European Global Navigation Satellite Systems Agency

GALILEO EGNOS
NAVIGATION SOLUTIONS POWERED BY EUROPE

Galileo programme: opportunities for Timing and Synchronisation

Eapec 2019

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GSA

Galileo and EGNOS

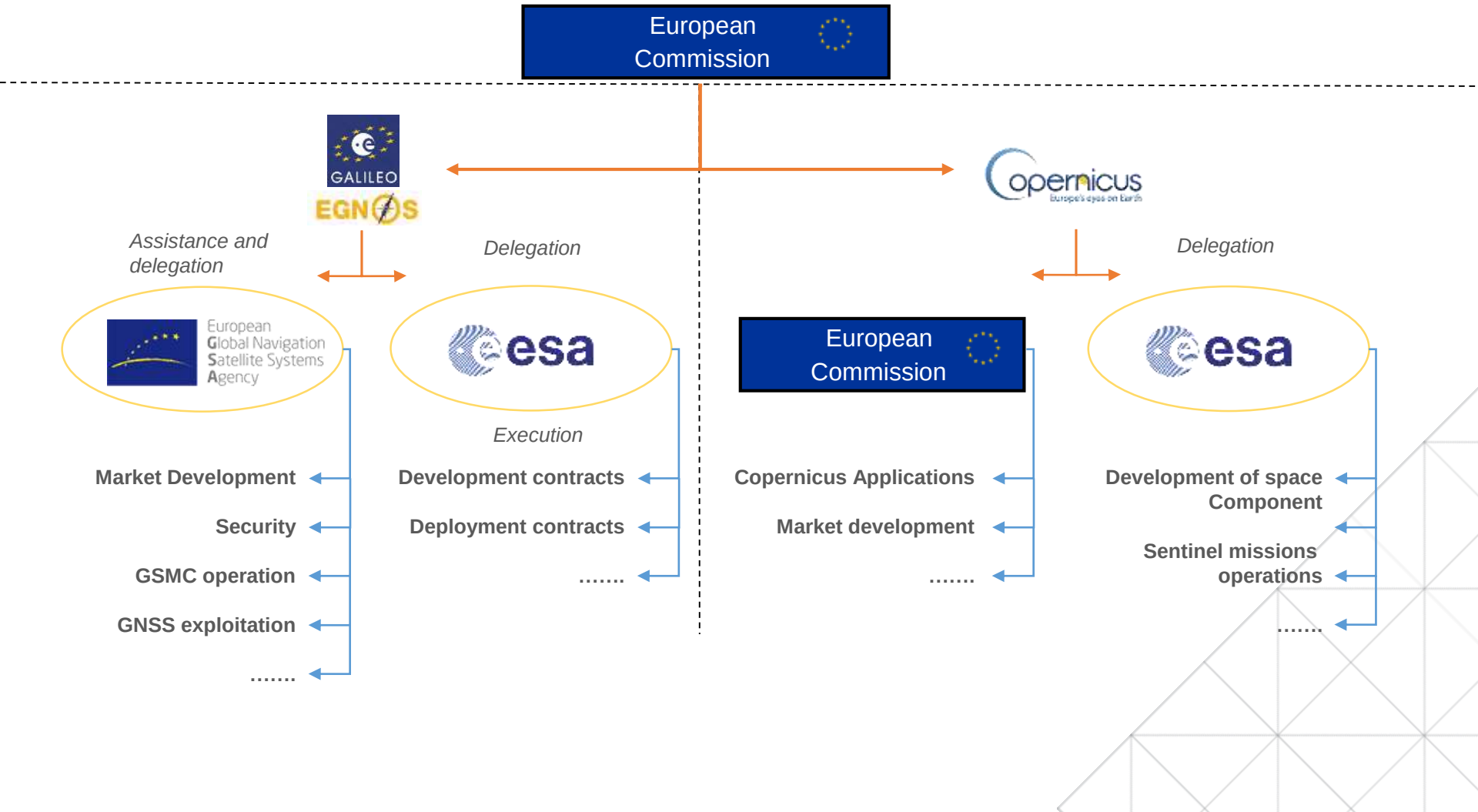
Timing & Synchronisation (T&S)

