European GNSS Agency

Where (exactly) are my things? Learn how Galileo can empower your IoT solution

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November 2018

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
  - United Kingdom

Galileo and EGNOS are the European GNSS programmes

European GNSS (EGNSS) location and timing

- **Worldwide GNSS system "made in EU"**
- Delivering free of charge Open service and High accuracy service
- 26 satellites already launched
- Initial Service Capability declared in 2016 and Full Operational Capability planned in 2020

- **Regional Satellite Based Augmentation System**
- Improves GNSS performance by providing improved accuracy and integrity
- European coverage
- Fully operational, free of charge and widely used in Europe since 2011

The Galileo implementation plan accelerates with Initial Services in 2016 and Enhanced Services in 2019

Last Galileo launch:
25th of July 2018
4 satellites launched in an Ariane 5 launcher from Kourou

Galileo is implemented in a step-wise approach

- **26 satellites** have been launched
- **4 satellites** are in production/being procured:
  - The remaining ones by 2020

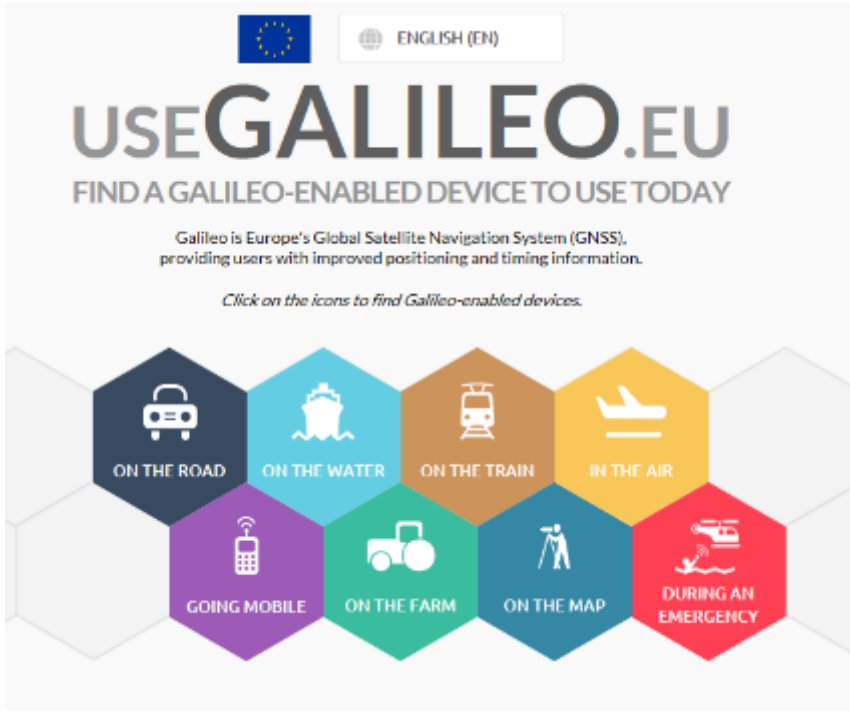
2016 — **Initial Operational Capability**
Initial services for Open Service (OS)

2019
Search and Rescue Service (SAR)
Public Regulated Service (PRS)
and demonstrator for High accuracy Service (HAS)

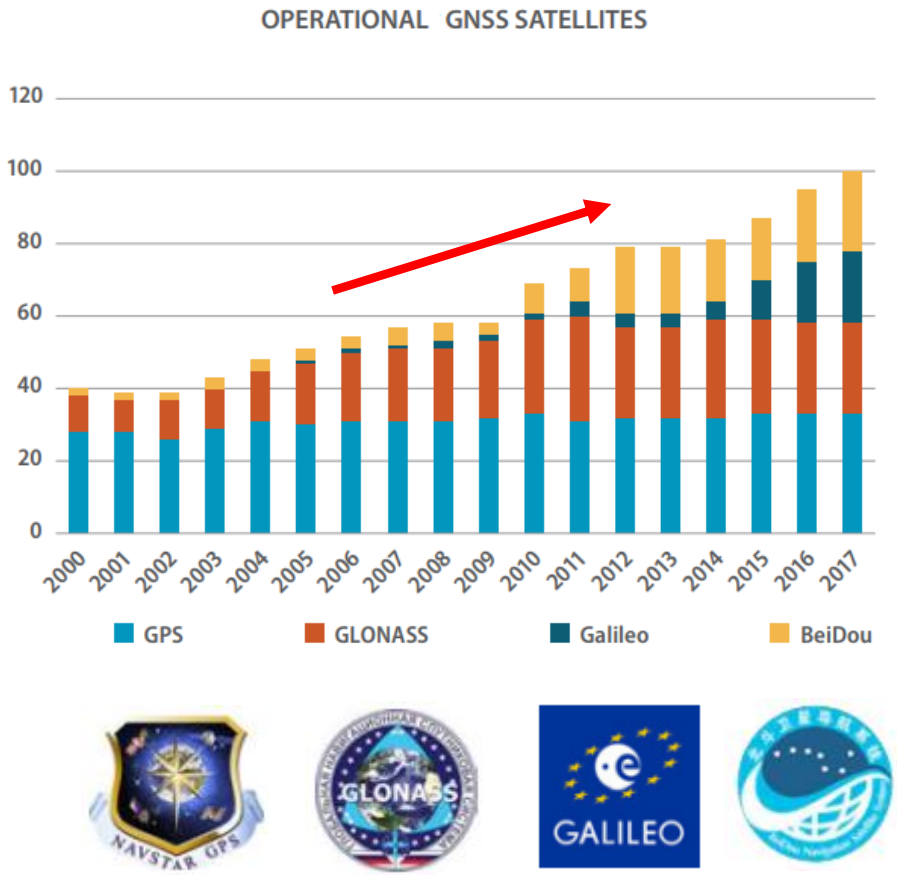
2019
Test signal for
OS Navigation Message Authentication
(OS-NMA) and High Accuracy (HA)

2020 — **Full Operational Capability**
Full services, 30 satellites
An independent civilian infrastructure

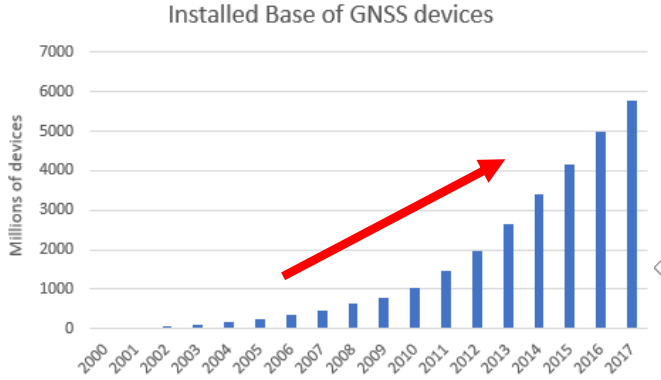
Galileo is used today in professional and consumer devices, including IoT chipset platforms



