GNSS applications
- Smart mobility applications improve the efficiency, effectiveness and comfort of road transportation through:
  - Navigation: the most widespread application, providing turn-by-turn indications to drivers through Portable Navigation Devices (PNDs) and In-Vehicle Systems (IVS).
  - 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, processing this traffic information to be distributed to users and other interested parties.

- Safety-critical applications leverage precise and secure positioning in situations with potential harm to humans or damage to a system/environment:
  - In connected vehicles GNSS positioning will be integrated with the information coming from other sensors and communication technologies in in-vehicle systems (IVS), enhancing the safety and comfort of the driver.
  - Dangerous goods tracking can be done by transmitting GNSS-based positioning data on the vehicles, carrying them along with other information about the status of the cargo.

- Liability applications the positioning data provided by liability applications are linked to legal and economic liabilities:
  - In Road User Charging (RUC) GNSS-OBUs support toll operators in charging based on the actual use of the roads and in managing 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:
  - The GNSS-enabled IVS are used in regulated applications, such as the pan-European eCall or the ERA-GLOMAD in Russia, which send an emergency call to 112 in the case of an accident, thus accelerating emergency assistance to drivers.
  - Enhanced digital tachographs leverage GNSS positioning to support road enforcers, recording the position of a given vehicle at different points during the working day.

In this chapter
- Key trends: Regulated applications and new commercial solutions will further drive GNSS growth.
- Industry: List of main players by value chain segment.
- Recent developments: In-vehicle system shipments outnumbered PNDs for the first time in 2013.
- Future market evolution: New applications will double the size of the market in the next ten years.
- User technology: Development of standards and sensor fusion as enablers of emerging innovative applications.
- Focus on European GNSS: EGNOS and Galileo contribute to accurate and reliable positioning.
- Reference charts: Yearly evolution of GNSS devices’ installed base and revenues by segment and geographic area.

NEW! This issue of the GNSS Market Report includes a new application: Digital Tacograph.
Regulated applications and new commercial solutions will further drive GNSS growth

**Key market trends**

- Policy developments, fast pace of innovation, new applications and commercial advantages from positioning information will further drive market penetration.
- Implementation decisions in Europe and existing use cases confirm the competitiveness of GNSS as a road tolling solution.

GNSS-enabled applications in Road transportation provide different benefits to end users, including improvements to productivity, safety, and the monitoring of operations and goods. GNSS enables manufacturers and system integrators to offer many added value services e.g.:

- PNDs produce Floating Car Data processed in road traffic monitoring services.
- In-vehicle systems support cooperative ITS and other safety-critical applications.

Industry players install on board own devices in vehicles, as the added value provided by positioning information is higher than the cost of hardware.

The boom of applications is leading to GNSS penetration in the EU exceeding 100%. The most mature services will be supported by a single, multi-service GNSS unit. The need for more robust solutions and the economies of scale is paving the way to the commercialisation of multi-constellation and multi-frequency GNSS receivers in vehicles.

Existing opportunities continue the convergence with other GNSS segments, especially LBS, as smartphone applications are replacing PNDs.

*The uptake of eCall for heavy vehicles depends on future regulatory developments.*

**GNSS has become the preferred solution for electronic tolling**

Thanks to its flexibility, GNSS-based tolling is being increasingly adopted. With GNSS-based tolling, users can be charged based on different criteria (type of road, time, distance, vehicle type, level of emissions), all of which are easily modifiable over space and time. Other benefits of GNSS in complex new networks include low transaction costs, minimal environmental impact and additional revenues from value added services.

At the end of 2014, the unique flexibility of GNSS enabled Slovakia to scale up GNSS-based tolling network operations in only three months:

- The charged network increased 7.5 times from 2,477 to 17,762 kilometres.
- Covered roads were extended to all motorways, 1st, 2nd and 3rd class roads.
- Traffic of vehicles weighing more than 12 tons is monitored through GNSS on restricted roads.

Slovakia has experienced the largest extension of road tolling networks worldwide so far.