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

- **160 Staff**
- **21 Nationalities**

- **GSA (Prague)**
- **Galileo Security Monitoring Centre (GSMC)**
  St. Germain en Laye, FR
  San Martín de la Vega, ES
- **European GNSS Service Centre (GSC)**
  Torrejon, ES
- **Galileo Reference Centre**
  Noordwijk, NL
- **EGNOS**
  Toulouse, Fr

GSA´s role within the European Space Programmes



GSA

Galileo and EGNOS

Timing & Synchronisation (T&S)

EGNOS already available serving EU citizens and industry

- Accuracy ~**1m, free**

Open Service (OS)

- Accuracy ~1m, **compliant to aviation standards** by providing correction data and **integrity**

Safety of Life Service (SoL)

- Accuracy <1m, **corrections provided via internet**

EGNOS Data Access Service (EDAS)

European coverage (under extension in other regions, e.g. North Africa)

Galileo is the European GNSS offering a wide range of services

- **Freely accessible** service for **positioning, timing** and **navigation message authentication**
- **Encrypted service** designed for **greater robustness** and **higher availability**
- Assists **locating people in distress** and **confirms** that **help is on the way**
- **Freely accessible high accuracy** positioning service
- Authentication service based on the **E6 signal code encryption and OS-NMA**, allowing for **increased robustness of professional applications**

Open Service (OS)

OS-Navigation Message Authentication (OS-NMA)

Public Regulated Service (PRS)

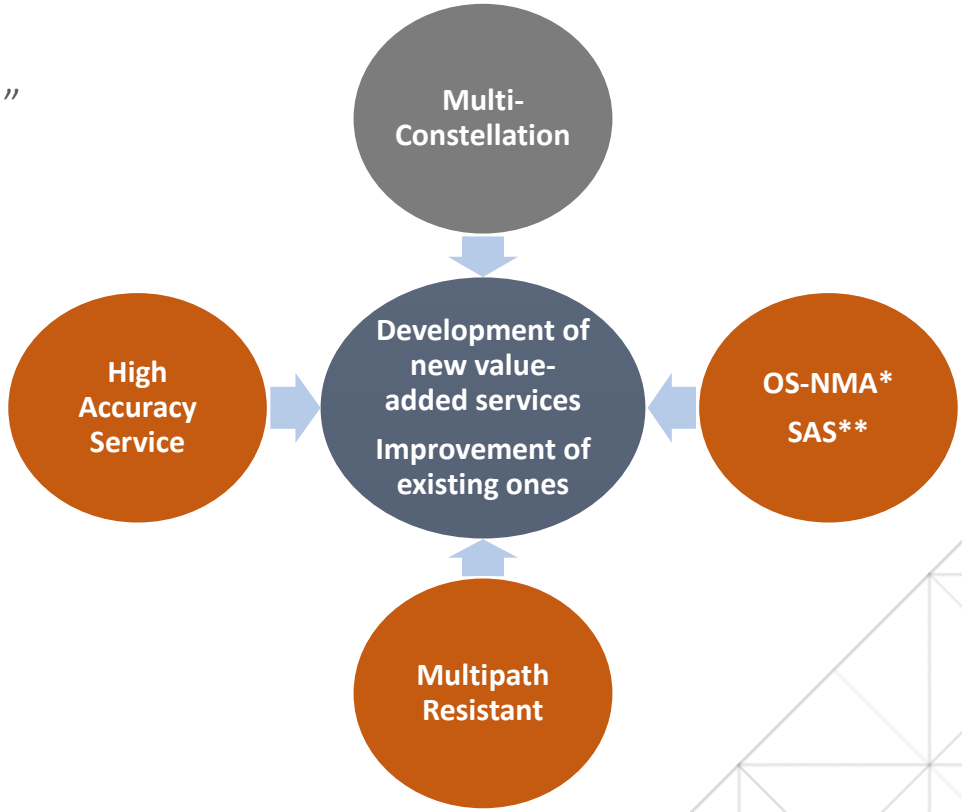
Search and Rescue Service (SAR)

