GNSS applications

- **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.

In the Road domain, connected vehicles, enabled by the uptake of modern automotive connectivity solutions, represent the evolution of modern vehicles towards becoming integrated platforms capable of supporting, thanks to GNSS, smart mobility services and a range of safety applications.

**What you can read in this chapter**

- **Key trends**: GNSS will play an important role in the vehicles of the future.
- **User perspective**: GNSS user requirements vary significantly in different application categories.
- **Industry**: List of main players by value chain segments.
- **Recent developments**: In-vehicle systems consolidated their leading role as navigation platform.
- **Future market evolution**: A range of commercial and regulated applications will drive GNSS growth.
- **Focus on European GNSS**: EGNOS and Galileo contribute to road safety and security.
- **Reference charts**: Annual evolution of GNSS devices’ installed base and revenues by application and region.
GNSS will play an important role in the vehicles of the future

Key Market Trends
- GNSS, together with other technologies, is a key answer to Autonomous Vehicles’ need of accurate positioning combined with reliability of localisation.
- Whilst OEMs and technology companies are leading the development of Autonomous Vehicle, governments across the world encourage these efforts and allowing testing on public roads.
- Business models continue evolving, with OEMs pushing towards the ownership of GNSS data and aftermarket companies increasingly specialising in data collection and elaboration.

Autonomous Driving is high on the R&D agenda of many converging sectors
Worldwide, all major car groups are currently working on their own Autonomous Driving technology, which has caught the interest of both premium and volume manufacturers. The German automobile industry is defending its lead in terms of the state of development and availability of autonomous driving functions, whereas car manufacturers in countries such as the USA and China are benefitting from the availability of autonomous driving technologies in mass-produced vehicles. Looking to the current developments by the OEMs in the different regions it is clear that the technology is already finding its way to the market. Several OEMs and speciality-OEMs are offering semi-autonomous driving technology in their newest, high-end models.

In parallel with efforts by OEMs, tech giants such as Apple and Google have invested massively in autonomous vehicles, leveraging on their data combination and elaboration capabilities to step in the automotive world.

To guarantee the necessary data availability to feed autonomous driving processes, in-vehicle sensors are of key importance. Together with other technologies such as LiDAR, radar sensors and cameras, GNSS is an enabler of the autonomous driving concept, although there are different technological trajectories on its final role once a dominant design will be established. At the present stage, GNSS is already in use, to assist the semi-autonomous vehicles during navigation using digital maps.

Further improvements in GNSS constellations will be further contributing to the path towards the fully autonomous vehicle, with Galileo features such as Open Service NMA and dual frequency playing a key role in providing an efficient, reliable, robust and low-cost defence against jamming or spoofing attacks.

The uptake of built-in GNSS could reshape the role of aftermarket players
More and more vehicle models are fitted with a GNSS-enabled IVS, which is set to become a platform to support both safety applications and infotainment services.

This trend will bring both challenges and opportunities to aftermarket suppliers. Currently, only the latest vehicle models are equipped with built in applications such as insurance telematics, eCall, ADAS and others. The current scenario is offering aftermarket solution providers the opportunity to offer application-specific devices to a large retro-fit market.

Integration is currently taking place in aftermarket solutions, which are moving towards supporting multiple applications through a single GNSS-enabled telematics platform. As a further step, in the future, ubiquity of IVS could make them the dominant platform for GNSS applications. Under this scenario, current aftermarket providers are expected to specialise in the service provision element, supported by IVS in a similar fashion to the smartphone-apps business paradigm in mobile devices.

EU and US policy makers joined by the industry take steps towards C-ITS
Near the end of 2016, both the EU and the US took key steps towards the implementation of Cooperative Intelligent Transport Systems (C-ITS). Following the Declaration of Amsterdam, the EU published its European Strategy on C-ITS, including the role of EGNSS, in December 2016. This strategy is seen as a first milestone towards cooperative, connected and autonomous driving which is expected to make the European road network a much safer environment. Prior to this, the US government had released a policy document on Autonomous Driving, providing a 15-point safety assessment on the manufacturing and sales of autonomous vehicles. Both policy efforts were supported by the industry, which stated its intention to start the full scale deployment of C-ITS enabled vehicles by 2019.
GNSS user requirements vary significantly in different application categories

The role of GNSS in autonomous vehicles
Although technical activities are ongoing and opinions on the use of GNSS for autonomous driving differ amongst the involved stakeholders, it is clear that autonomous driving technology requires highly accurate position and navigation in all scenarios.

This means 100% position availability at decimetre level or less, anywhere, anytime and under any condition, requirements that no individual technology can provide on its own. To overcome the shortcomings of these individual positioning technologies, sensor fusion is considered as the go-to-solution for the development of fully autonomous driving technology.