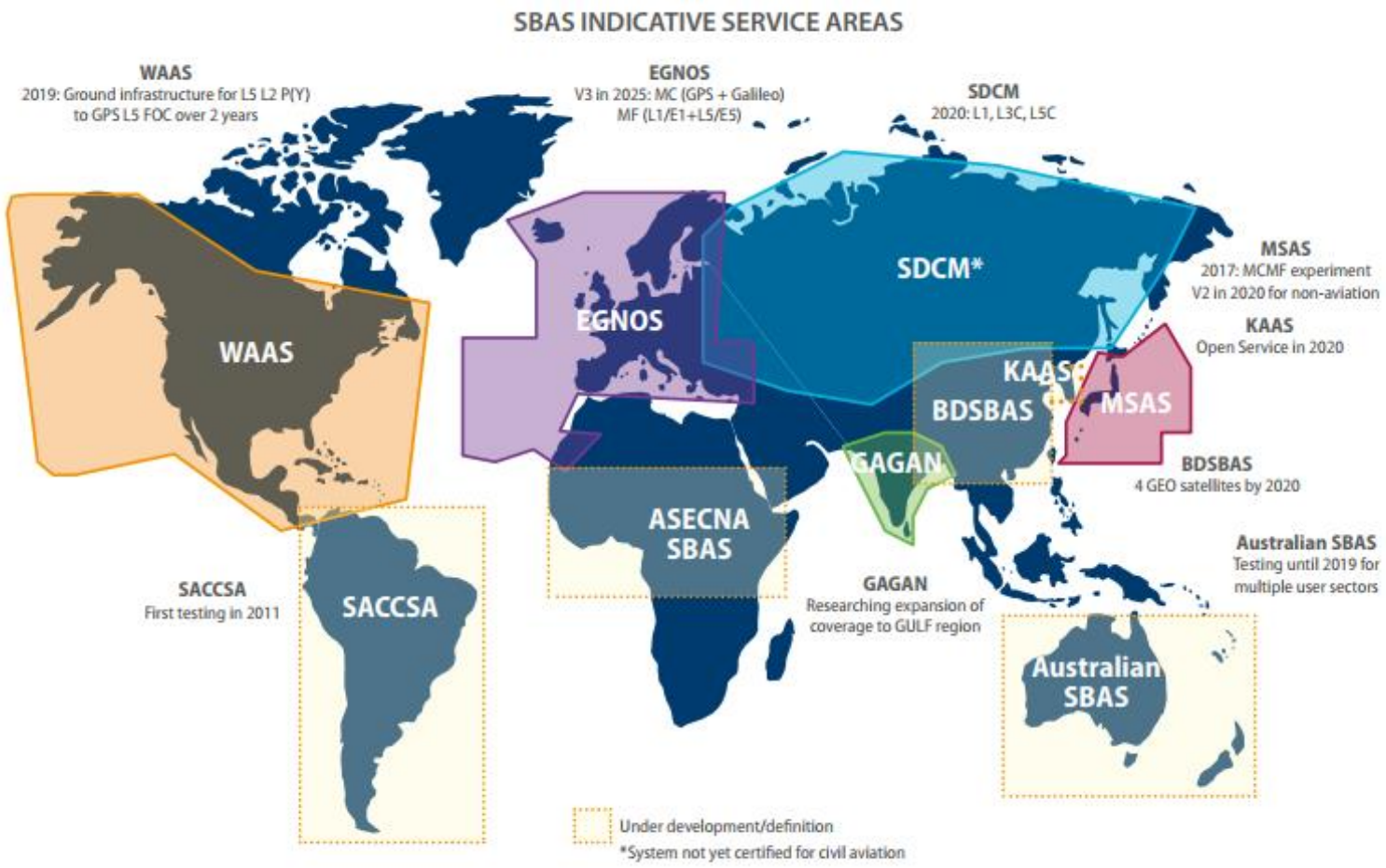
The continuous evolution of GNSS infrastructure responds to the increasing user demand



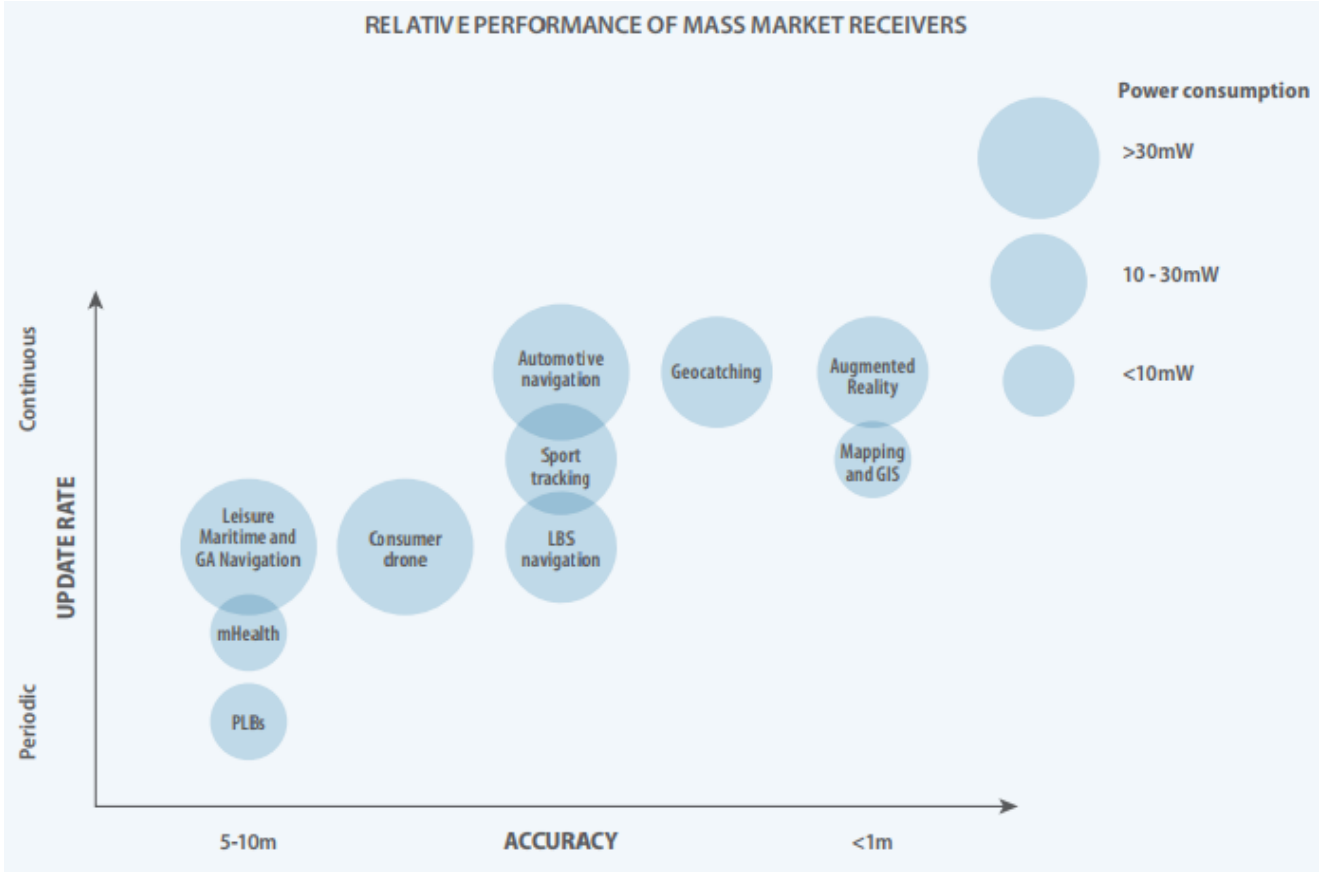
All global and regional GNSS constellations are developing, modernising and innovating, with more than 100 GNSS satellites now available