High Accuracy Service (HAS)

Signal Authentication Service (SAS)

Galileo is the European GNSS under civilian control, delivering unique features

- Worldwide navigation system "**made in EU**"
- Only constellation **under civilian control**
- Fully **compatible with other GNSS constellations**
- **Open service free of charge**, delivering **multiple frequencies**
- Only constellation that provide **Signal authentication providing trustability for civilians** and **global high-accuracy service for free**



*Open Service Navigation Message Authentication
**Signal Authentication Service

The Galileo implementation plan accelerates with launched 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

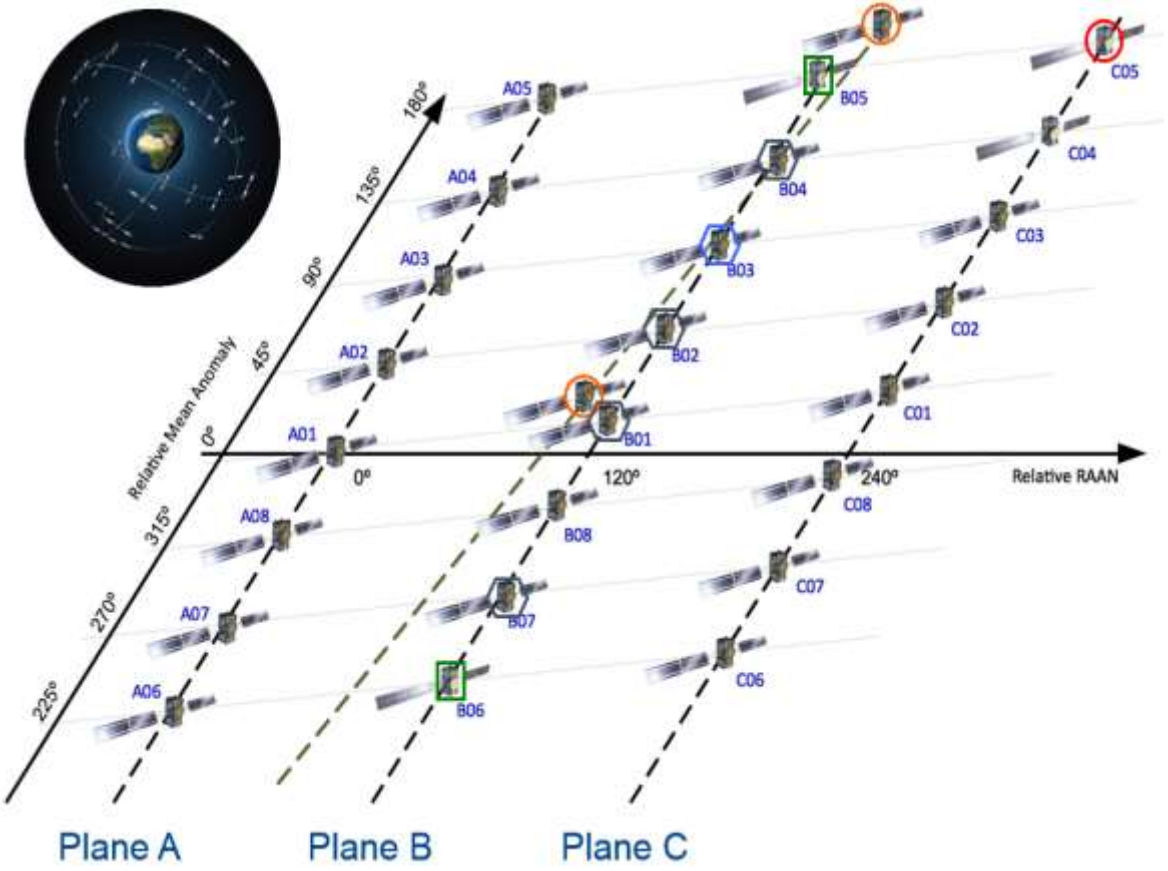
2016 — **Initial Operational Capability**
Initial services for Open Service (OS)

