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CORE case study: Key Performance Indicators for assessing a satellite navigation-based solution for tracking & tracing the transport of dangerous goods

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Abstract

CORE is a research project co-funded by the European Commission under the 7th Framework Programme. CORE analyses the aspects related to the use of advanced technologies for the freight transport and the logistics, to enhance the visibility and improve the security. The project implements various pilot demonstrations to prove and make concrete verifications in real use cases and along European and intercontinental logistic chains. One of the CORE's pilot demonstrations concerns a solution integrating GNSS (Global Navigation Satellite Systems) technologies for tracking & tracing the intermodal transport of chemicals and gas throughout road-rail paths across Europe. The developed solution is operated in real business cases/operations and evaluated through KPIs (Key Performance Indicators). In this paper, first an overview of the role of GNSS technology for tracking & tracing the transport of dangerous goods is given, then the CORE solution and demonstration, and the KPIs for the relevant evaluation and assessment, are presented.

Keywords: Dangerous goods, tracking & tracing, GNSS, transport safety, transport security, KPIs, business stakeholders, authorities.

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2. Introduction

Dangerous goods transport regulations aim to protect everyone either directly involved (consignors or carriers), or who might indirectly become involved (emergency services, public). Regulations assign duties and define rules, for minimising the hazards related to the carriage and the risk of incidents, and guarantee an effective response. Current regulations envisage paper form documents, for the purposes of transport operations, law enforcement and accidents (retrieved by police and emergency services).

Today, the majority of the companies transporting hazardous materials by road and rail have tracking & tracing solutions/services (based on satellite navigation), which gather in electronic form most of the information required in the paper transport documents.

Over the last few decades, there has been a growing awareness of the authorities towards the benefits generated by the adoption of these solutions on a large scale, for:

- Enhanced efficiency, safety and security (improved law enforcement and risk assessment, reduced accidents/relevant consequences, environmental damage and emergency response time);
- Introduction of electronic (digitalised) transport documents.

Various initiatives have been developed in Europe to:

- Increase the reliability of the tracking & tracing solutions/services through advanced technologies (e.g. based on the European GNSS[1] and on multiconstellation capabilities);
- Validate the use of telematics to meet regulations and encourage the adoption of electronic transport documents.

However these initiatives are fragmented, geographically spread, lacking of a common/harmonised approach for a technical/functional architecture and standards, at national and international levels. Moreover, they require information sharing by the involved business actors and stakeholders, without robust incentive models.

In this context, the on-going European research project CORE[2], launched in 2014 with a duration of 4 years and focused on the security of the freight/transport/logistics, develops various market lead demonstrations. One of them concerns the development/validation of a tracking & tracing solution based on GNSS technologies for the intermodal transport of chemicals and gas throughout road-rail paths across Europe.

Coordinated by Telespazio (one of the world's leading players in satellite services), the demonstration involves HOYER (a European transport company operating in the sector of chemicals and gas) as a business stakeholder/transport operator, the authorities/regulators from Italy and France (the Ministry of Transport of Italy and France), ERF (European Union Road Federation) and TTS Italia (Italian ITS[3] Association).

CORE demonstration is an end-to-end validation in real business cases/operations and cross border operations in two European countries: the road/rail transport of Argon through tank containers from Duisburg (Germany) to Terni (Italy) and from Linz (Austria) or Lyon (France) to Terni (Italy). Moreover, multiconstellation GNSS[4] technologies are used, based on the American system GPS[5], the European systems EGNOS[6] and Galileo, the Russian system GLONASS[7] and the Chinese system BeiDou.

The CORE tracking & tracing solution will be evaluated through KPIs, in order to assess its flexible architecture and standards, its capability to support best practice involving different countries, its generated advantages/benefits and impacts for the different stakeholders.

In this paper first an overview of the role of GNSS technology for tracking & tracing the transport of dangerous goods is given, then the CORE solution and demonstration, along with the KPIs for the relevant evaluation and assessment are presented.

3. Use of GNSS for tracking & tracing the transport of dangerous goods

The logistics and freight transport market has a huge potential for services based on GNSS.