In addition to the global services, the SBAS coverage is increasing

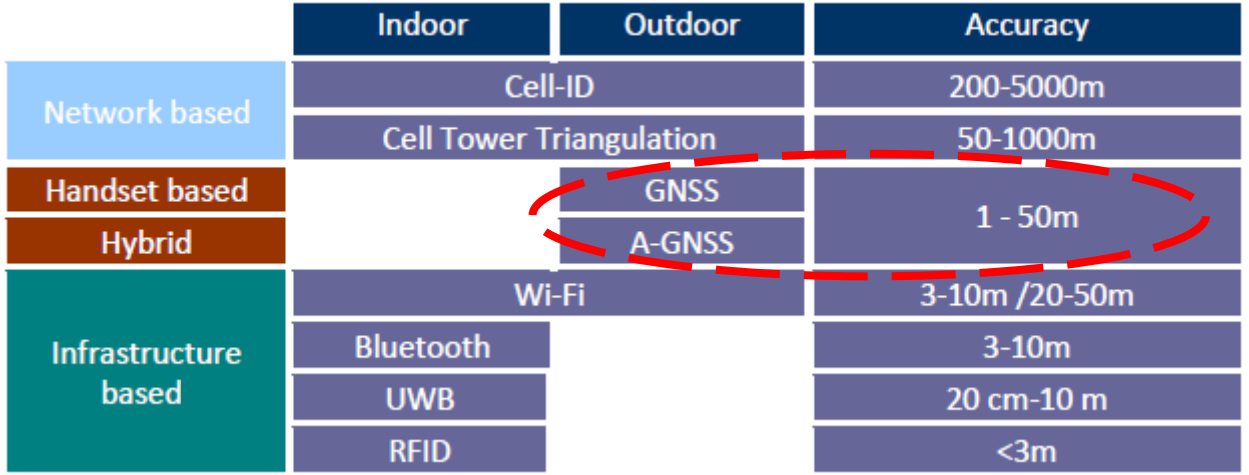


The users requirements for positioning differ significantly by application area



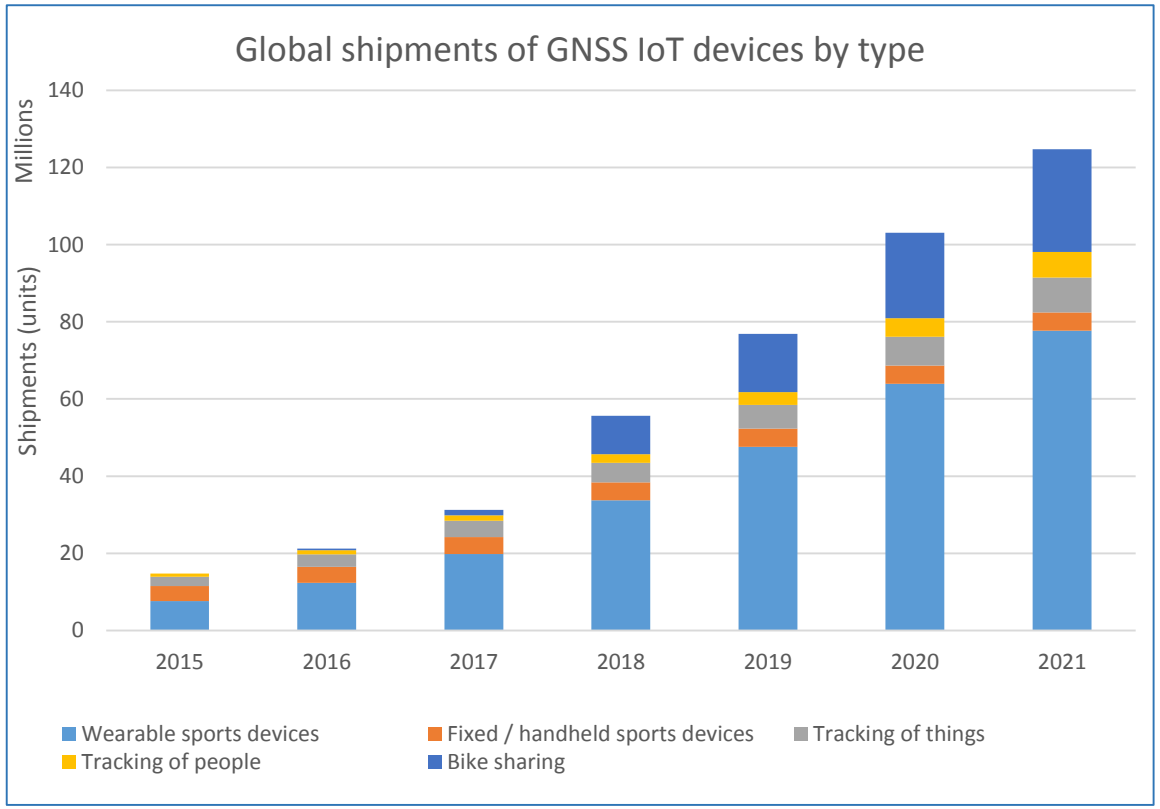
Several technologies can provide positioning capabilities relevant to locate “things”

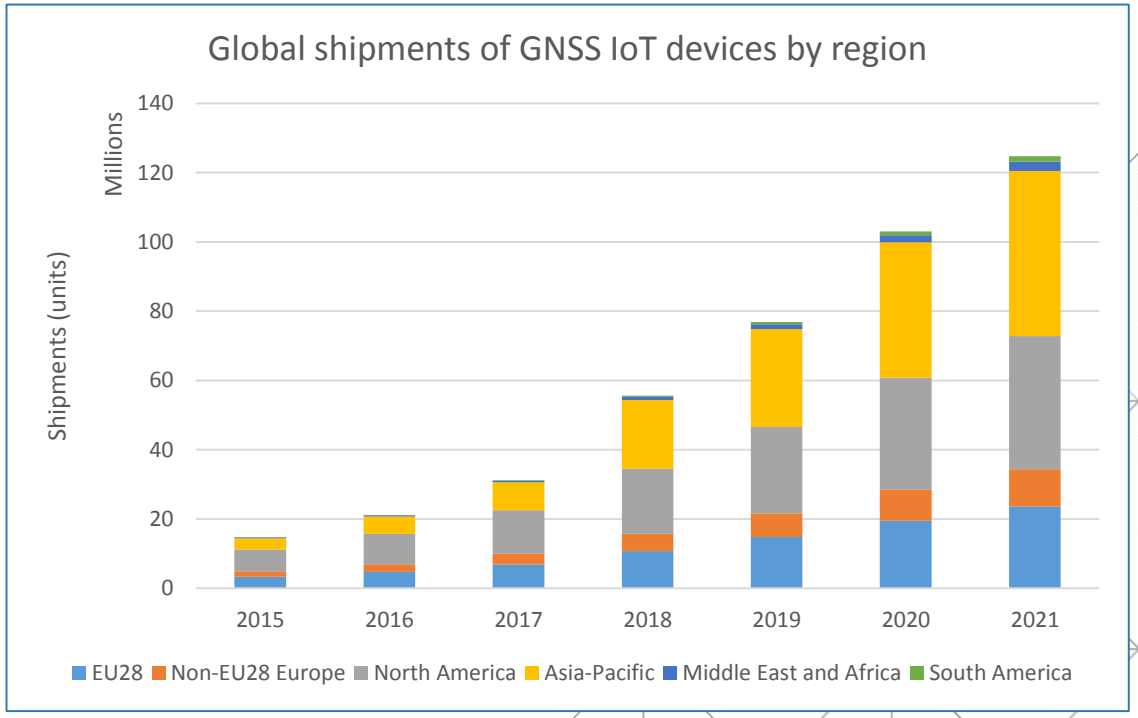
Main absolute positioning technologies and accuracy