In this frame, GNSS is an element of a sensor fusion equation including also LiDARs/Radars, Inertial sensors and cameras. The prominence of the GNSS role is expected to evolve through time. In the long run, the availability of HD maps available on the cloud through the 5G network could enable LiDAR and cameras to be the main support for fully autonomous navigation, with GNSS representing the key element for positioning the vehicle within the maps.

Before all these pieces come into the puzzle, cost-effective augmented GNSS solutions, capable of supporting lane-level, high integrity positioning over wide areas, could be the first go-to choice for industry players racing to hit the road first with their autonomous vehicles.

How autonomous and legacy vehicles will start sharing the road
Policy makers, manufactures and citizens have to face a reality in which man-driven and autonomous vehicles will share the same roads. Connected vehicles might pave the way for AVs with V2V, V2I and V2X communication contributing to the fluent integration of human-driven and autonomous vehicles.

At the time being, drivers might feel uncomfortable with the idea of driving alongside an AV that will behave as a machine and not like any other human driver. Very likely a first step to address this point would be to only allow the active use of the autonomous driving mode on highways. Compared to dense urban areas, highways provide a less complex environment for AVs as behaviour of other vehicles on these roads is easier to predict. Linked to this first step, the criticality of the AVs will be to determine the optimal action in the presence of somewhat unpredictable human drivers. In turn, a possibility to initially overcome this issue could be to allow the use of semi- and fully autonomous vehicles only on designated road lanes.

Overview of the main user requirements in Road
The table depicts, in alphabetical order, the key user requirements as assessed through the GSA’s continuous monitoring with the user community. Only high priority requirements are shown, i.e. other requirements might also be relevant for considered applications, and the table is subject to updates. Information on the parameters is provided in Annex 2.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Key GNSS requirements</th>
<th>Other requirements</th>
<th>Smart mobility: Road navigation, automated parking, dynamic ride sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety critical: Automatic actions in V2X, autonomous driving</td>
<td>Accuracy Authentication Availability Integrity Robustness TTFF</td>
<td>Connectivity (mainly short range) Interoperability</td>
<td>Authentication Integrity</td>
</tr>
<tr>
<td>Payment critical: RUC, pay-as-you-drive, taxi meter</td>
<td>Accuracy Authentication Integrity Robustness</td>
<td>Connectivity (short range and long range)</td>
<td></td>
</tr>
<tr>
<td>Regulated: Smart tachograph, eCall, tracking and tracing</td>
<td>Authentication Integrity Robustness TTFF</td>
<td>Connectivity (short range and long range)</td>
<td></td>
</tr>
<tr>
<td>Smart mobility: Road navigation, automated parking, dynamic ride sharing</td>
<td>Connectivity (long range)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mobility as a Service: why accuracy and authentication matter
Mobility as a Service (MaaS) represents a shift as compared to the private car ownership paradigm. In MaaS, a unique journey planning and management service identifies the best transport option for users, through a smart combination of public transport and vehicle rental or sharing, based on the specific travel needs.

Within MaaS, GNSS plays a key role. On the one hand, it enables service providers to manage and optimise the use of the assets required to provide the different transport options. On the other hand, it enables the provision of smart mobility solutions to the users, including navigation, traffic information and journey planning directly.

In the frame of MaaS, accuracy and availability in urban areas, as well as the need of trustable transactions, represent important requirements, which Galileo is well positioned to satisfy thanks to its additional satellites and to Open Service Navigation Message Authentication (OS NMA).
The Value chain considers the key global and European companies involved in the GNSS downstream activities.

* European based companies. The world region is referred to the headquarter of the company, the actual area of activity might be wider.

The European¹ GNSS industry in the global arena

With u-blox, STMicroelectronics and TE Connectivity, Europe held three positions in the 2015 global top five of GNSS component and receiver manufacturers, reaching 32% of the global GNSS revenues. Overall, EU companies lead this market with a share of 51% followed by Asia and North America, with 27% and 22% of the market, respectively. European GNSS system integrators, led by Volkswagen and Robert Bosch amongst many others, on the other hand generated 30% of global turnover, trailing behind Asia (48%).

¹ In the market share analysis, Europe is defined as EU28 plus Norway and Switzerland.
**In-vehicle systems consolidated their leading role as navigation platform**

Since 2008, when road GNSS shipments surpassed the mark of 50 mln devices, the market has grown to 76 mln shipments in 2016. Over the same period, the shipment of In-Vehicle Systems (IVS) shipments has skyrocketed from 12 mln units in 2008 to 33 mln in 2016, keeping the total shipments of navigation applications stable as it is compensated for the rapid decline of Personal Navigation Device (PND), driven both by the increased share of new vehicles being equipped with an IVS and the growing use of smartphones as a source of navigation.