GNSS solutions for monitoring, tracking & tracing the transport of goods are widely available on the market, and largely adopted in operations, with resulting benefits in terms of increased efficiency and safety.

As proven in many European research projects, the advantage generated by the use of EGNSS, EGNOS and Galileo, particularly when combined with other GNSS (i.e. the Russian GLONASS and the Chinese BeiDou) is to provide a more precise and reliable position information with respect to the use of the American GPS alone.

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[1] EGNSS
[2] Consistently Optimised Resilient Secure Global Supply-Chains, 7th Framework Programme, www.coreproject.eu
[3] Intelligent Transport Systems
[4] Multi-GNSS
[5] Global Positioning System
[6] European Geostationary Navigation Overlay Service
[7] GLObal NAvigation Satellite System

For the transport of dangerous goods, the use of GNSS is not only a matter of intelligent and efficient logistics, it also implies social interests for the involved authorities. Today, the majority of the companies transporting hazardous materials by road and rail have GNSS-based tracking & tracing solutions/services. Furthermore, over the last few decades, there has been a growing awareness of the authorities in order to validate and support the relevant adoption on a large scale, for regulatory, law enforcement and risk assessment purposes.

4. The CORE demonstration

The CORE project has developed a solution using multi-GNSS/EGNOS for the transport of chemicals and gas, aimed to:

- Perform a technical demonstration of the value of 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;
- Validate the generated benefits in terms of higher efficiency, safety and security, improved traffic management, incident prevention and risk management.

The next figure shows the architecture of the CORE solution for tracking & tracing the intermodal transport of dangerous goods via road/rail tankers. The solution is built on elements based on existing facilities/state-of-the-art components, purposely enhanced/integrated with new developments.

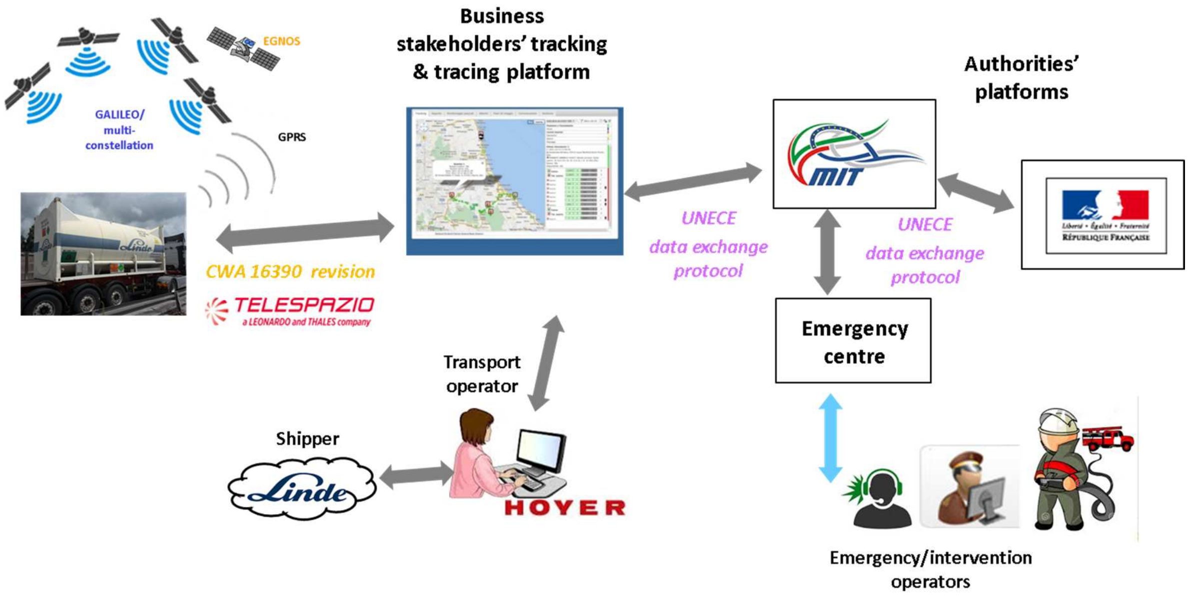

Fig. 1 Architecture of the CORE tracking & tracing solution

The tracking device installed on the tanker integrates a new-generation multi-GNSS (i.e. GPS/EGNOS/GLONASS/Galileo/BeiDou) receiver[8].