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)

2021 — **Full Operational Capability**
Full services, 30 satellites
An independent civilian infrastructure

Galileo Constellation Status



Navigation Payload (22 Operational)

- 26 satellites in orbit
- 2 in testing (L3)
- 1 spare (GSAT0204)
- 1 unavailable (GSAT0104)

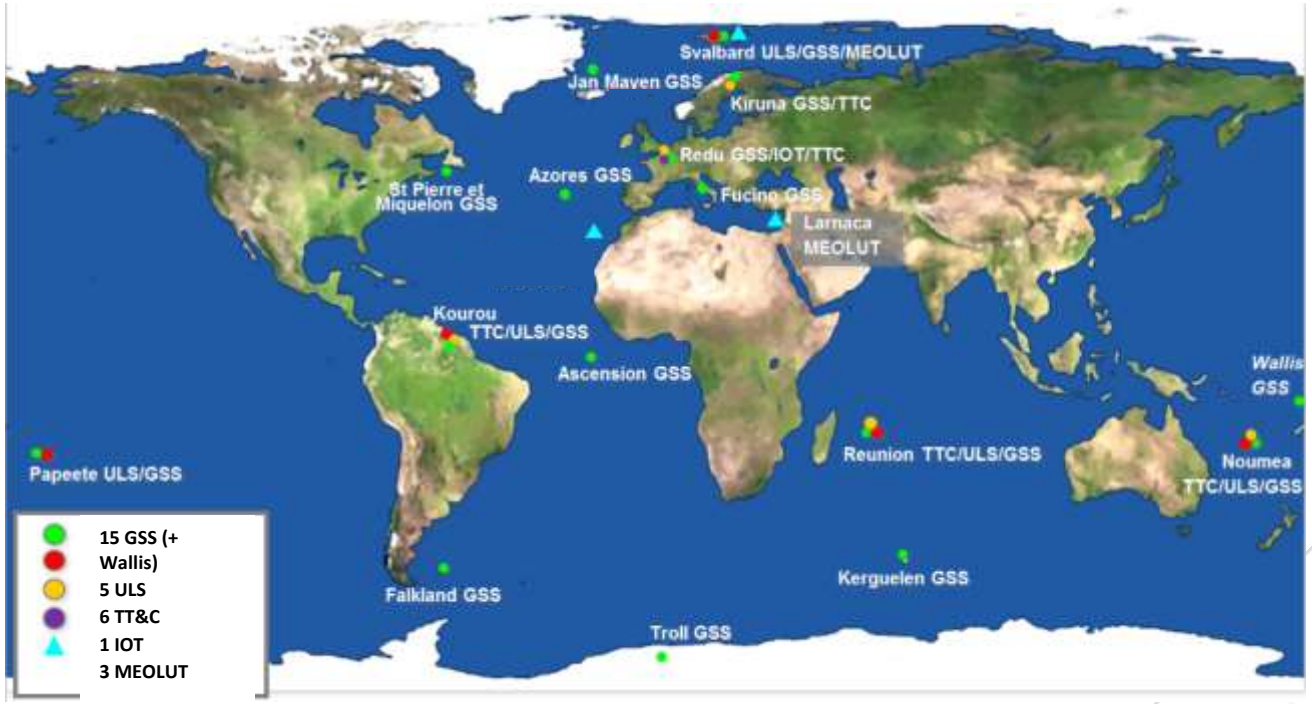
Search and Rescue Payload (19 in service)

- 2 out of 26 satellites with no SAR Transponder (by design)
- 4 under commissioning (L10)
- 1 spare (GSAT0204)

"0" unoccupied reference slots

Galileo Ground Segment

- European GNSS Agency (GSA)
- Galileo Control Centres (GCCs)
- Galileo IOT Service
- LEOP Service (LOCC)
- Galileo Security Monitoring Centres (GSMC)
- Future Galileo Security Monitoring Centre (GSMC)
- Galileo ILS Centre
- Galileo Service Centre (GSC)
- SAR/Galileo Data Service Provider (SGDSP)
- Galileo Reference Centre (GRC)



The Timing Service Provider (TSP)

Main objective of TSP is to provide to the Galileo Precise Timing Facility (PTF) the necessary information for maintaining the Galileo System Time (GST) synchronised to the International Atomic Time (TAI), or equivalently UTC.