Supported by an increasing popularity amongst insurers and users in markets such as Italy, UK and United States, Insurance Telematics witnessed a significant growth (CAGR of 54%) between 2012 and 2016, reaching 9 mln units in 2016.

Shipments of On-Board Units (OBUs) for heavy truck Road User Charging (RUC) contributed to 1.5 mln units in 2016, with shipments stabilising after seven years of sustained growth. Due to the growing number of countries that use GNSS technology for road tolling (see box below), the estimated installed base of RUC OBUs reached 5.2 mln units in 2016.

**EU legislations expected to boost shipments of GNSS devices**

Starting from April 2018, all new car and light duty vehicles models sold in EU have to be equipped with an eCall system. When a serious accident occurs, eCall will automatically dial the European 112 emergency and provide the emergency services with the necessary data related to the accident such as the exact position of the vehicle crash, allowing emergency response to react more efficiently and effectively. It is expected that around 10% of the new vehicles sold in Europe will correspond to new models equipped with eCall in 2018 and this penetration rate will sharply increase over the years. By 2021, around 90% of the newly sold European cars, around 13 mln vehicles, could have an eCall system installed.

Focusing on commercial vehicles, the Smart Tachograph will be introduced starting in June 2019. GNSS will support enforcement of legislation in Road transport, benefitting fair competition among road operators and road safety. The Smart Tachograph will be harder to tamper with and will allow remotely access some tachograph data. This will reduce the need for lengthy on-road stops, saving time for both the driver and the road enforcement authority. As the Smart Tachographs will introduce GNSS, it will offer a better enforcement to respect the driving and rest times of the drivers, by providing the start and final position of the vehicle as well as speed and direction to the road enforcers. By 2025, it is estimated that around 1.4 mln vehicles will be equipped with a Smart Tachograph with an internal GNSS chipset.

**More than 43,000km of GNSS-enabled road tolling in the EU**

Across Germany, Slovakia, Hungary and Belgium more than 43,000km of roads in the EU are currently being charged by GNSS technology for the electronic tolling scheme of heavy goods vehicles. By 2019, Bulgaria is set to join this group of countries potentially adding 16,000km of roads to the total of EU roads tolled through GNSS. Outside the European Union, Switzerland and the Russian Federation are also using GNSS technologies in conjunction with other technologies for their tolling scheme. Singapore recently announced that it will have the first GNSS urban congestion charging system for all vehicles by 2020. Some EU Member States are also considering road tolling for passenger and light vehicle. In the case of Belgium, GNSS is likely to be the preferred technology.


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**GNSS Market Report | Issue 5, 2017**
A range of commercial and regulated applications will drive GNSS growth

Shipments of IVS are foreseen to continue growing, reaching 63 mln by 2025 and doubling the shipments of 2015. Through the IVS, OEMs will be able to offer a range of Connected Vehicle services, progressively adding additional revenue streams to their value proposition.

In the long run, IVS will increasingly become platforms for applications that are currently aftermarket. It is the case of insurance telematics, as key players are expected to leverage on embedded hardware and focus on service provision.

Boosted by the EU legislation requiring all new vehicle models sold in the EU from 2018 onwards to be equipped with an eCall system, eCall shipments are expected to reach 38 mln units by 2025. From 2018 onwards, the Russian eCall equivalent, ERA-GLONASS, is also expected to be introduced in other members of the Eurasian Economic Union, bringing GNSS-supported emergency call to countries such as Kazakhstan and Belarus.

Combined shipments of commercial vehicle related applications such as RUC OBUs, Smart Tachographs and commercial Fleet Management Systems will grow from 4.3 mln units in 2015 to 15.4 mln units by 2025 with Fleet Management Systems making up for almost 50% of the annual shipments. Several commercial vehicle OEMs already pre-fit their new models with the hardware and basic software to support Fleet Managements System services.

Autonomous Vehicles set to be a game changer for the automobile industry

Similar to how the Autonomous Vehicles will change our driving experience, they are also expected to bring a major change to the automobile industry. The traditional competitive landscape of the automobile industry has OEMs, Tier 1 and Tier 2 suppliers both cooperating and competing against each other. However, the idea of autonomous vehicles has attracted new players to this decade-old industry. New players such as mobility providers, tech giants and speciality OEMs are also trying to grab a share of the automobile market. The industry is relying more and more on data and software, of which GNSS is a core sensor; it is here that these new entrants have an edge on the classic OEMs.

