European pathways to introduce EGNOS and Galileo for dangerous goods transport

A. Di Fazio \textsuperscript{a,*}, D. Bettinelli \textsuperscript{a}, E. Louette \textsuperscript{b}, J.P. Mechin \textsuperscript{c}, M. Zazza \textsuperscript{d}, P. Vecchiarelli \textsuperscript{d}, L. Domanico \textsuperscript{e}

\textsuperscript{a}Telespazio S.p.A., Via Tiburtina 965, 00156 Rome, Italy
\textsuperscript{b}MEDDE – Ministère de l’Écologie, du Développement durable et de l’Énergie, Tour Séquoia, 92055 Paris-La Défense, France
\textsuperscript{c}CEREMA – Centre d’études et d’expertise sur le risques, l’environnement, la mobilité et l’aménagement, Rue Pierre Ramond – CS 60013, 33166 Saint-Médard-en-Jalles cedex, France
\textsuperscript{d}MIT – Ministero delle Infrastrutture e dei Trasporti, Viale dell’Arte 16, 00144 Rome, Italy
\textsuperscript{e}TTS Italia, Via Flaminia 388, 00196 Rome, Italy

Abstract

Every year the transport of dangerous goods amounts to more than 154 billion tonne-km on European roads, railways and inland waterways (source: Eurostat http://epp.eurostat.ec.europa.eu, year 2013). When speaking about dangerous goods movement, traceability and monitoring are not only a matter of an intelligent and efficient logistics. They also imply aspects related to security and safety, being a concern common to involved industries and authorities. For this reason, tracking & tracing the shipment of dangerous goods requires an efficient collection of timely and precise information about the various operations. Besides, reliability is a fundamental requirement, especially in the case of intermodal transport where different operators and modalities are involved. About 85% of the shrinkage in the overall supply chain occurs while materials, components or finished goods are in transit. In this respect, the satellite navigation technology is a key element, as it enables:

- The continuous localization, control and monitoring of goods traffic during transport.
- The collection of data to be further analysed for statistical reporting and incident prevention.

\footnotesize* Corresponding author. Tel.:+39-06-4079-6329; fax: +39-06-4099-9333.
\textit{E-mail address:} antonella.difazio@telespazio.com
Systems based on the use of satellite positioning are today widely adopted in the transport of dangerous goods operations. Tracking & tracing devices (installed on board of the asset transporting the goods) can also integrate sensors to enable the monitoring of the status of the goods and different telecommunication means (satellite and/or terrestrial) for positions/data transmission.

Various past and on-going European initiatives are also introducing the use of the European satellite navigation (EGNSS, European Global Navigation Satellite System), starting from EGNOS (European Geostationary Navigation Overlay Service) and in view of Galileo.

Among these initiatives, the project SCUTUM (SeCUring the EU GNSS adopTion in the damageUs Material transport, www.scutumgnss.eu) concluded in 2011, exhaustively and successfully demonstrated that EGNOS provides precise and reliable localization and tracking, and thus it is particularly suitable for monitoring the transport of dangerous goods. Today, thanks to SCUTUM, EGNOS is used to monitor around 1,200 road tankers transporting dangerous goods by road in Europe (Italy, France, Austria, Slovakia, Hungary, Romania, Czech Republic).

Capitalizing on SCUTUM’s achievements, the on-going project CORE, started in 2014 and with a duration of 4 years, is extending the use of EGNOS to the intermodal transport of dangerous goods, and analysing the advantages of the introduction of Galileo.

As done in SCUTUM, also CORE is expected to launch an operational best practice in Europe. Moreover, similarly to SCUTUM, the project’s results will feed the on-going UNECE OTIF WG (United Nations Economic Commission for Europe Organisation Intergouvernementale pour les Transports Internationaux Ferroviaires Working Group) on Telematics in relation to the use of telematics for the transport of dangerous goods, specifically for what the EGNSS is concerned.

**Keywords:** European satellite navigation; ITS; tracking & tracing; dangerous goods; safety; security; risks mitigation

---

### 1. Introduction: setting the scene

#### 1.1. Issues

An efficient freight transportation system helps support the economy. Getting goods from one place to another at a reasonable cost and with the minimum impact on the environment and communities is essential.

Carrying goods always involves the risk of traffic accidents, and if the goods carried are dangerous, there is also the risk of an incident, such as spillage of the goods, leading to hazards such as fire, explosion, chemical burn or environmental damage. The accidental events involving these goods have produced, in some cases, damages to the involved persons and to the environment on a vast scale.