The tracking device measures the position through the multi-GNSS receiver with EGNOS activated in compliance with the CEN[9] Workshop Agreement CWA 16390 revision and the status of the transported products through sensors.

CWA 16390:2012[10] is the technical specification for the development of solutions and applications based on the services provided by the European GNSS EGNOS for tracking and tracing the transport of goods. Following its publication in 2012, CWA 16390 was adopted by several European industries, and used by France's and Italy's Ministry of Transport in their national/regional systems for the management of dangerous goods transport. In parallel with the development of the solution and with the demonstration, CORE has undertaken a standardisation process consisting in the revision of CWA 16390. The relevant outcome, i.e. CWA 16390:2018[11] (revision of CWA 16390:2012), takes into account obsolescence due to the evolution of the EGNOS services and to also

[8] Multi-GNSS receivers are today available on the market for mass-market/professional/automotive applications.
[9] European Committee for Standardization
[10] CWA 16390:2012, ftp://ftp.cen.eu/CEN/Sectors/List/ICT/CWAs/CWA16390.pdf
[11] CWA 16390:2018, https://www.cen.eu/WORK/AREAS/ICT/Pages/default.aspx

include aspects related to the configuration of the chipsets, to multi-GNSS features and the utilisation of Galileo Open Service authentication.
The data (i.e. position compliant with CWA 16390 revision and sensors' measurements) are sent to the tracking & tracing platform of the business stakeholders, which is also able to deliver information about the reliability of the position using EGNOS through a service provided by Telespazio.
The position (and the information on the relevant reliability) and the sensors' measurements are transmitted to the platform of the Italy's Ministry of Transport and here they are:

- Elaborated by means of risk assessment/prevention tools/functionalities, for the monitoring and surveillance of the transport of dangerous goods in country, and for alarm raising in case of anomalous conditions;
- Dispatched to the emergency centers for the activation of the necessary interventions;
- Forwarded to the platform of the France's Ministry of Transport for cross-border freight flows monitoring and control.

The CORE solution is compliant with the architecture defined by the UNECE[12] WG[13] that is updating the regulations for the international transport of the dangerous goods[14], and envisaging the exchange of data between the platforms of business stakeholders and the platforms of the authorities within a country and among countries.
In this way, the CORE's results:

- Verify the advantages of multi-GNSS/EGNOS in terms of reliability and enhancement of transport's safety;
- Validate/contribute the architecture and data exchange of the UNECE joint WG on telematics;
- Support the revision of CWA 16390 undertaken by UNI[15], and propose the relevant integration in the UNECE data protocol.

At present, the CORE solution is being validated in a demonstration phase carried out with the involvement of HOYER in the role of business end-user, and the Ministry of Transport of Italy and France in the role of national authorities.

5. The use/business cases of Argon

As above introduced, the demonstration is based on real business cases of tankers transporting Argon from Duisburg (Germany) to Terni (Italy), and from Linz (Austria) or Lyon (France) to Terni (Italy).
The choice of business cases has been based on a combination of commercial interests from HOYER, operational constraints and for including Italy/France cross-border paths.
In the starting phase of the project, it was immediately clear that HOYER would have chosen a use/business case based not only on the product, but also on the routing as they would need to have the possibility to monitor the tank containers and have access to them regularly during the demonstration phase.
The main criteria HOYER took into consideration to decide which use/business case would have been the best option for this project were the following:

- More European countries interested by the transport (Italy to be one of them);
- Intermodal way of transportation (railway/road);
- Dedicated business (in the dedicated business the tank containers are always on the same routing for the same customer and same product);
- Product sensible to pressure and/or temperature;
- Product classified as dangerous goods was a preferred solution, as HOYER is transporting around 500.000 tons of dangerous goods per year, and these kinds of products are more sensitive to changes compared to not dangerous one.

