Excerpt from the GNSS MARKET REPORT, ISSUE 5 (2017)
GNSS applications

Main Line Command & Control Systems assist train command and control on lines with high traffic density, referring primarily to the European Train Control System (ETCS) in Europe and some other regions across the world, as well as Positive Train Control (PTC) in North America. GNSS can also be a source of additional input, e.g. for enhanced odometry in ETCS or to support PTC.

Low Density Line Command & Control Systems provide full signalling capabilities supported by GNSS on lines with low to medium traffic. These lines are usually located in rural areas, where cost savings can be vital for the viability of a service.

Asset Management includes such functions as fleet management, need-based maintenance, infrastructure charges and inter-modal transfers. GNSS is increasingly seen as a standard source of positioning and timing information in these systems.

Passenger Information Systems on-board trains show the real-time location of a train along its route. Increasingly, the GNSS location of a train is also supporting platform and online passenger information services.

Driver Advisory System (DAS) uses real-time geo-location to help train drivers operate their trains (driver assistance). The goal of a DAS is to enable an optimised operation of train traffic.

What you can read in this chapter

- Key trends: GNSS enables safety increases and cost reductions.
- User perspective: GNSS is becoming a key enabler in safety and non-safety critical applications.
- Industry: List of main players by value chain segments.
- Recent developments: Driver Advisory Systems (DAS) adjusting the driving to optimise the traffic flow and save energy and money.
- Future market evolution: GNSS will become standard equipment within a decade.
- Focus on European GNSS: EGNSS on the way to be introduced in safety critical applications.
- Reference charts: Annual evolution of GNSS devices’ installed base and revenues by application and region.

GNSS enables safety increases and cost reductions

Key Market Trends
- GNSS is becoming a generic system widely used in non-safety relevant applications.
- GNSS based solutions can offer enhanced safety for lower cost, e.g. as investigated in railway signalling.
- GNSS begins to be implemented also for safety relevant applications with different maturity depending on the region, e.g. in India, China and the Middle East.

Different levels of maturity for GNSS consideration in Rail application
The way GNSS is used for train applications is different from one region to another. The number of initiatives in the world shows the consideration provided to Rail and GNSS developments.

In Europe, investigations are on-going to include GNSS as a complementing system for safety relevant operations in the frame of the European Rail Traffic Management System (ERTMS). As a strong demonstration of the willingness of Europe to consider GNSS as an innovative solution to decrease costs, GNSS technology has been included in the ERTMS roadmap and is referred to as one of the five key game changers of the future railway signalling systems. Shift2Rail, the first European rail joint technology initiative for the railways, has been launched as a concrete action to accelerate the integration of advanced technologies. This initiative will foster the use of GNSS in innovative rail product solutions.

In the US, PTC (Positive Train Control) implementation is on its way. PTC combines control, communications, and information systems safety, security, precision, and efficiency for train movements and includes GNSS as a technology for positioning of the train.

In the Asian region, India benefits from one of the largest railway networks requiring emphasis on the safety of the applications. Huge investments are planned by the Indian government and trials are on-going to deploy Satellite Imaging for Rail Navigation (SIMRAN) providing real time passenger information system thanks to GPS.

Russia developed an Integrated Train Protection System (called KLUB-U) using both GPS and GLONASS technologies for train positioning.

China is currently strongly investing in infrastructure modernisation with the construction of new railways. GNSS based localisation systems are already used on some rail lines. The entry into operation of BeiDou, planned in 2020, will contribute to the wider-scale deployment of such solutions, and not only in China.

Rail infrastructure in the Middle East and North Africa has experienced huge growth, especially regarding railway construction in the last 10 years, and with heavy investments planned ($200 bln). The champion in this region is Saudi Arabia where half of the investments were made, followed by Algeria and Qatar.

In the Rail segment, safety comes first
The introduction of rail applications must consider the constraints in the specific railway environment in order to find adequate solutions complemented by sensors for train positioning (e.g. limited satellite visibility due to tunnels, significant multipath or even electromagnetic interference).

Important work has been conducted for safety relevant rail applications to agree on rail safety relevant requirement matching with the expected performance requirements. Preliminary accuracy and integrity requirements have been identified within UNISIG, which is influencing also the development of ERTMS specifications for Command and Control Systems. Experimentations and measurement campaigns are underway to complete GNSS requirements with respect to rail safety applications.