- **Network based**: (Cell-ID, E-OTD, TDOA etc.) using the telecommunication networks
- **Handset based**: (GNSS) the handset itself is the primary means of positioning the user. The A-GNSS corresponds to a hybrid technology based on the GNSS but using the cellular network
- **Infrastructure based**: (Bluetooth, UWB, Wi-Fi or RFID) the position is computed by evaluating of the distance between the device and transmitters (for example a Bluetooth beacon or a Wi-FI router)

GNSS in IoT: the use today and in near future



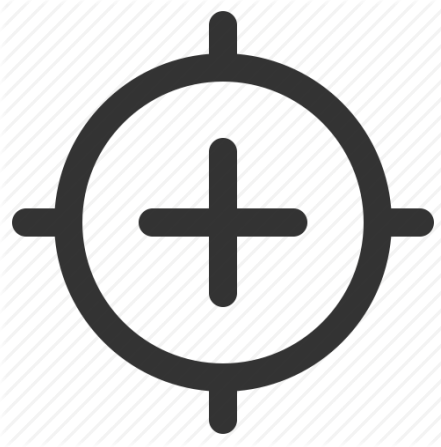


The demand for better location performance is driving the evolution of GNSS technology along three main areas

Ubiquity

As PNT applications continue to expand in consumer and commercial segments, demand is also growing for uninterrupted, ubiquitous, and seamless access to position information

Accuracy



The development of new semi-professional applications supported by mobile devices is pulling the demand for increased location accuracy

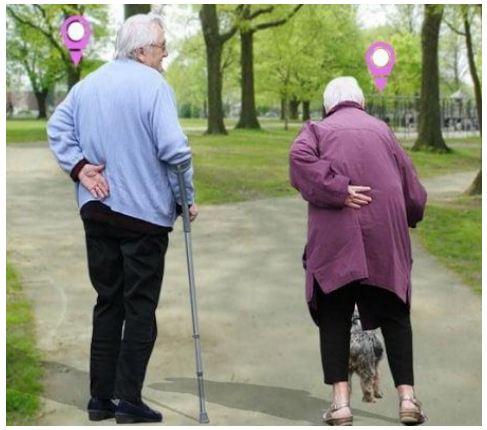
Security

Addressing jamming and spoofing is key especially where PNT is at the core of safety-critical or commercially sensitive applications

Ubiquity High availability of location information is increasingly demanded by IoT applications

Floating sharing

Autonomous robots



Elderly people monitoring

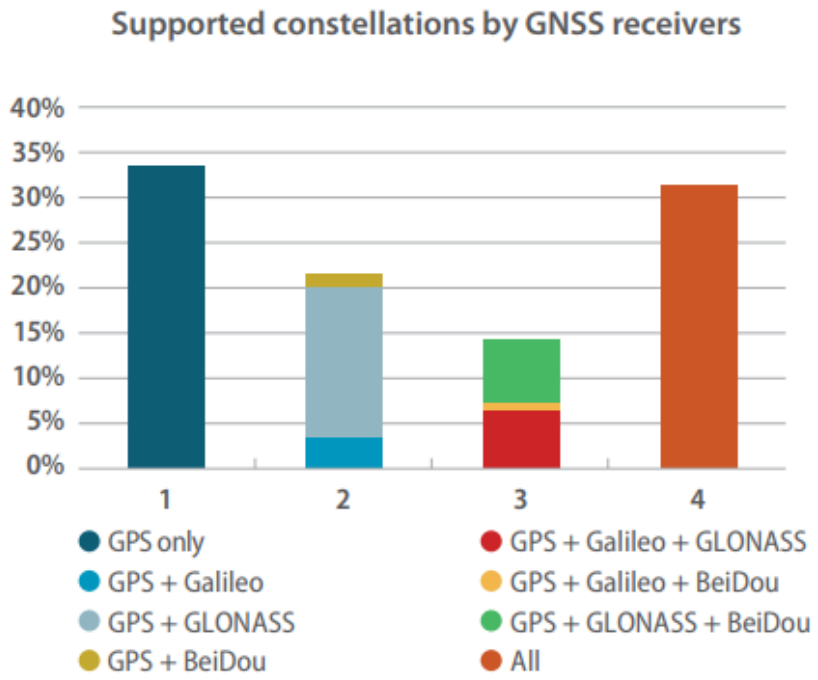
Lone worker protection

Law enforcement

Ubiquity

What works best in geolocation?

Multi-constellation for better availability



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Multi – constellation is already widely used in many applications

The most popular way to provide multi-constellation support is to cover all constellations, which represents over 30% of receivers

Main benefits include:

- ✓ Increased availability
- ✓ Increased accuracy
- ✓ Improved robustness

Accuracy

Emerging applications are more and more demanding in terms of accuracy

Augmented reality

Self-driving cars

Drones

mHealth

Autonomous robots

Smart farming

Accuracy

Augmented Reality (AR) adds value both to high precision and mass market applications

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

Accuracy

Autonomous vehicles drive the accuracy and robustness requirements

Audi and Italdesign presenting Pop.Up in 2018

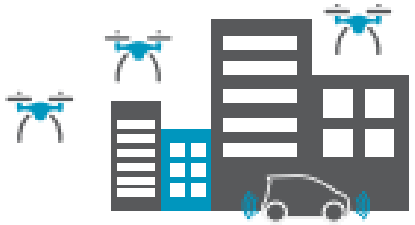
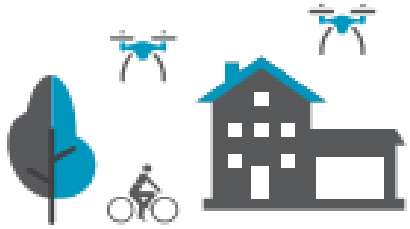
NEXT self-driving pods – live tested in Dubai 2018