Based on these requirements, the choice was the Argon case.
Argon is a noble gas, colourless, odourless, non-flammable and nontoxic as a solid, liquid, and gas. Argon is chemically inert under most conditions and forms no confirmed stable compounds at room temperature. It is produced industrially by the fractional distillation of liquid air.
Argon is mostly used as an inert shielding gas in welding and other high-temperature industrial processes where ordinarily non-reactive substances become reactive. For example: an Argon atmosphere is used in graphite electric furnaces to prevent the graphite from burning, Argon is used in incandescent, fluorescent lighting and glow starters, Argon is used in other gas discharge tubes and it makes a distinctive blue-green gas laser.

[12] United Nations Economic Commission for Europe
[13] Working Group
[14] UNECE WG in telematics for dangerous goods
[15] Ente Italiano di Normazione

Although used more commonly in the gaseous state, Argon is commonly stored and transported as a liquid, affording a more cost-effective way of providing product supply.
Liquid Argon is a cryogenic liquid. Cryogenic liquids are liquefied gases that have a normal boiling point below –90°C. Liquid Argon has a boiling point of –186°C. The temperature difference between the product and the surrounding environment, even in winter, is substantial.
Keeping the surrounding heat from the product requires special equipment to store and handle cryogenic liquids. Transport needs cryogenic tank containers, constructed, in principle, like a vacuum bottle. The tank containers are designed to keep heat away from the liquid that is contained in the tank. Vaporisers convert the liquid Argon to its gaseous state.
HOYER tank containers are, for this kind of transport, cryogenic tank containers and this type of tank container have been used for this use/business case. They are 20' ISO[16] frame tank containers which means that they have standard measures and that they can be used for intermodal business without any dimension restrictions.
Due to the characteristics of this product, it is classified as follows:

- Hazard Class: 2.2;
- Identification Number: UN1951;
- Proper Shipping Name: Argon, Refrigerated Liquid, 2.2, UN1951.

The hazards associated with liquid Argon are:

- Exposure to cold temperatures, which can cause severe burns;
- Over-pressurisation due to expansion of small amounts of liquid into large volumes of gas in inadequately vented equipment;
- And asphyxiation due to displacement of oxygen in the air in confined work areas.

The use/business cases selected for CORE are related to transport performed for Linde (shipper) and have the following routing:

- Loading on site (e.g. Duisburg – D) day A;
- Rail on the same day (day A);
- Germany – Italy – A/C: arrival day C in the morning;
- Unloading in Italy: day C in the afternoon;
- Arrival back to Germany: day E (the tank is then ready to load again).

Hence, the entire roundtrip is completed within 5 days.
Currently HOYER has 25 dedicated Argon tank containers on this routing, for 2 different customers. Some of them are used for the CORE demonstration.
The loading and unloading places are not connected to the railway terminal. Hence HOYER needs first to drop off the tank from the production site to the terminal by road (by means of a truck and a chassis), and again at destination from the railway terminal to the unloading site.
Loading and unloading are performed by the drivers.

6. KPIs

As above mentioned, the demonstration is presently on-going. Launched in April 2017, it will run until end of April 2018. Technical data/parameters and feedbacks/inputs from the involved stakeholders are being collected and analysed in order to evaluate and assess the CORE tracking & tracing solution, in terms of architecture's flexibility and standards, capability to support best practice involving different countries, generated advantages/benefits and impacts for the different stakeholders.
For this purpose, the following KPIs have been identified:

- KPI 1 - Usefulness of the information/sensor information
- KPI 2 - Position Information Accuracy
- KPI 3 - Position Information Guarantee
- KPI 4 - Continuity
- KPI 5 - Robustness
- KPI 6 - Costs-capital expenditure
- KPI 7 - Costs-operational expenditure
- KPI 8 - Economic benefits
- KPI 9 - Social benefits.

Their formulation has been done on the basis of the considerations and the expectations of the involved

[16] International Organization for Standardisation

stakeholders, belonging from both business and authority typologies, namely HOYER (representing the business user) and France's and Italy's Ministry of Transport (representing the government users). The above KPIs allow to:

- Tailor the detailed design of the solution;
- Characterise the solution, in terms of technical parameters, user satisfaction, economic and social benefits;
- Drive the validation/assessment of the solution based on the results of the demonstration.

