# Apportionment of GNSS in Automated Driving and integrity requirements for road safety critical applications

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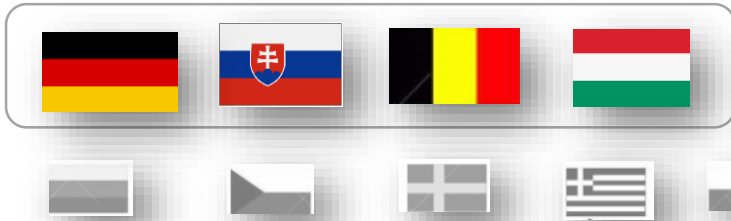## European Space Week 2019

*Helsinki, Tuesday 3rd. December*

Market Development - European GNSS Agency

# Galileo is used today in the majority of professional devices and consumer platforms

## Commercial vehicles

**72% from the EU total tolled roads (+79,000 Km)** correspond to a GNSS-based scheme

*Soon*: **Bulgaria, Czech Republic, Sweden, Greece, Poland, Lithuania…**

### EU Regulations

*Smart Tachograph regulation mandates EGNOS and Galileo to control driving time **from Jun.2019***

*Updated EETS Directive mandates EGNOS and Galileo in free-flow tolling using satellite positioning in EU **from Oct.2021***

➢ **1.48 Million EGNOS** (71% of total GNSS)

➢ **1.28 Million Galileo** (62% of total GNSS)

## Passengers cars

### EU Regulations

ECALL - SAVING LIVES

*eCall regulation (EU) mandates EGNOS and Galileo in every new type of car/van sold in Europe **from Apr.2018***

*24 car brands, +35 models*

➢ **ca. 3 Million vehicles** *(end-2019)*

# European GNSS is crucial in the design of Cooperative and Automated Driving

- Vehicles, infrastructure, and pedestrian are **location-aware and will synchronize the output data** from diverse sensors via V2V and V2I communication protocols

- GNSS is crucial for **timing synchronization and to get decimetre/centimetre-level** absolute location in combination with inertial navigation, odometry, HD maps and even Machine-Learning and Artificial Intelligence



*Source: Continental AG*



*Source: Continental AG*



- The UNECE World Forum for automotive regulations declared the need of clear **cybersecurity rules**:

  ✓ GNSS authenticated message is recommended

*COM(2018) 283 final: On the road to automated mobility: An EU strategy for mobility of the future*

# Background

- Several recommendations were made by the Road panel during the **User Consultation Platform 2018** (Marseille, France) to further investigate the apportionment of GNSS in Automated Driving and the integrity requirements suitable for road safety critical applications.

- In June 2019, **GSA concluded a technical analysis** with the support of industry players in the frame of GSA/OP/09/16/Lot 3/SC2.

- Future versions of the Report on Road User Needs and Requirements (RUR) should incorporate the outcomes of this analysis.

# Initial assumptions

- **New standards for ADS** (ISO/SAE 21434, ISO PAS 21448) have been issued or are under preparation. However, there is no consensus, among experts and academics, on the "correct" ADS functional architecture.

- Each car manufacturer is developing its ADS with **a different integrity approach involving the use of all the sensors, but not with the same weight**. In this sense, GNSS provides absolute localization with 3D/HD Maps, LiDAR, Radar and IMUs.

- It has to be distinguished between the **Integrity at Position Level** (i.e. at User Level) covered by the Artificial Intelligence or Machine Learning applied to all the sensors' measurements; and the **Integrity at System Level** (i.e. usability of the GNSS SIS).