Since January 2018 two TSPs areinstalled at the Galileo Control Centres (in Italy and Germany) are operative.

GSA

Galileo and EGNOS

Timing & Synchronisation (T&S)

GSA's role: Understand the users and market, stimulate the demand, create a competitive EU offer

MARKET SEGMENTS

- Road
- Maritime
- Aviation
- Rail
- Location Based Services
- Agriculture
- Surveying & Mapping
- Timing & Synchronisation
- Governmental

DOWNSTREAM VALUE CHAIN

Navigation Signal Providers → Chipset, receiver → Devices → Content & Apps → Service providers

UNDERSTAND MARKET & USER NEEDS

STIMULATE DEMAND & ADOPTION

CREATE EU OFFER

HORIZON 2020

Fundamental Elements

E-GNSS USER ADOPTION

EU PUBLIC BENEFITS

TLC, Energy and Finance are the main T&S sub-segments

GNSS FOR TIMING&SYNCHRONISATION (T&S)

- **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

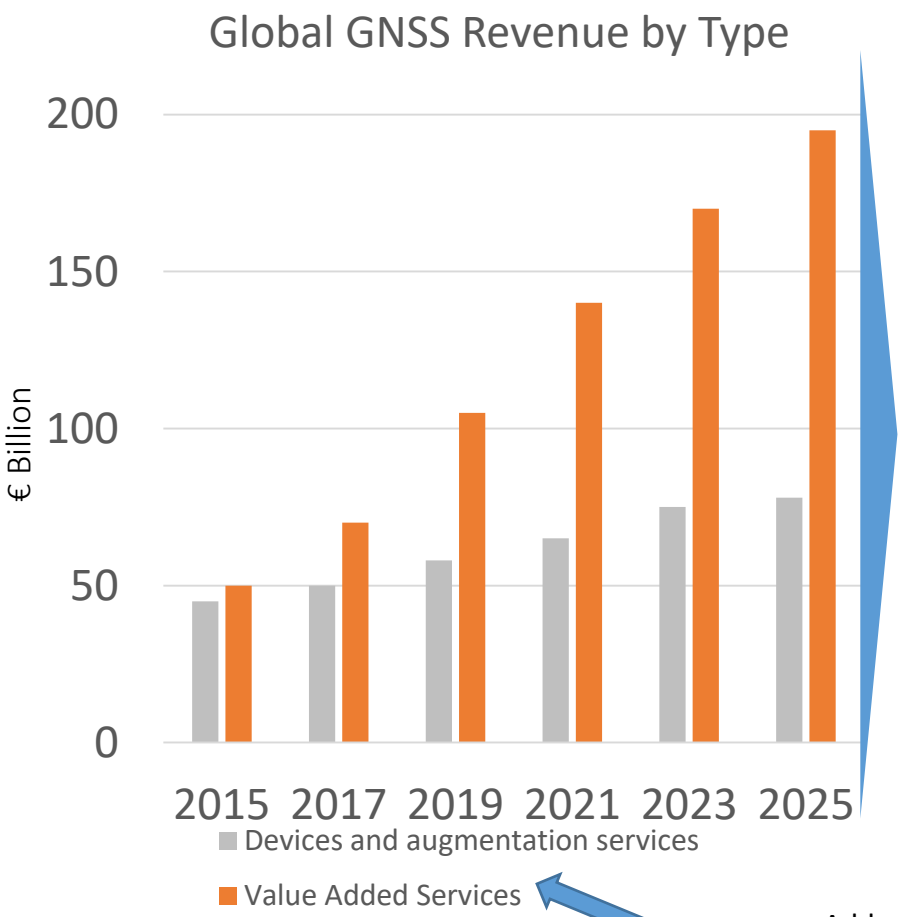
Precise T&S is crucial for **Critical Infrastructure** (CI), an asset essential for maintaining vital societal functions related to health, safety, security and social well-being of people in the following domains:

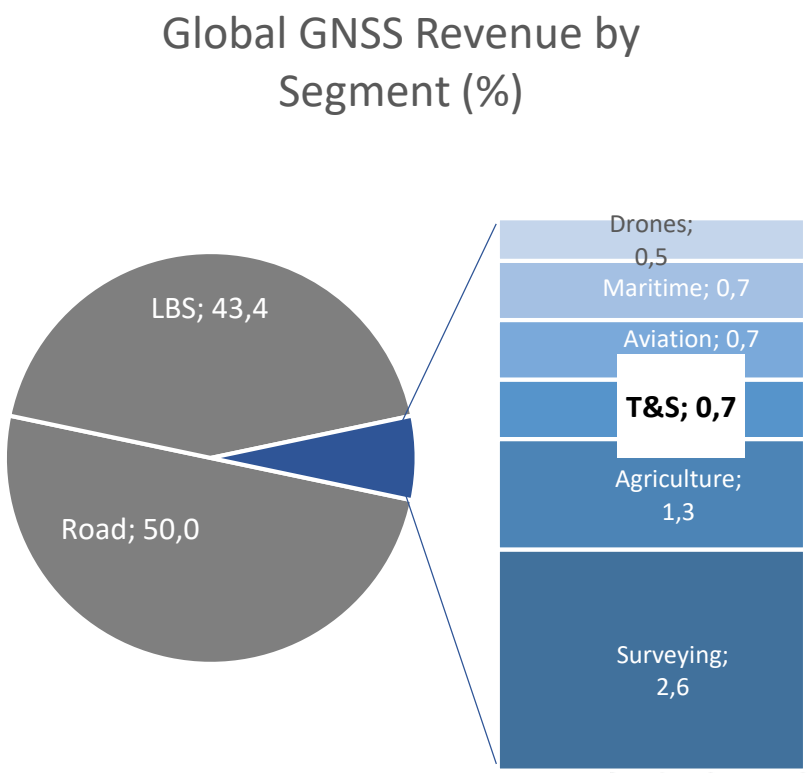
Telecommunication uses the GNSS timing function for handover between base stations in wireless communications, time slot management purposes and event logging. The main applications are: **Satellite Communication** (SATCOM), **Professional Mobile Radio** (PMR), **Digital Cellular Network**, **Public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