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

Accuracy Positioning is among the challenges that the drone market has to address to develop to its full potential

Challenges for the drone market:

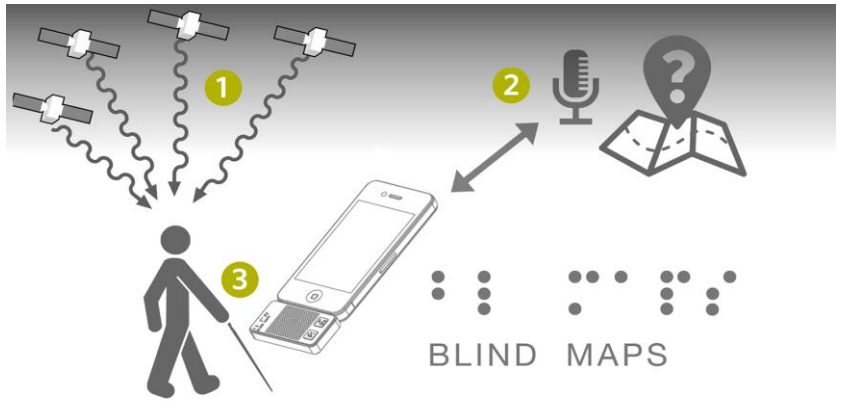
- ✓ Precise and reliable tracking information
- ✓ Diverse connectivity requirements
- ✓ Hybridisation of various data sources
- ✓ Harmonisation of regulation

Urban environment	Suburban environment	Rural environment
		
GNSS: Centimetre level accuracy, high update rate **Connectivity:** High bandwidth important, range might be compromised		**GNSS:** Metre level accuracy, update rate can be compromised **Connectivity:** Long range connectivity, bandwidth might be compromised
Example technology requirements:		
Dual-frequency GNSS, differencial GNSS, 5G	Dual-frequency GNSS, 5G, Satcom	Low cost GNSS, Satcom, ADS-B

Accuracy

Many mHealth applications rely on GNSS, some of them with high accuracy needs

Mobile Health (mHealth) is a sub-segment of eHealth and covers medical and public health practice supported by mobile devices



Main mHealth application categories leverage fusion of big data with GNSS:

Disability assistance:
- ✓ Navigation solutions for the blind
- ✓ Navigation solutions for upper/lower body-impaired individuals
- ✓ Tracking of Alzheimer patients

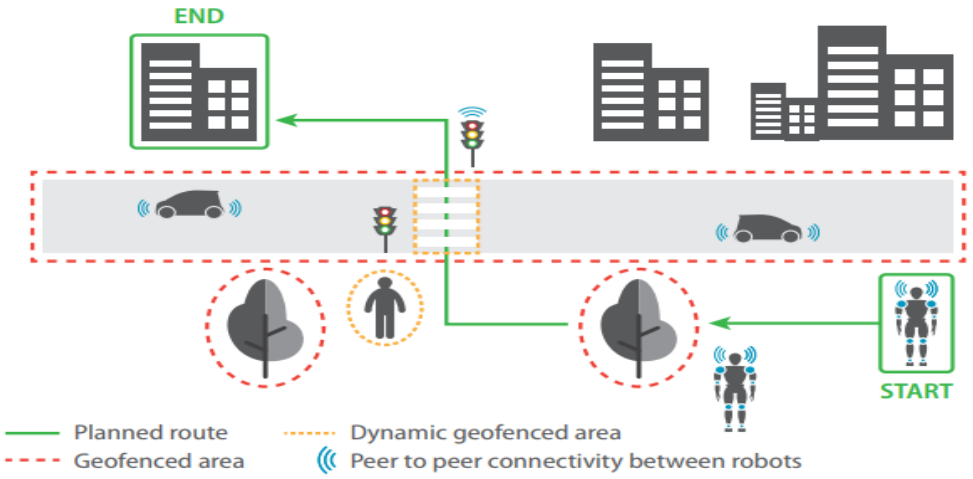
Well-being:
- ✓ Wearable tracking devices for leisure purposes
- ✓ Wearable tracking devices for professional sports

Emergency:
- ✓ Personal location beacons for Search and Rescue (SAR)
- ✓ Disaster management smartphone-based applications

Accuracy

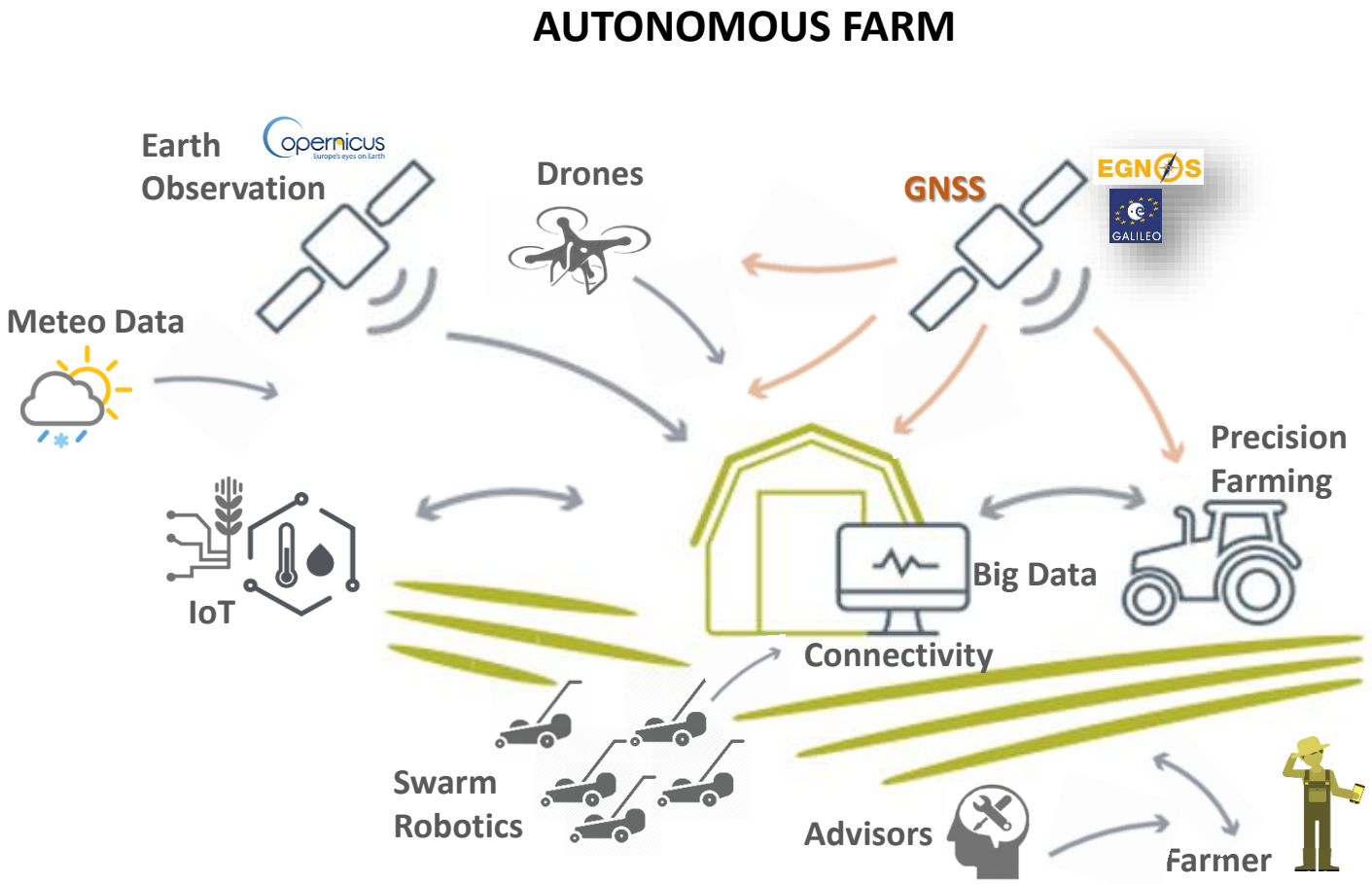
Autonomous robots require high levels of precision to navigate