*ADS: Automated Driving Systems*

# User Requirements for road safety critical applications

GNSS apportionment models

| USE CASE | ACCURACY | AVAILABILITY | CONTINUITY RISK | INTEGRITY RISK | TTA[1] | ALERT LIMIT[2] |
|---|---|---|---|---|---|---|
| Autonomous Emergency Steering with visual impairment | 1m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 100ms | 3.5m |
| Autonomous Emergency Braking with visual impairment | 1m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 100ms | 3.5m |
| Crossroad passing | 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 36ms | 0.7m |
| Crossroad passing with visual impairment | 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 36ms | 0.7m |
| Active Lane Control with visual impairment | 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 21ms | 0.7m |
| Turn with visual impairment | 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 50ms | 0.7m |
| Trajectory Prediction | 1m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 100s | 3.5m |
| Lane Change Assist with visual impairment | 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 21ms | 0.7m |
| Multi-Layer Bridge/Streets [H] | H: 0.2m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 21ms | H: 0.7m |
| Multi-Layer Bridge/Streets [V] | V: 1m | 99.7%-99.9% | 1E-5/hour | 1E-7/hour | 21ms | V: 3.5m |

| GNSS Medium-Use Architecture | | | |
|---|---|---|---|
| Accuracy [m] | Availability | Continuity Risk | Integrity Risk |
| 2.265 | 99.950% | 5.000E-06 | 5.000E-08 |
| 2.265 | 99.950% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.950% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.950% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.933% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.950% | 5.000E-06 | 5.000E-08 |
| 2.265 | 99.950% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.950% | 5.000E-06 | 5.000E-08 |
| 0.453 | 99.950% | 5.000E-06 | 5.000E-08 |
| 2.265 | 99.950% | 5.000E-06 | 5.000E-08 |

- Three Type of architectural approaches have been defined depending on the role of GNSS (i.e. High, Medium and Low) in the automotive technology-mix. In addition, GNSS is currently used in ADS without any integrity capability.

# Conclusions *(GNSS apportionment)*

- The analysis of the current used technologies in Automated Driving Systems showed that the use of GNSS in the **ADS is linked to a manufacturer design choice** at the same level that the GNSS performance (e.g. Tesla in not making use of GPS in their ADS Level 3 functions, but might include it in the Levels 4 and 5).

- In any case, still **absolute localization is playing a key role in the future ADS for Level 3-4-5 and the GNSS is one of the core technologies considered**, even if GNSS is combined with other sensors to provide absolute localization (e.g. 3D HD Maps used with LiDARs and Radars, or the improved performance of IMUs).

- For what concerns the performance, that **shall have a global coverage** since the market of the manufacturers is global, the analysis showed that, in average (Medium-Use Architecture), the needs for the absolute location performance will require:

  - ➢ **Accuracy** better than **0.45m** (95% confidence level)
  - ➢ **Availability** of accuracy better than **99.95%**
  - ➢ **Continuity Risk** lower than **5 x 10-6**

# Conclusions *(Integrity)*

- Each ADS manufacturer have different design choice and it is unfeasible to define a unique Integrity concept. However, the recommendation is **to consider the range for the Integrity requirements** with some margins *(e.g. from 10-7 for 300 s to 10-8 for 15s).*

- Another important driver for the selection of the localization technologies is the **Time to Market**. The first ADS products will be launched around 2025. Therefore, the **selection of the technologies will be performed in the period 2020-2022 and testing in 2021-2023**.

- After the products are in the market, new or updated technologies (e.g. new GNSS features) are unlikely to be injected in the solution due to the fact that the manufacturers will have their Return of Investment to be covered. Then it is **very difficult to change the legacy**.

- Apart for the Integrity, it has been recognized that **Galileo is fully adopted by the major part of the ADS manufacturers** to take advantage of its performance for High Accuracy, Authentication, Availability and Continuity: **Galileo is being tested in at least 25 Autonomous Vehicle`s prototypes worldwide (75% from total)**

# Next steps

## 1- Technical analysis to be delivered to the CEN/CENELEC TC5 WG1

**EN 16803: Use of GNSS-based positioning for road Intelligent Transport Systems (ITS)**

**2016**

- **Part 1: Definitions and system engineering procedures for the establishment and assessment of performances:** overall framework and operational procedures for the establishment of GNSS-based performances for ITS