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

T&S is a strategic GNSS market



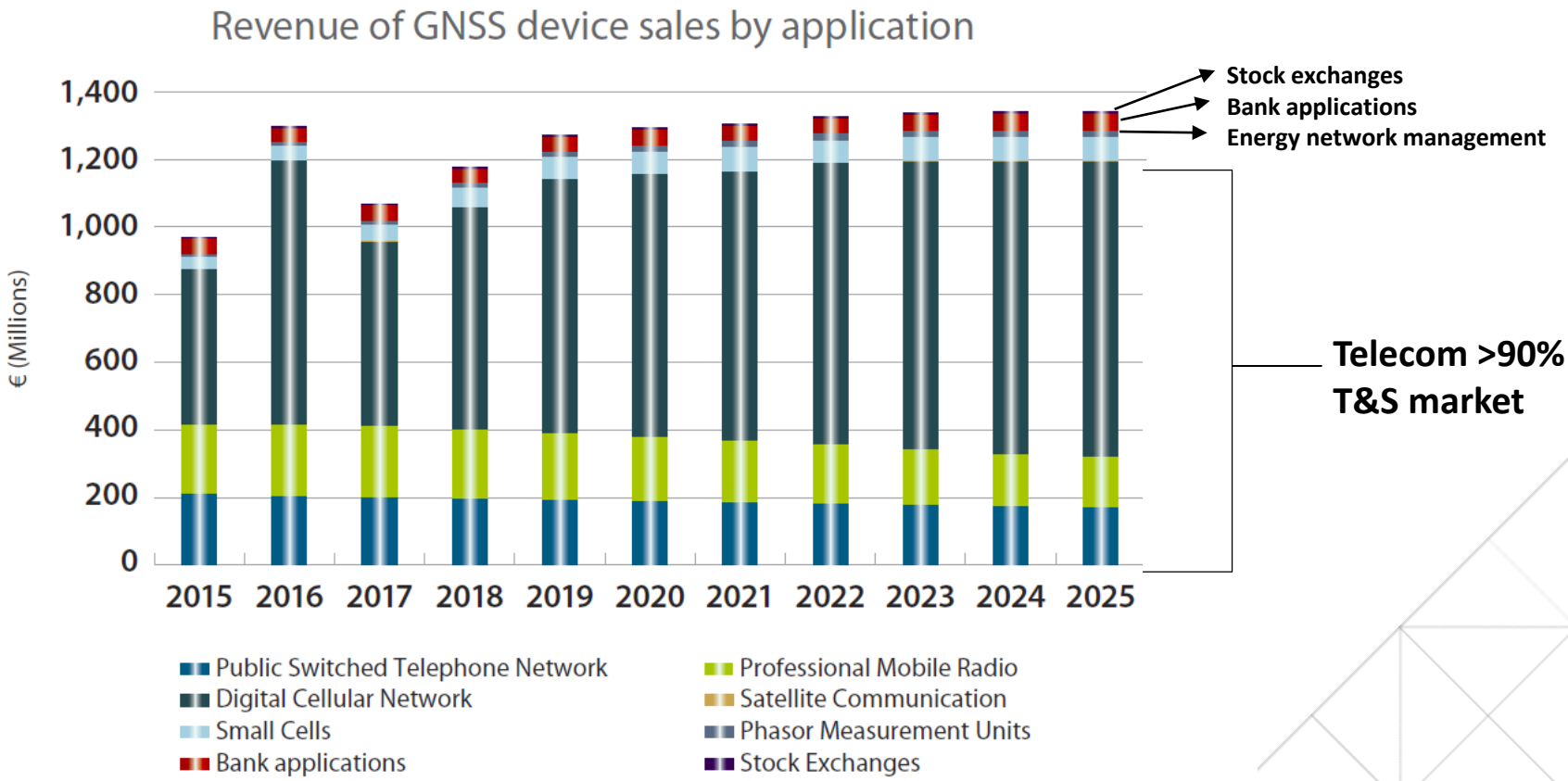


Added-value services are all services that create an added value to users by leveraging on GNSS technology

Source: GSA Market Report, Issue 5 (2017)

Market size: GNSS T&S devices sales to reach €1.3 bn driven by telecom applications

T&S market 15-25
CAGR: 5.3 %



Source: GSA Market Report, Issue 5 (2017)