In addition to Slovakia, Germany, Switzerland and Hungary have successfully implemented GNSS-based tolling. Other countries are also leveraging the benefits:

- Belgium and Russia have launched similar projects implementing GNSS-based schemes.
- France, Finland, Bulgaria, Denmark, The Netherlands and Lithuania have all declared their interest in GNSS-based schemes.
The EU GNSS industry in the global arena

In Europe, the Road GNSS industry is concentrated in component and receiver manufacturers (48%), with North American and Asian manufacturers sharing the rest of the market. For system integrators, the European automotive industry plays a strong role, but behind Asia (see GNSS Market Overview section of the Report for more information). Key European market players are chipset manufacturers CSR and STMICROELECTRONICS, antenna manufacturer Laird, car manufacturers Volkswagen, FCA (Fiat), and tier 1 supplier Bosch.

* European companies
Value chain considers the key global and European companies involved in the GNSS downstream activities.
In-vehicle system shipments outnumbered PNDs for the first time in 2013

Since 2008, annual GNSS shipments worldwide have stabilised to 50 mln units per year thanks to the success of navigation solutions, in particular Portable Navigation Devices (PNDs). GNSS units provided by such companies as TomTom and Garmin accounted for almost 80% of shipments in 2008.

In the last five years, smartphones had a disruptive impact on the PND market.* This was in large part due to the improvement in GNSS receiver performance (e.g. AGNSS and multi-constellation), introduction of supporting technologies thanks to sensor fusion (e.g. dead reckoning), as well as the progressive increase in screen size and user friendliness of navigation apps for road navigation with pre-installed and self-updating maps.

The decrease in PND sales has been compensated by the growth of In-Vehicle Systems (IVS) shipments, which experienced an average annual increase of 11% from 2009 to 2013. Such growth is motivated by the commercial opportunities offered by IVS as a platform, enabling navigation and connected vehicles, as well as many other GNSS-enabled services that meet user demand for comfort, infotainment and safety. This trend means that automotive manufacturers, such as Toyota, General Motors, Volkswagen, Ford and Nissan, have become the largest system integrators of GNSS-based solutions.

A number of additional applications, including road user charging (RUC), insurance telematics and eCall, accounted for 3 mln additional units shipped in 2013.

*Smartphones are included in the LBS segment section of the GNSS Market Report.

A Short History of Road Navigation

*’80s: The aftermarket system called Etak was launched in the mid-1980s. It relied on dead-reckoning and mapping data stored on cassettes.

*’90s: Appearance of the first navigation systems using GPS and relying on maps stored on CDs.

*1998: Debut of PNDs such as Garmin StreetPilot, costing more than 500 dollars.

*2000s: Advent of navigation systems with maps stored on hard drives, including the first added value features like lane guidance and traffic information.

*2002: Telenav develops a mobile navigation product for Motorola phones using an external GPS receiver.

*2003: Navigator was created for BlackBerry 7520, RIM’s first GPS-enabled device.

*2007: The iPhone hits the market, paving the way for the boom in navigation apps.

*2011: Smartphones start to outperform dedicated devices in GNSS navigation performance.

*2013: While smartphone apps continue to boom, IVS shipments outnumber those of PNDs.
New applications will double the size of the market in the next ten years

The road navigation PNDs market has reached full maturity. In the coming years, In-Vehicle Systems (IVS) and smartphone apps with pre-installed and self-updating maps will progressively replace PNDs. In the future, automotive manufacturers will take advantage of IVS to provide value added services, such as connected and autonomous vehicles and other safety-critical applications.

PND manufacturers are reacting with the launch of HUD (head-up display) devices, including the Garmin HUD, which deliver navigation cues, along with such information as speed and time to destination while allowing the driver to keep their eyes on the road. HUD innovation is creating market opportunity for new players focused on usability and user experience, such as Navdy.

Regulated applications will drive further growth in the Road market for GNSS. In particular, eCall-like systems worldwide (such as ERA GLONASS in Russia) are foreseen to account for 30 mln shipments in 2020.

Among commercial applications, insurance telematics solutions are foreseen to progressively penetrate the market, with annual shipments hitting 5 mln units in 2020.

A look into the near future: GNSS supporting autonomous driving

Autonomous vehicles can take over activities traditionally performed by the driver, thanks to their ability to sense the environment, navigate and, if combined with connected vehicle solutions, communicate with other vehicles and road infrastructure. Widespread adoption of autonomous driving can reduce traffic accidents and improve traffic flow, as well as improve driver comfort.