A target value has been given for each KPI, obtained on the basis of the expectations of the involved stakeholders. Considering that, as above mentioned, the CORE demonstration involves two types of stakeholders, KPIs have been differently analysed with relevant target values (in a few cases the values coincide), one from the business stakeholders' perspective and one from the institutional/authorities' perspective, for taking into account the different needs on costs, expectations, benefits.

At the time of writing (i.e. early December 2017), the demonstration is still running, and the activity of gathering/collecting the data/inputs necessary for the KPIs evaluation is on going. Due to the different nature of the KPIs, the data/inputs are heterogeneous (e.g. technical parameters/indicators, feedbacks) and have been gathered/collected in different modes (e.g. by means of technical instruments or through interviews of stakeholders, surveys, investigations, meetings/consultations). Depending on the nature of the KPIs, the methodology targeted on the relevant analysis and evaluation has been defined, along with the specific necessary data/inputs (to be gathered/collected) have been identified. For a certain KPI, the measured value is that resulting from the analysis and evaluation of the gathered/collected data. The measured value is compared with the target value initially identified.

The outcomes of the comparison allow to identify advantages/benefits, gaps, derive lessons learnt, recommendations for possible improvements, and guidelines for the solution operational adoption/exploitation.

The identified KPIs are listed in Table 1, for each KPI the corresponding target values (and relevant metric) for the types of involved stakeholders are also reported.

Table 1. List of KPIs

KPI ID	KPI	Target (business/HOYER)	Target authorities/Italy's and France's Ministry of Transport)	Observations
1	Usefulness of the information/ sensor information	YES Mandatory: 1. Position 2. Product temperature 3. Product pressure 4. Minimum voltage/battery level (e.g. message in the case of low battery level) Optional: 1. Product level 2. Safety valve opened	YES UNECE data protocol: • Mandatory: electronic (digitalised) transport document • Optional: 1. Position 2. Alarms	Quality (including timeliness) of the information from sensors contained in the tracking & tracing data, and its ability to support operations Technical indicator impacting on the ability to cope with the needs of users, both business stakeholders and authorities (operational feature) [flag]
2	Position information accuracy	< 5 meters	< 5 meters	Precision of the position information contained in the tracking & tracing data (measured position versus true position) Technical indicator impacting on the trustablity of the tracking & tracing solution (operational feature) [distance]
3	Position information guarantee	96%	96%	Reliability of the position information contained in the tracking & tracing data (measured as the % of positions for which the PL, giving the guarantee of the position information from satellite navigation, is available)

				Technical indicator impacting on the trustablity of the tracking & tracing solution (operational feature) [%]
4	Continuity	7 days	15 days	Time during which the tracking & tracing solution is working without interruptions (measured as the mean time between failures or between instants in which the tracking & tracing solution is not able to be used) Technical indicator impacting on the ability to cope with the needs of users, both business stakeholders and authorities (operational feature) [time]
5	Robustness	1 hour	15 minutes	Acceptable maximum time for the duration of a failure or time intervals in which the tracking & tracing solution is not working or not able to be used Technical indicator impacting on the ability to cope with the needs of users, both business stakeholders and authorities (operational feature) [time]
6	Costs-capital expenditure	Tracking device 900 € (taking into account that the price of a tracking device decreases with the number of tracking devices that are ordered) + installation costs (handling included) 500 € (taking into account that the weight of a tracking device including battery shall be < 10 kg)	Typically, authorities issue public tenders for the development/set-up of a solution (including or not a minimum number of tracking devices). The cost depends on the number of tracking devices and the complexity of the solution/functionalities. The minimum costs-capital expenditure (including 1 year of maintenance) is in the range of 820.000 € The cost for 30 tracking devices (typically authorities can just participate in the initial design of the tracking devices with the production of a few tens of units, that is part of the costs-operational expenditure), that is maximum 165.000 €.	Investment costs required for the tracking & tracing solution including its certification, set-up and customisation, and installation Operational indicator impacting on the satisfaction from the perspective of users (both business stakeholders and authorities), and hence acceptability for adoption [monetary]
7	Costs-operational expenditure	7 €/month per tracking device (that also includes the cost related to the external service provider's web access for the monitoring/tracking & tracing service) + 1,7 €/month for battery replacement (i.e. maximum 50 € per tracking device for battery replacement with a duration of the battery minimum 2,5	The minimum costs-operational expenditure is in the range of 50.000 €. Typically, authorities do not participate in the operations/maintenance of the tracking devices (they just participate in the initial design of the tracking devices with the production of a few tens of units that is part of the costs-operational expenditure).	Running costs for the tracking & tracing solution, including annual variable costs for operation, maintenance and repair Operational indicator impacting on satisfaction from the perspective of users (both business stakeholders and authorities), and hence acceptability for adoption [monetary]

