pdf)



# Linking space to user needs



How to get in touch:



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



[EGNOS-portal.eu](http://EGNOS-portal.eu)



[GSC-europa.eu](http://GSC-europa.eu)



[UseGalileo.eu](http://UseGalileo.eu)



The European GNSS Agency is hiring!

**Apply today** and help shape the future of satellite navigation!