**2019/20**

- **Part 2: Assessment field tests for basic performances of GNSS-based positioning terminals:** testing procedures to assess the basic performances (Availability, Accuracy and Integrity)

**2020/21**

- **Part 3: Assessment field tests for security performances of GNSS-based positioning terminals:** testing procedures to assess the performances submitted to RF attacks such as spoofing or jamming

**2021/22**

- **Part 4: Methodology for the recording of relevant data sets (Record & Replay):** define the way the data files are built and validated

## 2- New safety technologies will become mandatory in Europe from 2022, some of them relying on GNSS



*http://europa.eu/rapid/press-release_IP-19-1793_en.htm*

- Advanced emergency braking (cars, vans)
- Alcohol interlock installation facilitation (cars, vans, trucks, buses)
- Drowsiness and attention detection (cars, vans, trucks, buses)
- Distraction recognition / prevention (cars, vans, trucks, buses)
- Event (accident) data recorder (cars, vans, trucks, buses)
- Emergency stop signal (cars, vans, trucks, buses)
- Full-width frontal occupant protection crash test - improved seatbelts (cars and vans)
- Head impact zone enlargement for pedestrians and cyclists -safety glass in case of crash (cars and vans)
- Intelligent speed assistance (cars, vans, trucks, buses)
- Lane keeping assist (cars, vans)
- Pole side impact occupant protection (cars, vans)
- Reversing camera or detection system (cars, vans, trucks, buses)
- Tyre pressure monitoring system (vans, trucks, buses)
- Vulnerable road user detection and warning on front and side of vehicle (trucks and buses)
- Vulnerable road user improved direct vision from driver's position (trucks and buses)
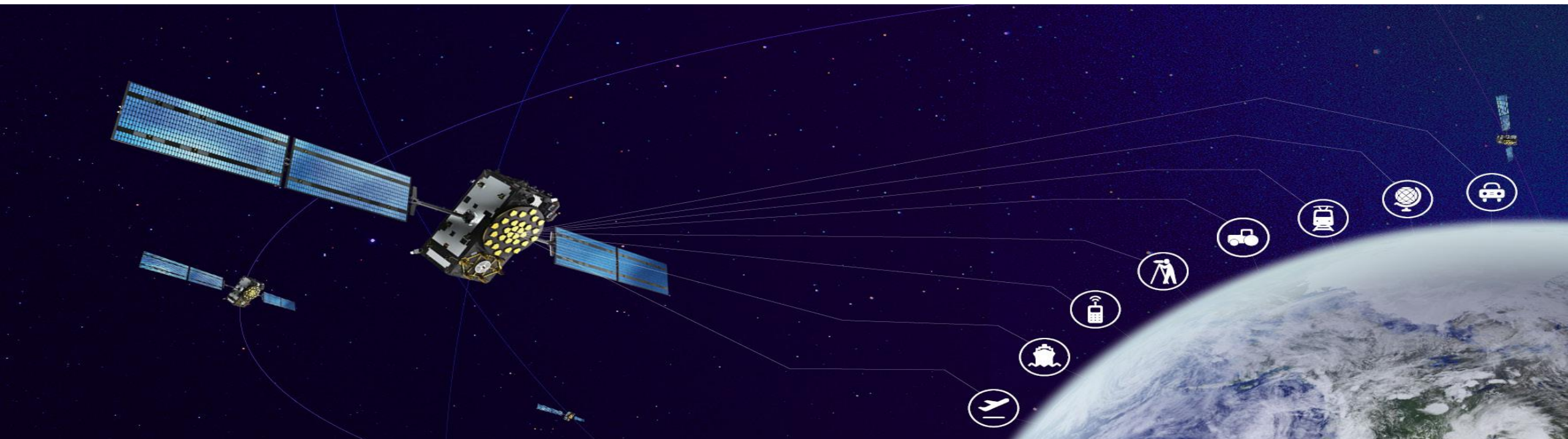
# Thank you!

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Market Development - European GNSS Agency