- ✓ 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



Accuracy

GNSS is at the core of main Smart Farming applications requiring high precision



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

Accuracy

What works best in geolocation?

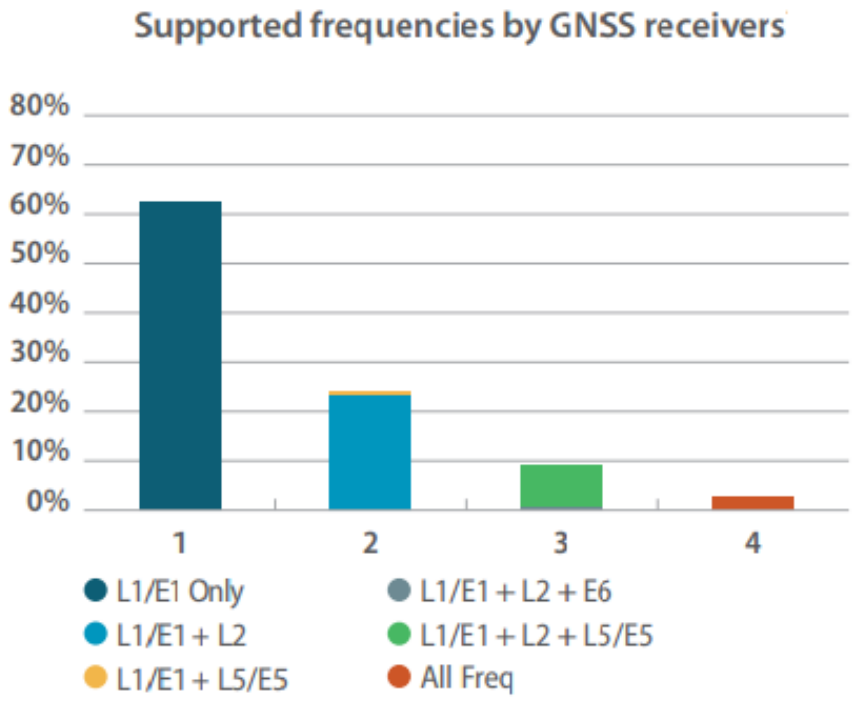
Multi-frequency for better accuracy and robustness

Receivers beyond traditional high-precision applications are also demanding performance that can best be supported by multi-frequency

This has resulted in a drop of nearly 10% in the production of receivers that are single-frequency only, over the last two years

Main benefits include:

- ✓ Increased accuracy
- ✓ Improved robustness



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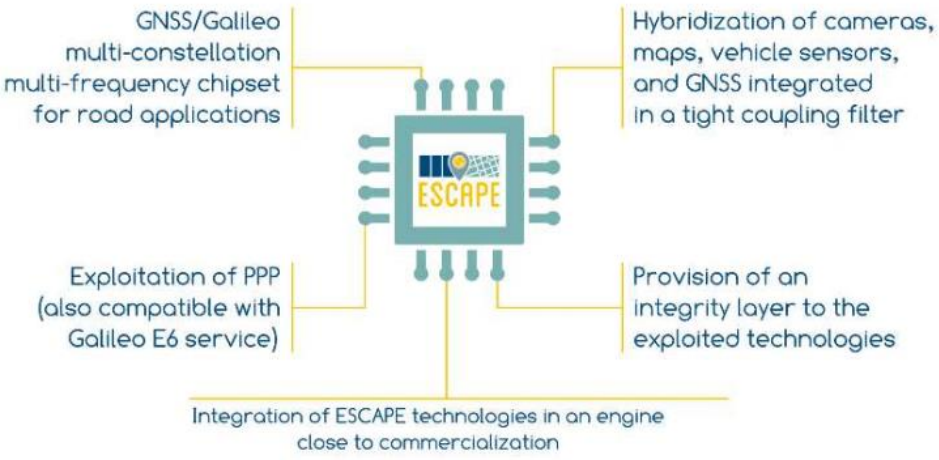
Accuracy Dual-frequency entered mass market addressing consumer demand for accuracy

First dual frequency phone was launched in May 2018

Providing enhanced performance, the Mi 8 offers users better positioning in urban environments

Xiaomi Mi8
Powered by Broadcom 4775
Dual frequency E1/L1 and E5/L5

Dual frequency enters the functional safety automotive grade receivers



GSA funded project ESCAPE develops the highly automated positioning engine

Accuracy

Why E5/L5 is the best second frequency of choice for your solution?

- Wide band signal providing increased **accuracy**
- Exceptional resistance to **multipath**
- In combination with E1 providing **iono-free** solution
- All constellations support this frequency, the number of available signals will grow rapidly
- E1/E5 combination is recognized in **all segments,** professional, automotive and also mass market

Future GNSS/RNSS common frequencies, showing the potential of E5a/L5 and of E1/L1 combination

	L5 / L5OC / E5a / B2a	L2 / L2C / L2OC	E6 / LEX	L1 / L1OC / E1 / B1
GPS	30	30		30
GLONASS	24	24		24
Galileo	30		30	30
BeiDou	35		35	35
QZSS	3	3	3	3
IRNSS	7			
	129	←	ARNS* Bands	→ 122

Frequency band used by the system, with N = number of satellites

Frequency band not used by the system

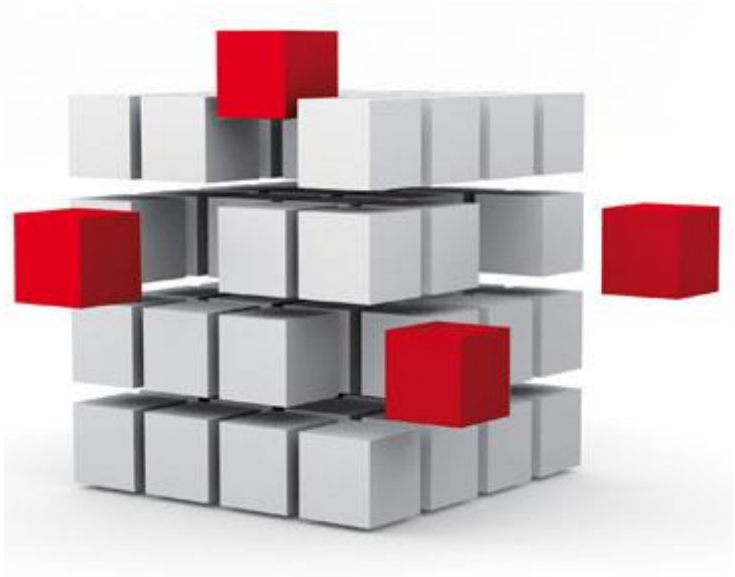
** ARNS = Aeronautical Radio Navigation Service: Frequency bands allocated worldwide to GNSS on a primary basis, granting a better protection against interference*