T&S User Requirements by market segment

Segment	Traceability to UTC	Time accuracy to UTC	Phase accuracy	Frequency accuracy	Integrity	Stability/ Robustness	Availability	Resilience
Cell network – 4 G (LTE TDD)	Essential	+- 1.5 µs at base station; +- 100 ns at master PRTC (Primary Reference Time Clock)	+- 1.5 µs	Use of Time reference, 16 ppb at base stations (~1,3 ms for 24 h)	Added value for failure diagnostics	Outages shall be minimized < 24h for PRTC / < 60 s for base station	Indoor and canyon reception desired	Resilience to interference critical
Cell network – 5 G	Essential	+- 0.5 µs at base station/ +- 30 ns at master PRTC	Use of Time reference	Use of Time reference 5 ppb (~400 µs for 24 hours)	Added value for failure diagnostics	Outages shall be minimized < 24h for PRTC / < 60 s for base station	Indoor and canyon reception desired	Resilience to interference critical
PSTN	Yes	+- 1 µs for stratum 1	Use of Time reference	0,01 ppb (0,8 µs for 24 hours) for Stratum 1	Added value for failure diagnostics	GPSDO (GNSS Disciplined Oscillators) can compensate extended periods of time	Canyon reception desirable but not necessary	Resilience to interference critical
PMR - Current	No	Not required	>10 µs	200 ppb (~18 ms for 24 hours)	Added value for failure diagnostics	GPSDO can compensate for short outages	Indoor and canyon reception desired	Resilience to interference critical
PMR – Future	Unlikely	Probably will follow 4G/5G trend	>100 ns	Unknown	Added value for failure diagnostics	GPSDO can compensate for short outages	Indoor and canyon reception desired	Resilience to interference critical
Satcom	Yes	100 ns for TDMA based-systems[16](Stratum 1)	Timing reference used	Unknown	Added value for failure detection	Atomic GPSDO compensate outages (~ 24 h)	Canyon reception desirable but not necessary	Resilience to interference critical
Financial timestamping	Yes	100 µs (EU) / 50 ms (US)	N/A	N/A	Crucial and Liability-critical	Atomic GPSDO compensate outages (~ 24 h) on enterprise level could compensate	Canyon reception desirable	Resilience to interference critical
Power Grid Synchronisation	Yes	1 µs at PMU level (IEEE C37.238) and/or 100 ns for Traveling Wave Fault Detection	Use of Time reference	Use of Time reference	Not critical. Added value for failure diagnostics	GPSDO can compensate extended periods of time	Indoor and canyon reception desired	Critical, with increased reliance on PMU controlled infrastructure
Autonomous cars	As 4G networks, tending towards 5G networks				Crucial and Liability-critical	As 5G networks	Indoor (parking) and canyon reception desired	Resilience to interference critical

Possible contribution of Galileo against jamming and spoofing threats

Open Service authentication

- 'Navigation Message Authentication' (NMA) on the Open Signal
- Can counter intentional and non-intentional threats
- Low impact in receiver equipment and no performance degradation

Signal Service authentication

- More robust Service Authentication on the E6 signal

Public Regulated Service

- Encrypted and robust navigation service specifically designed to be more resistant to jamming interference and spoofing
- Capability to ensure continuity of service to authorized users even in times of crisis

GALILEO contribution to anti-jamming and anti-spoofing can bring important benefits to key sectors of the global economy

A Galileo Application offerings can be released leveraging Galileo differentiators

Market Offerings	Description	TLC	Power grids	Fin	Labs
1.Galileo time integrity leveraging OS in the first place, and then OS-NMA after 2019 AO#1	Validation and performance assessment of the timing information disseminated by the Galileo System	✓	✓✓	✓✓	✓
2. Trusted time distribution and remote audit leveraging OS in the first place, and then OS-NMA after 2019 AO#2	Dissemination of UTC time and frequency over Internet using NTP (or PTP) and remote assessment of the client clock synchronisation by providing audits and report	✓	✓	✓✓	✓
3. Certified Time steering and monitoring leveraging CS from 2020 AO#3	Dissemination of precise and accurate time using multi-GNSS Galileo based Time Transfer techniques and a real-time internet link, allowing the real-time monitoring and certification of the time offset between the User Terminal and the Time Reference Facility	✓	✓✓	✓	✓
4. Robust accurate time leveraging CS from 2020 AO#4	Robustness against GNSS signals and system failures and/or attacks like jamming or spoofing and robustness against failures or attack to communication network	✓✓	✓	✓	✓✓

Timing receiver for critical infrastructure (2 projects)

GIANO (Galileo based Timing Receiver for Critical Infrastructure),

- The project main objective is to develop an innovative Galileo-based timing receiver based on flexible architecture, improving **resilience and robustness of European Critical Infrastructures** at a reasonable cost

GEARS (The Galileo Authenticated Robust Timing System)

- The objectives are:
  - improve **performances and resilience of Galileo** and GNSS Timing receiver
  - develop and demonstrate the **effectiveness of unique Galileo services** to operators
  - strengthen market adoption through **standardization** activities

Final Remarks

- Galileo is up and running
  - More than 600 million users (nearly all the smartphones are now using chip Galileo enable) and
  - All new car models are using emergency system eCall based on Galileo since 1st April 2018
- EGNOS has already proved its value, more than 300 airports in Europe are using EGNOS already (nearly 600 procedures)

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