The growth of GNSS adoption is expected to continue in non-safety relevant applications. Many rail freight cars, for which GNSS could be used in asset tracking, currently contain no power supply. Alternative solutions and their associated costs are investigated (such as battery and advanced receivers in terms of power efficiency).
GNSS is becoming a game-changer in safety and non-safety critical applications

Perspective Use of GNSS in Rail

GNSS is already used in applications in which people's safety is not at stake, such as passenger information applications, which are mainly mature applications.

The main axes of development for GNSS applications in Rail are safety relevant and liability relevant applications. The European GNSS differentiators can play a key role in these applications. Within the ERTMS framework, GNSS could be used as a means to introduce the virtual balise in the ERTMS ETCS Level 2/3 and to provide the train integrity monitoring function for the ETCS Level 3.

Outside the ERTMS framework, GNSS is already being deployed for train control most commonly in the USA, for Positive Train Control applications.

GNSS integration in safety relevant applications has reached different levels of maturity and readiness. Automatic train operation, ERTMS/ETCS and automatic train protection are still at a conceptual levels. Low density line signalling, train approaching warnings and traffic management are more advanced and close to be ready for operations.

Overview of the main user requirements in Rail

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.

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<th>Applications</th>
<th>Non-safety critical applications</th>
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<td>Asset management</td>
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<th>Key GNSS requirements</th>
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<td>Connectivity</td>
<td>Connectivity Power Consumption</td>
<td>Interoperability</td>
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<td>Consumption</td>
<td>(communication link)</td>
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ERTMS/ETCS Specifications

The European Rail Traffic Management System (ERTMS) initiative aims to provide a new generation of train control and signalling capabilities (ETCS - European Train Control System), which includes automatic train protection by continuously supervising train speed and braking.

ERTMS has two basic components:

- ETCS, the European Train Control System, is an automatic train protection system (ATP) to replace the existing national ATP-systems.
- GSM-R, radio system standard for signalling data transmission.

The ERTMS technology has different levels of capacity and performance. In level 1, 'Eurobalise' radio beacons transmit trackside signals as a movement authority to the train equipment. The maximum speed and braking curve are obtained and automatic train protection is ensured with these data. In level 2, it is possible to remove trackside equipment, as the trains automatically report, on a regular basis, their navigation data to a Radio Block Centre, which transmits back the next movement authority. Level 3 does not rely on trackside equipment for the train location and train integrity supervision.

ERTMS will intervene if the train over-speeds, to bring it back to safe levels. It works as a safe monitoring system that is supervising the speed of each train based on track and train data. Precise knowledge of the train speed, thus, is a central topic in the ERTMS developments.

In the year 2016, GNSS was identified as one of the key technological game changers of future ETCS, within which the virtual balise technology could potentially be included.
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
The rail industry is spread in Europe, Asia/Russia and North America, considering components and receivers as well as system integrators. European companies have a market share of 31% among components and receivers manufacturers, the market being dominated by North American companies. The top 3 European companies are: Septentrio, TE Connectivity and Erwin Kayser-Threde.

European companies are ranked at the second place among system integrators, controlling 33% of the market, where key operators have strong exports both to North America and Asia. The top 3 European companies are Alstom, AZD Praha and Siemens. Since Market Report 4, the EU share has decreased. This is primarily due to the acquisition of Ansaldo STS by Hitachi, Ansaldo STS controlling 35% of the market share on its own.

1 In the market share analysis, Europe is defined as EU28 plus Norway and Switzerland.
**Driver Advisory Systems (DAS): adjusting the driving to optimise the traffic flow and save energy and money**

**Driver Advisory Systems principles**
The DAS (Driver Advisory System) allows the exchange of information between the railway system and the human operator (the driver), with the purpose of optimizing the driving of the train. The on-train system calculates an energy efficient speed profile to achieve the pre-planned or dynamically updated train timings, and generates detailed driver advice to follow the profile and achieve the timings. The control centre is responsible for conflict detection and calculation of new target train timings. GNSS is used as one of the sensors in the DAS equipment.
The main applications targeted by the DAS system are:
- **Real time location** allowing traffic management by conflict detection and providing accurate location report.
- **Speed management** enabling low energy driving, increasing reliability on arrivals time and allowing proper management of braking before conflict.