Synergies between these different players are also on the rise. Recently, multiple partnerships between OEMs, map makers, mobility and technology providers have been forged. As an example, Ford and Geely (Volvo cars), both traditional OEMs and Uber, a mobility provider, are cooperating to offer autonomous driven car-sharing services. Across the entire automotive industry, acquisitions and partnerships between traditional players and new technology entrants (e.g. Google, Apple, Lyft, etc.) are taking place.

Deployment of autonomous vehicles foresees different scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Conservative</th>
<th>Disruptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040s</td>
<td>Conditionally autonomous vehicles will account for 30-35% of new sales.</td>
<td>90% of new sales will be represented by fully autonomous vehicles.</td>
</tr>
<tr>
<td>2030s</td>
<td>18 mln sales of semi autonomous vehicles, first use cases of fully autonomous vehicles.</td>
<td>Fully autonomous vehicles sum up to 15% of new sales.</td>
</tr>
<tr>
<td>2020s</td>
<td>Large-scale testing of autonomous vehicles on public roads.</td>
<td>Fully autonomous vehicles launched on the market by tech giants and premium OEMs.</td>
</tr>
<tr>
<td>2016</td>
<td>Semi-autonomous vehicles tested on private and public roads supported by UNECE updating the 1968 Vienna Convention on Road Traffic.</td>
<td></td>
</tr>
</tbody>
</table>

FUTURE MARKET EVOLUTION

ROAD
EGNOS and Galileo contribute to road safety and security

Galileo will provide significant added value to the connected and autonomous vehicles of the future, thanks to its dual-frequency, high accuracy and Galileo’s unique authentication feature.

With these distinct features, (speciality-) OEMs, tech giants and software developers who are working on the cars of the future will be able to counter the threat of intentional and malicious GNSS interferences such as spoofing and jamming. In particular, Galileo’s authentication feature, which will be available on both the Open and Commercial Service, will provide effective means to detect spoofing for applications such as autonomous vehicles, RUC, digital tachograph and insurance telematics.

EGNOS improves GPS accuracy and provides information on the reliability of the positioning information. The successful use of EGNOS in the tracking and tracing of hazardous goods transport across Europe contributes to a more efficient and effective response in case of an emergency scenario.

Due to the reliability and augmented accuracy of the positioning signal, EGNOS also plays a vital role in the Road User Charging schemes in several EU Member States (e.g. Slovakia and Belgium) and it contributes to the precise localisation of vehicles involved in a collision or accident within the scope of the pan-European eCall initiative.

InLane project to deliver lane-level information to in-vehicle navigation

The consortium within the EU-funded InLane project is working on the fusion between computer vision and GNSS technologies in order to achieve the required level of positioning that allows the safe operation of autonomous vehicles.

The project is developing dynamic maps that receive real-time updates via the Cloud crowdsourcing techniques, with the aim to deliver up-to-date lane-level information to in-vehicle navigation. This will provide drivers the opportunity to choose not only the most optimal route to get to their destination, but also the most optimal lane. Especially in dense urban environments such as multi-lane roads and highways, these maps will contribute to the reduction of risk associated with last-minute manoeuvres associated with lane-changes.

More information on: http://inlane.eu/

TAXISAT project: results pave the way for successful commercialisation of WEpods self-driving shuttle components

The WEpods come without driving wheel, brakes or accelerator pedals and are undergoing final tests on public roads in the provinces of Gelderland and the North Rhine-Westphalia, the Netherlands and Germany respectively – while similar driverless pods are already being used on dedicated lanes on Heathrow Airport and Rotterdam.

In 2014, the navigation module of these driverless “pods” was designed within the TAXISAT project, demonstrated during the Citymobil2 project and are finally being commercialised under the WEpods brand, after final tests in the beginning of 2017. Once they will run commercially, the passenger will be able to book a seat through an app and specify their starting points and their destinations.

More information on: http://wepods.com/
Installed base of GNSS devices by region

Installed base of GNSS devices by type

Total revenue of GNSS device sales and services by region

Total revenue of GNSS device sales and services by type

- **EU28**
- **Non-EU28 Europe**
- **North America**
- **Asia-Pacific**
- **Middle East + Africa**
- **South America + Caribbean**

- **Personal Navigation Devices (PND)**
- **Road User Charging (RUC)**
- **Insurance telematics**
- **In-Vehicle Systems (IVS)**
- **eCall**
- **Advanced Driver Assistance Systems (ADAS)**
- **Smart Tachograph**
- **Fleet Management Systems**
- **Map software updates**
- **Connected vehicles**
- **Connected vehicles**

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