Accuracy

Galileo can further contribute to IoT with its innovative High Accuracy Service

High Accuracy

- Based on PPP transmission in E6B
- FREE provision



Characteristics

- User positioning accuracy with **decimeter level error** (*≈20cm*)
- **No need of additional** ground communication **channel** (*448 bps allocated on Galileo E6B*)
- **No need of proximity to base stations** to access corrections (*as opposite to RTK*)
- **Triple frequency** to further **increase accuracy** and **reduce** PPP **convergence time**
- Improved line-of-sight and **better coverage** at high latitudes

Security

Authentication of position is expected to reduce the associated spoofing and jamming risk in many application categories

Road
(AD, PAYD, RUC)

Logistics
(proof of delivery)

Mobile
payments

Timing &
Synchronisation

Commercial Marine

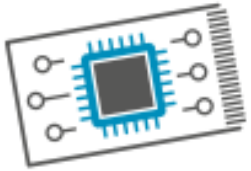
Augmented Reality

Drones

Security

Spoofing, the emerging threat

GNSS SPOOFING CAPABLE DEVICES EVOLUTION COST



1989	2009	2013	2014	2016	2018
First commercial GPS simulator: STR2740 simulator	First low cost record, replay and GPS simulation	BladeRF SDR board able to simulate GNSS signal	HackRF one SDR board	LimeSDR-mini	A USB3 to VGA adapter able to replay GNSS signal
150,000 €	6,000 €	650 €	300 €	99 €	5 €

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Security

OS-NMA, the unique Galileo Authentication feature will bring more benefits to IoT

Authentication

- **Data level**: Navigation Message Authentication
  Integrated in the E1-B band for OS. Aimed at consumer users and offered for free. Already prototyped and under testing

"Navigation Message Authentication" is defined as the ability of the system to guarantee to the users that they are utilising **non-counterfeit navigation data** that comes from the Galileo satellites and not from any other (potentially malicious) source

Characteristics

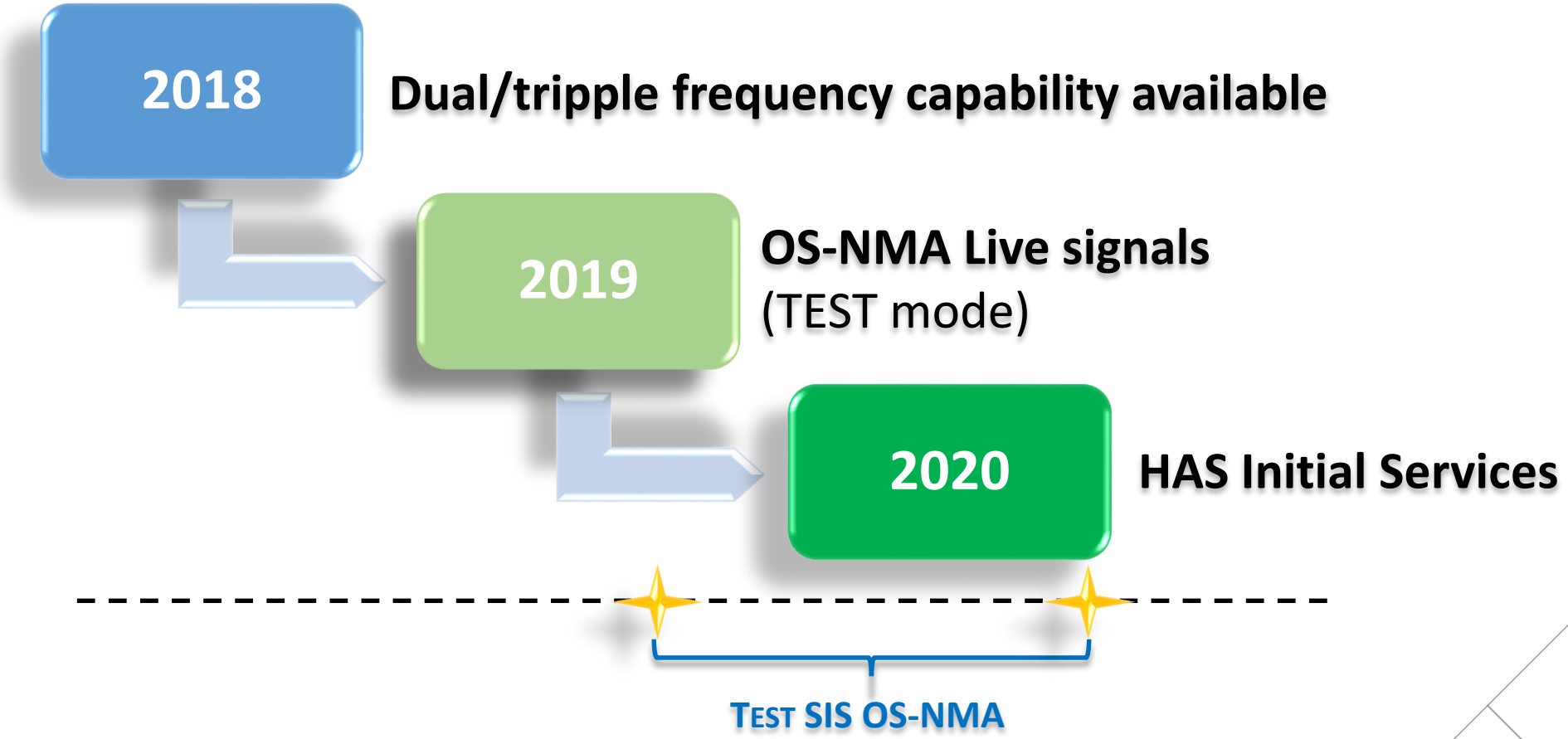
- Contributes to **mitigate** a well known **GNSS vulnerability** (spoofing)
- Clear **differentiator w.r.t. other GNSS** available to the civil community
- Fully **backward compatible.** Does not affect users not interested
- Disseminated on the first Galileo frequency (**E1B**)
- **Open access:** asymmetric cryptography. No need to store secret keys in the Rx, just public key
- Long-term **cryptographically secure**

Security

OS-NMA is being prototyped

- Autonomous Driving positioning engine for vehicles (ESCAPE)
- Smart Tachograph OS-NMA enabled user terminal (PATROL)
- Autonomous driving positioning engine for trucks (ProPART)
- Professional grade GNSS technology (FANTASTIC)