The DAS systems can be classified into two main categories:
- **Standalone DAS** (S-DAS) has all data downloaded to train at or prior to journey start. It realises a static exchange of information.
- **Connected DAS** (C-DAS) realises a communications link to the Control Centre (or Traffic Management Centre) in each controlled area in which the train operates. This enables the provision of schedule, routing and speed restriction updates to trains in near real time, and also receipt of information from trains to the Infrastructure Manager control centre to improve regulation decisions. It aims to optimise the traffic flow of the railways as a whole by dynamic re-planning of the timetable to avoid conflicts.

**Markets Targeted**
The first market targeted by DAS is freight and low density line trains looking at savings in energy consumption. The second market of interest is passenger and high density line trains for which the benefits are obtained through line capacity optimisation and conflict management. As indicated by the analysis of CUBRIS made with the GREENSPEED product, one to several tens of million euros could be saved by speed management thanks to DAS.

**DAS market trends**
The number of installed devices has **quadrupled over the last 5 years**. While the standalone systems still dominate the market, the connected driver advisory systems have experienced a more important growth over the past.

DAS systems have been deployed mainly for freight traffic in Europe. Trials have been conducted in France, Germany, Sweden, Norway and Spain. DAS is deployed in the UK for diesel and electric high speed passenger trains and freight trains. 75% of the passenger trains are equipped with DAS in Denmark.

![Installed base of GNSS devices by application](chart.png)
The asset management application is expected to be driving shipments of GNSS devices. For around 220,000 trains in the world dedicated to freight, the number of wagons that could be potentially equipped with GNSS is around 2.8 million.

In the coming years, safety relevant applications (Signalling and train control) based on GNSS will be increasingly developed. These applications require a very high level of performance and depending on the strategy regarding those safety critical applications, GNSS may be used as:
- a primary means of localisation to enforce safe train movement in the US with PTC.
- a potential solution to deploy less Eurobalises while increasing location accuracy in Europe with ERTMS.

In any case, GNSS is to be considered as an innovative solution permitting to cut operational costs while increasing safety.

As an example, trackside equipment investment and maintenance such as balises or automatic block protection equipment (track circuit or axle counter) are very costly. GNSS is an opportunity to reduce reliance on balises and therefore to decrease infrastructure costs. At the same time, interoperability considerations must be carefully evaluated as is the case in the current on-going ERTMS work.

GNSS penetration is likely to continue to increase in the upcoming years. The availability of Galileo will also strengthen this trend as it solves possible sovereignty issues, being civilian operated, and it provides authentication on top of more accurate and more reliable position solutions in combination with other constellations.
EGNSS on the way to be introduced in safety critical applications

Galileo is in the starting block. The initial operational capability declared in December 2016 allows real experience of Galileo operational signals to foster the use of EGNSS by the railway community.

The multiconstellation environment, with interoperability of GALILEO with GPS, permits to enhance currently achievable performances especially regarding availability and accuracy. This will reinforce the use of GNSS in rail applications in the future.

ERSAT EAV: Looking at the harmonisation of the European ERTMS standard

ERSAT EAV project verifies the suitability of EGNSS (EGNOS and Galileo early services) for safety railway application, in particular in regional lines scenarios. In this context, a safe localisation of the trains, based on satellite technologies, will be defined and developed, leading the way for the harmonisation with the European ERTMS standard, by implementing the solution on a pilot line as reference. The ERSAT EAV project will prioritise the EGNSS uptake for the rail sector, fostering the competition and the innovation of the European space, rail industry and research community. It is also enhancing a strong coordination and synergy with the specific sector of European Railways and the main actors involved, building up a system centred on the ERTMS platform.

As of the 24th February 2017, the testing of the ERSAT EAV system has been completed in Sardinia. The end goal is to have this new technology approved and certified according to the standards on a European-wide scale, with the first line being activated in Italy by 2020.

GNSS penetration: Signalling and Train Control applications

GNSS penetration: Non-Safety Critical applications

GNSS penetration is defined as installed base of GNSS devices relative to the installed base that would prevail if every addressable user was fully equipped.

Installed base of GNSS devices by region

Revenue of GNSS device sales by region

Installed base of GNSS devices by application

Revenue of GNSS device sales by application