Hence, when dangerous goods are involved in the transport, ensuring safety conditions is essential for the quality of people and freight transport. The notion of safety is applicable in two different sectors: either the transported people (passengers and staff) and the freight; or the exposed people and locations. Moreover, from the last decade, also the aspects related to security have been assuming particular relevance.

In this context, the attention of the authorities has been continuously growing towards the carriage of dangerous goods. Authorities are working with the freight industry, with the common objective of minimising the risks of incidents. Various actions have been undertaken and are conducted by authorities through complementary measures at different levels:

- At regulatory level, by establishing effective and proportionate regulations to ensure goods are moved safely and securely across their country. Particularly security regulations are part of wide efforts to help the freight industry in protecting itself against a range of threats including theft, deliberate sabotage and acts of terrorism.
- At policy level, by encouraging freight transport companies to choose to transport freight by rail or water rather than road, though the risk associated to the rail transport of dangerous goods is major with respect to road (source: SECTRAM – Sicurezza nel Transporto Merci).
• At cross-border operations level, by developing/agreeing on common working methods and rules for a smooth cooperation beyond borders with the goal of facilitating the monitoring and the supervision of the dangerous goods traffic flows, of reducing the risks of dangerous situations and incidents.

• At technological level, by incentivising the use of telematics solutions and advanced technologies in order to enhance the supervision and monitoring of the dangerous goods movement for prevention purposes, and to improve the emergency operations in the case of an accident. The objectives of the authorities are on one hand to avoid serious accidents and on the other hand to minimise possible damages. When an accident occurs, these substances may be a threat to people and the environment and thus the authorities must quickly precisely know where the accident happened, and find out whether the cargo contains explosive, corrosive, radioactive or flammable substances. In this respect, grants and public funds have been put in place for national projects in the Intelligent Transport Systems (ITS) frameworks, to support the development and set-up of operational systems. Moreover, authorities have been and are already today involved in various European and international research initiatives to exchange their national experiences, to share best practices and to define common guidelines.

1.2. Market size

In 2013, the volume of dangerous goods traffic in Europe was more than 154 billion tonne-kilometres in the different land modes of transport (i.e. road, railway and inland waterways/rivers), of which over 77 billion tonne-kilometres were carried by roads with flammable liquids taking a major share. Next figure shows the % in tonne-kilometres of different categories of dangerous goods transported by road source: Eurostat year 2013).

![Fig. 1. Share of dangerous goods by road (by type, % in tonne-kilometres).](image)

1.3. Regulatory framework

Dangerous goods are assigned to different classes depending on their predominant hazard. The United Nations (UN) classifies dangerous goods in nine classes and, where applicable, sub-classes.

There are regulations to deal with the carriage of dangerous goods, the purpose of which is to protect everyone either directly involved (such as consignors or carriers), or who might become involved (such as members of the emergency services and public). Regulations place duties upon everyone involved in the carriage of dangerous goods, to ensure that they know what they have to do in order to minimise the risk of incidents and guarantee an effective response.
Carriage of dangerous goods in Europe is regulated internationally by agreements and European Directives, with biennial updates for taking account of technological advances. Parallel legislation and safety requirements are implemented by Member States via domestic regulations which typically directly refer to the technical agreements.

In order to ensure consistency between all these regulatory systems, UN has developed mechanisms for the harmonization of hazard classification criteria and hazard communication tools, and of transport conditions for all modes of transport. In response to the terrorist attacks in the United States on 11 September 2001, the UN updated the existing applicable agreements and European Directives adopting further recommendations to make sure dangerous goods are carried as securely as possible. Additionally, the UNECE (United Nations Economic Commission for Europe) is in charge of administering regional agreements that ensure the effective implementation of these mechanisms as far as transport of dangerous goods by road, rail and inland waterways is concerned. In the frame of UNECE’s activities a Working Group (WG), the UNECE OTIF WG on telematics has been established specifically with the aim to elaborate guidance and to outline high level specifications and reference architectures for the development of technological solutions, to support the authorities in supervising and monitoring the movement of dangerous goods and in the oversight of the relevant traffic and flows across their territory and at the cross-borders. This also includes the analysis of the use of tracking & tracing systems, combining positioning technologies and sensors, allowing a continuous localisation along with information on the status of the transported goods and anomalous conditions occurrences. In this respect, UNECE OTIF WG on telematics has completed a “Who does what” table setting out who needs which information and when, in the carriage of dangerous goods and defining what information can be provided by the tracking & tracing systems. Presently UNECE OTIF WG is working on the definition of an architecture/message standard for a telematics system to deploy the electronic transport document and to improve emergency information management in transport of dangerous goods. This is based on the concept of Trusted Parties (TP), two TPs (TP1 and TP2) are foreseen, the first acting at institutional level while the second acting at commercial level and exchanging information.