Autonomous vehicles are enabled by the combination of different technologies and sensors, allowing the IVS to identify the optimal path of action. GNSS plays a key role by providing relevant inputs for integrated navigation, such as vehicle location and speed. Multiple constellation, horizontal protection levels and advanced detection techniques provided by computer vision or LiDAR will be combined to ensure the robustness of the final positioning.

This market generates huge business opportunities. Several automotive manufacturers are thus investing heavily in developing the technology. Already, the Mercedes S-Class Sedan is capable of following traffic, automatically braking and maintaining its lane. In 2017, General Motors is planning to launch a new Cadillac using advanced cruise control on highways. The magnitude of opportunities has also attracted new players to the automotive market, including Google and its Self-Driving Car.
Development of standards and sensor fusion as enablers of emerging innovative applications

Given the principle of GNSS positioning - with performances highly influenced by the conditions of the operational environment - and the need to ensure appropriate performance throughout the equipment’s lifetime, the development of standards and certification references on positioning performance is fundamental for device vendors and service providers, especially when it concerns safety-critical applications.

In this context, European Standardisation Organisations aim to produce standards for the use of geo-positioning services for navigation and localisation applications. These aim to produce procedures for the establishment of performances of road transport systems based on GNSS.

The development of such standards will certainly have a positive impact on future road ITS industry developments, especially in regards to the need to provide industry with the highest practicable degree of uniformity in the provision and operation of GNSS services.

Additionally, the automotive industry agrees on the future view of a sensors’ fusion, with GNSS as a core component, integrated into a car to provide enhanced positioning capabilities to be used with a plethora of innovative applications.

The combination of computer vision, 3D Maps, LIDAR, and pattern recognition technologies with GNSS enables the driverless car concept and other applications. Similarly, R&D projects have already demonstrated that the integration of GNSS with Vehicular Ad-Hoc Networks (VANET) communications allows the computation of “Local Protection Level” ellipses around the vehicle that can be used, for example, for safety-related applications.

The charts below show that GLONASS and Galileo are the most adopted constellations following GPS.* This is in light of the eCall and the ERA–GLONASS emergency call projects soon to be operational in Europe and Russia respectively. These projects aim to automatically send an emergency call to 112 in case of an accident, thus accelerating emergency assistance to drivers.

* For the methodology applied to the charts please go to page 15 of the Report.
EGNOS and Galileo contribute to accurate and reliable positioning

EGNOS improves GPS accuracy and provides information on the reliability of the positioning information. As a result, there are national RUC schemes already considering EGNOS (e.g. Slovakia and Belgium), and initiatives to track dangerous goods and to support the localisation of vehicles within the pan-European eCall initiative.

Galileo will bring immediate benefits to the Road segment by increasing availability through multi-constellation. In particular, applications in urban environments will be positively impacted. Galileo is expected to provide authentication, ensuring that the position is computed with a real satellite signal and not a spoofed one. This unique feature will enhance the level of security of applications such as RUC, digital tachographs and insurance telematics.

European EGNSS R&D Programmes support the competitiveness of the EU industry

GAIN paves the way to environmentally friendly road mobility

Innovative solutions such as GNSS can mitigate the negative economic, social and environmental impact of increasing road traffic.

The GAIN project implemented an Enhanced Active Green Driving (EAGD) system where Vehicle-to-Vehicle communication is integrated with positioning algorithms based on EGNOS/EDAS, detecting and mitigating multipath in urban areas. The GAIN dynamic information system allows more accurate real-time speed optimisation and reduced fuel consumption. In 2014, the solution was successfully tested in real scenarios, including roundabouts and crosswalk approaches.

More information at http://www.gain-project.eu

Source: GAIN project

FOSTER ITS to ensure more secure positioning and timing

The growth of liability critical applications such as RUC, insurance telematics and digital tachographs will require an increasingly secure positioning with respect to interferences like jamming or spoofing.

The FOSTER ITS project deals specifically with this need for robust positioning. Building upon the outputs of the TACOT project, FOSTER ITS is addressing solutions for attack detection and confidence in Position Velocity and Time (PVT) data by developing a secured multi-constellation GNSS module. Planned outcomes of this project include the rapid marketing of a multi-constellation module with different possible features, along with a development kit for system integrators to assess its performance.

Source: Courtesy of Siemens Electronic Tolling