Gradual implementation of Galileo new features



Internet of Things segmentation (from GNSS provider perspective)

HIGH END

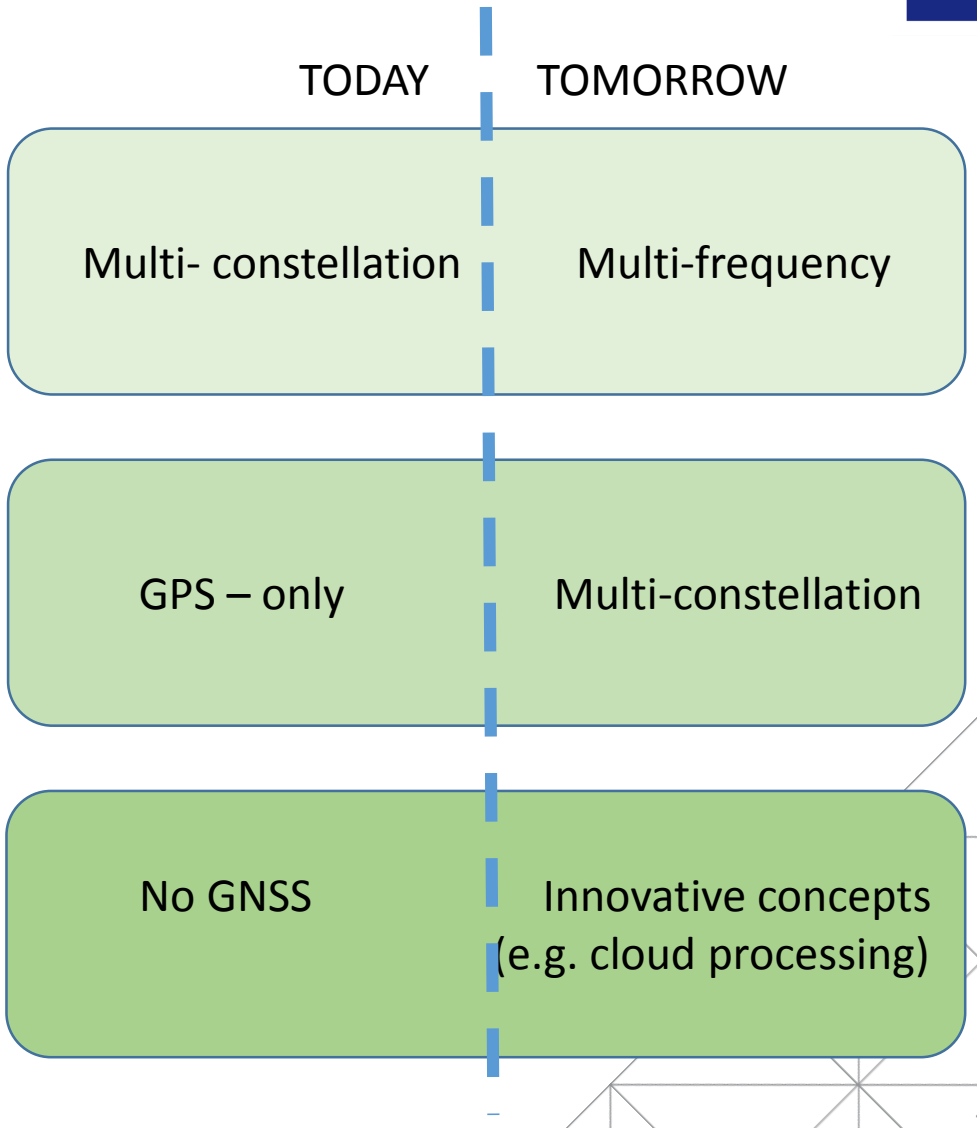
Lower power consumption and cost constraints
(fleet management, drones, smartphones)

MID RANGE

Medium power consumption and cost constraints
(asset tracking, wearables, bike sharing, smart lightning)

LOW END

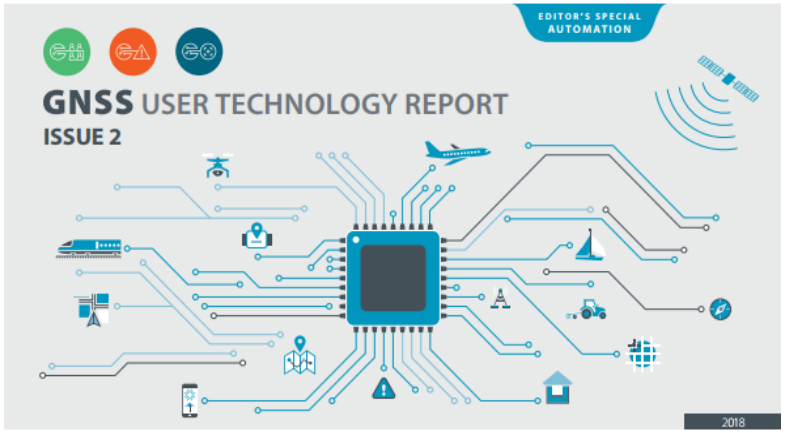
High power consumption and cost constraints
(low value asset management and tracking)



Get the GSA reports on GNSS market and technology to support your planning and decision making

The **GNSS Market Report** is a comprehensive source of knowledge and information on the dynamic, global GNSS market. The report is published every two years, with the latest edition released in 2017

Download for free at https://www.gsa.europa.eu/market/market-report



The **GNSS User Technology Report**, a sister publication to the GSA's GNSS Market Report, is published every two years and takes an in-depth look at the latest state-of-the-art GNSS receiver technology

Download for free at https://www.gsa.europa.eu/european-gnss/gnss-market/gnss-user-technology-report

Support EU competitive offer: Funding mechanisms promote the development of Galileo within apps and receivers

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

Fundamental Elements

Fundamental Elements projects focus on fostering the development of innovative Galileo- and EGNOS-enabled receivers, antennas and chipsets technologies

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

The new H2020 call is open! H2020-SPACE-EGNSS-2019

Type of Action	Topic	Indicative budget (EUR mln)	Funding rate
IA	EGNSS applications fostering green, safe and smart mobility	**10.00**	**70%** (except for non-profit legal entities, where a rate of 100% applies)
IA	EGNSS applications fostering digitisation	**4.00**	
IA	EGNSS applications fostering societal resilience and protecting the environment	**4.00**	
CSA	EGNSS awareness raising and capacity building	**2.00**	**100%**
	TOTAL budget:	**20.00**	

- **Participation of SMEs** is strongly encouraged!
- Proposals addressing **PRS (Public Regulated Service)** are <u>not</u> in the scope of this action
- A **combination of EGNSS with other technologies** required to make the application(s) work, is also encouraged

Opening: 16 October 2018
Deadline: 05 March 2019

IA: activities aimed at producing plans and arrangements or designs for new, altered or improved products, processes or services
CSA: consisting of accompanying measures such as standardisation, dissemination, awareness-raising and communication, networking, policy dialogues and studies

Linking space to user needs

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Security With OS-NMA, users can verify that signal comes from a Galileo satellite and not from a potentially malicious source