1.4. Use of satellite navigation for tracking & tracing systems

Tracking & tracing systems are largely adopted in the freight transport and logistics sectors, especially those based on the satellite navigation (GNSS – Global Navigation Satellite Systems) and the GPS (Global Positioning System) are the most used. They also offer a wide range of applications and services, with resulting advantages in terms of enhanced efficiency. Moreover, when dangerous goods are transported, traceability and monitoring are not only a matter of an intelligent and efficient logistics, it is also a question of safety and security. The benefits are not only from the perspective of transportation providers but also from the perspectives of the authorities and the involved public entities.

To give some quantitative figures, two studies can be mentioned:

---

1 For land transport they are:
- Accord européen relatif au transport international des marchandises dangereuses par route (ADR), for the transport of dangerous goods by road;
- Accord européen relatif au transport international des marchandises dangereuses par voies de navigation intérieures (ADN) for the transport of dangerous goods by inland waterways;
- Règlement concernant le transport international ferroviaire des marchandises dangereuses (RID) for the transport of dangerous goods by rail (OTIF);

2 UNECE is a forum for the countries of North America, western, central and Eastern Europe and central Asia. UNECE’s mission is to promote the sustainable transport which is safe, clean and competitive, through the development of freight and personal mobility by inland transport modes, and though the improvement of traffic safety, environmental performance, energy efficiency, inland transport security and efficient service provision in the transport sector.

3 Organisation Intergouvernementale pour les Transports Internationaux Ferroviaires.

The “CIP Report” (a monthly publication issued by the Centre for Infrastructure Protection and Homeland Security based in the United States). Joe McKinney and Arthur Radford affirmed that the availability of precise information about supply chain activities results in average cost savings from supply chain operations of 3% to 5% and inventory investment savings of 7% and more. These savings combined will reduce unit costs of goods sold by an average of 0.5%.

A Swedish study “Assessment of Telematic Systems for Road Freight Transport” (from the School of Computing Blekinge Institute of Technology Sweden). According to this study, the monitoring of sensitive goods enables to reduce the costs related to transport administrations by 5%, the total number of heavy goods vehicles related road accidents by 0.2% and moreover, more information will lead to about 0.1% reduction in the costs of missing and delayed goods.

2. The European Global Navigation Satellite System (EGNSS)

EGNSS is the Europe’s initiative for a state-of-the-art GNSS, and it includes EGNOS (European Geostationary Navigation Overlay Service) and Galileo.

EGNOS is a regional system and it is the first pan-European satellite navigation system. EGNOS is a Satellite-Based Augmentation System (SBAS) that augments the GPS by providing correction data that enable to improve GPS position accuracy, and integrity information about the GPS system. EGNOS is operational and it is offering the following services:

- **EGNOS Open Service (OS)**, launched in 2009, is delivered free of charge for use by anyone with an EGNOS-enabled or SBAS-compatible receiver. Being based on GPS frequencies and complementary signal design, the EGNOS signal does not require major changes for receivers. Today, many mass-market receivers available on the market are also EGNOS-enabled. EGNOS OS is particularly suitable for mass market and some applications like surveying.
- **EGNOS Safety-of-Life Service (SoL)** is authorized for European civil aviation and operational since March 2011. EGNOS SoL delivers the integrity message verifying the usability of the GPS system and providing timely warnings (within six seconds) when the system or its data should not be used for navigation.
- **EGNOS Data Access Service (EDAS)** launched in 2012, delivers a terrestrial commercial data service that is particularly suitable for professionals. It consists of a server that gets data directly from the EGNOS system and disseminates them via terrestrial networks in real time, with a guaranteed maximum delay, security, and performance. Software solutions connect to EDAS and use its provided data to implement products and value-added services built on them. For example, service providers can deliver EGNOS data via different telecommunication means, augment EGNOS OS performances to improve its availability and GPS position accuracy, or qualify and guarantee the GPS position information by exploiting EGNOS’s integrity feature.

Galileo will provide a highly accurate, guaranteed global positioning service specifically designed for civilian purposes, to its users worldwide. Additionally, while providing autonomous navigation and positioning services, Galileo will assure interoperability with the GPS – USA and Global Navigation Satellite System (GLONASS) – Russia, the two other already deployed global satellite navigation systems as well as with Beidou, the global Chinese GNSS system. The fully deployed system established under the Galileo programme will consist of 30 satellites and the associated ground infrastructure.

Though conceived for aviation, EGNOS has concrete perspectives of utilization also in other markets. Through its services, EGNOS gives opportunities for users to have more accurate and reliable positioning, for enhancing existing applications and developing new ones. Because of their capability to provide more precise and trustable information on the position with respect to GPS-only, EGNOS OS and EDAS are particularly suitable for transport applications (such as road, freight transport and logistics) requiring accurate and reliable positioning. Moreover, the use of EDAS enables to further enhance the performance and data with greater added value than those obtained through EGNOS OS only.

For the freight transport market, EGNOS OS and EDAS empower the tracking & tracing systems based on GPS, they enhance the real-time positioning and provide a more robust and reliable traceability. In the case of the
dangerous goods transport, this is an advantage for both the involved business operators and authorities, in terms of higher safety and security.

3. Use of EGNOS for tracking & tracing systems: the state-of-the-art

Over the past decade, the European Commission (EC) has incentivized the development of solutions and applications based on EGNSS, starting with EGNOS today and in the perspective of Galileo. Today products and solutions using EGNOS OS and EDAS, and ready for Galileo, are available on the market for commercial and professional applications, such as tracking & tracing of professional and regulated fleets, intermodal (road/rail/maritime) asset tracking (containers and tankers), city logistics, monitoring of vehicle transiting/movements in limited traffic areas.

The dangerous goods transport is a very promising and mature market in relation to the use of EGNOS, thanks to the value that it can give and the benefits that can be generated. In this market, the European efforts have brought to successful and tangible results, and best practices of EGNOS use in operation are in place.

A European Research & Development (R&D) project, named SCUTUM and ended in December 2011, demonstrated that, for the transport of dangerous goods, EGNOS adds value to GPS, thanks to its ability to provide a more accurate and reliable traceability with respect to GPS only. This results in higher confidence in the monitoring and supervision and position information. The generated benefits are in higher safety and efficiency, thus possibly supporting a “smart” transport of goods and the establishment of liability schemes among the various stakeholders along the supply chain (e.g. consignors, transport operators, emergency responders, enforcement and control authorities, and regulators).

Next figures show the system for tracking & tracing the transport of dangerous goods by road developed in SCUTUM, and the scheme of the tracking device installed on board of the tanker.

![Diagram of SCUTUM system for tracking & tracing the transport of dangerous goods by road.](image-url)
EGNOS augments the GPS signal. It provides more precise positioning services (up to 3–4 metres) and in addition, it gives users information on the reliability of the GPS signals (‘integrity data’).

As above mentioned, though designed for use in aviation, EGNOS services have interesting applications also in other transport non-aviation domains. EGNOS OS and EDAS are suitable for transport and mobility applications in the ITS sector, particularly for those applications requiring accurate and reliable positioning.

The receivers today integrated in operational systems/tracking devices are enabled to use EGNOS.

Software solutions and technologies are needed to utilize EDAS, and they allow to build/offer commercial value added services exploiting EGNOS features. There are software solutions and technologies ready and available on the market.

The next figure presents one of the outcomes of extensive trials conducted in various road environments in the frame of the SCUTUM project.

Users of the EGNOS OS get an enhancement to the accuracy of the position measured with GPS of approximately three metres. EDAS could bring further enhancements by approximately four metres. Moreover, the use of EDAS provides an information (called ‘protection level’ and obtained by suitably processing the ‘integrity data’ of EGNOS) for qualifying/guaranteeing the measured position.

Moreover, SCUTUM also carried out a technical standardization with the support of CEN (European Committee for Standardization), leading to the elaboration of a CEN Workshop Agreement (CWA) named “CWA 16390 Interface control document for provision of EGNOS CS/EDAS based services for tracking and tracing of the transport of goods”. CWA 16390 is the technical specification for the development of products and applications based on EDAS. CWA 16390 specifies the minimum data (and relevant type) to be exchanged and allowing to use EDAS. Through CWA 16390, SCUTUM also contributed to UNECE OTIF WG. Published in 2012, CWA 16390 is presently adopted in Italy in commercial operational systems for tracking & tracing road tankers transporting hydrocarbon (for example, SITIP II – Sistema Informativo Telematico Integrato dei Porti Pugliesi II). CWA 16390 is being successfully used in the French project GeoTransMD (GEOlocalisation des TRANSPORTs de Matières Dangereuses), and it has been recently validated also for tracking & tracing the shipment of intermodal (road/rail/maritime) containers.
Today, because of SCUTUM, EGNOS is used in the operational transport of dangerous goods by road in Europe (Italy, France, Austria, Slovakia, Hungary, Romania, Czech Republic), and around 1,200 road tankers are monitored with GPS+EGNOS (the tracking devices installed on-board of the vehicles are enabled to use EGNOS OS and EDAS).

Moreover, SCUTUM also explored other applications/domains for EGNOS in the short term in Europe and in preparation of the global market for Galileo. In particular, the rail transport of dangerous goods was considered by SCUTUM as the next promising step, being rail the sector beside road where EGNOS opportunities have to be exploited further.

4. Use of EGNOS for tracking & tracing systems: the way-forward

Capitalizing on these outcomes, in the frame of the ongoing European project CORE\(^5\), the experience of SCUTUM is extended to the intermodal road/rail transport of chemicals and gas shipped across Europe. The goal is to:

- Develop a demonstrator for the tracking & tracing of intermodal tankers, based on the SCUTUM system enhanced for a multi-GNSS environment (positioning obtained with GPS+EGNOS is expected to be more robust with a multi-constellation GNSS, such as GLONASS and Galileo, thanks to the availability of more satellites in view).
- Prove and validate the developed demonstrator in real business cases.
- Further contribute to UNECE OTIF WG as far the role and added value of the continuous localization and tracking & tracing information in the TP1/TP2 architecture are concerned.

Next figure shows the demonstrator that will be set-up in CORE for tracking & tracing the intermodal transport of dangerous goods.

\(^{5}\) Consistently Optimised Resilient Secure Global Supply-Chains, www.coreproject.eu
The demonstration will be carried out with the involvement of HOYER, a European transport company operating in the sector of chemical and gas, in real business cases of tankers transporting Argon from Duisburg (Germany) to Terni (Italy), and from Linz (Austria) or Lyon (France) to Terni (Italy). This will be done through real-life operations/demonstration, in terms of technical indicators, user satisfaction, economic and social benefits, identification of existing gaps and definition of possible future improvements, by analysing the gathered feedbacks and collected results.

More specifically the demonstration will:

- Prove the advantages of the precise and trustable information on the position for the intermodal transport operations where a variety of heterogeneous stakeholders is involved in different operations and transport modalities, and validate the generated benefits in terms of higher efficiency, safety and security, improved traffic management, incident prevention and risk management.
- Contribute to standardization in relation to the use of EGNSS based telematics for the transport of dangerous goods. In this respect, an enhancement of CWA 16390 is planned to consider EGNOS system evolutions and Galileo entering into operations.
- Contribute to UNECE OTIF WG, also thanks to the involvement of the Ministry of Transport of France and the Ministry of Transport of Italy. The architecture of the demonstrator will be conceived and designed in line with TP1/TP2 with T3 Platform acting as TP2, GeoTransMD acting as a French TP1, and SITIP II acting as an Italian TP1. In this respect, this CORE demonstrator will be a proof-of-concept of the benefits generated by tracking & tracing, and particularly by reliable information obtainable thanks to the use of EGNSS, specifically in cross border operations.
5. Conclusions

Safety and security can be greatly enhanced synergistically when encouraging all businesses to start robust and reliable real-time tracking & tracing of their shipments of dangerous goods. The newly available “precise information” about the status of a certain dangerous material (and of potentially dangerous events that occur currently unnoticed) represents fertile ground for many operational and relational improvements in business. At the same time a few crucial pieces of data can be provided to regulators that are responsible for public security.

Tracking & tracing systems can improve the efficiency and the safety of connecting products with the consumers who buy them each and every day. When dangerous goods are transported, the benefits are not only from the perspective of transportation providers but also imply public and social interests. Presently GPS tracking continues to be the most used solution.

In the last decade, various European projects have developed and extensively proven various solutions based on the EGNOS technology, especially for applications and markets for which safety, security and liability play a dominant role. In fact, EGNOS enhanced positioning and integrity provide precise and reliable localization and tracking, and thus meet the challenge of regulations and qualified transport services.

In the frame of the ongoing European project CORE, the experience of SCUTUM is extended to the intermodal road/rail transport of chemicals and gas shipped across Europe and to include also multi-constellation GNSS technologies.

The standardization is one of the key element enabling to turn from prototypes into products, from proven demonstrations into fruition. Therefore, CORE also contributes to standardization and through it also to relevant regulatory initiatives.

Moreover, CORE will perform technical demonstration and benefits validation of using GPS + EGNOS and Galileo (also in a multi-constellation environment) to validate generated benefits in terms of higher efficiency, safety and security, improved traffic management, risk management and incident prevention.

References

CEN (European Committee for Standardization) https://www.cen.eu.
School of Computing Blekinge Institute of Technology Sweden, “Assessment of Telematic Systems for Road Freight Transport”.
The “CIP Report”. Centre for Infrastructure Protection and Homeland Security of US.