		years)		
8	Economic benefits	At operation level 10%, due to time savings Economic benefits are expected, thanks to possible insurance savings in case a suitable model is applied similar to that applied to truck insurances through a black-box. There are also benefits thanks to safety enhancement, that cannot be commercially quantified, nevertheless provide a big added value for the company (it is a good selling point).	N/A	Benefits from business stakeholders' perspectives. Benefits generated by: -Increased monetary saving, thanks to higher efficiency (e.g. less fuel, optimisation of resources), and/or -Reduced monetary loss, thanks to increased safety/security (e.g. less accidents, less damages) Operational indicator impacting on the ability to meet the expectations of business stakeholders', and hence acceptability for adoption [%]
9	Social benefits	N/A	60 minutes, being the elapsed time for the emergency information to be available/activation of the emergency response plus the time of emergency response	Benefits from authorities' perspective. Benefits generated by: -Risks reduction and thus safety/security gains, thanks to an enhanced capability to prevent/mitigate risks and detect near-miss events -Improved response to emergencies, thanks to the availability of reliable and continuous tracking & tracing data and thus better knowledge Operational indicator impacting on the ability to meet authorities' requirements, and hence suitability to support regulations/law enforcement/emergency [%]

7. Preliminary results on the evaluation and assessment of KPIs

As mentioned in the above section, the demonstration will run until the end of April 2018 and the work for the evaluation and assessment of KPIs is in progress. Preliminary results are already available for some KPIs, and they are reported in this section.

7.1. KPI 2 & KPI 3 - Position Information Accuracy & Position Information Guarantee

KPI 2 & KPI 3 are related to the position information characteristics.
In this respect, as above mentioned, the tracking devices of CORE tracking & tracing solution make use of EGNSS, and more specifically GPS/EGNOS/Galileo-multiconstellation.
In order to evaluate KPI 2 Position Information Accuracy, data of the tracking device measured in stationary conditions[17] (i.e. static GNSS data) have been collected for two whole days (in order to check the reproducibility of the results).
The horizontal and vertical Distance Root-Mean-Square (DRMS) have been calculated. DRMS are the root mean square of the distances from the average 3D position to the positions collected during the period of data collection/analysis. DRMS are statistical dispersion indices linked to data precision (quantifying the difference between measures repeated in the same position). Moreover, they are often used to provide an indication of the

[17] A laboratory unit in static condition, allowing to have a known environment as needed to make a reliable analysis. When in motion, the environmental conditions generate uncontrolled disturbance affecting the analysis.

accuracy (i.e. measured position versus true position) when applied to static GNSS data. Therefore, the calculated values of DRMS represent evaluated KPI 2 Position Information Accuracy.
The next table reports the DRMS values calculated for the following two cases:

- Use of GPS + EGNOS, with position data not compliant with CWA 16390 revision;
- Use of GPS + EGNOS with position data compliant with CWA 16390 revision;

showing that, for both, the calculated horizontal DRMS is always < 5 metres (that is the target value for the considered KPI).

Table 2. Calculated values of DRMS representing evaluated KPI 2 Position Information Accuracy

	GPS + EGNOS, with position data not compliant with CWA 16390 revision	**GPS + EGNOS with position data compliant with CWA 16390 revision**
	Date (dd/mm/yyyy): 03/04/2017	
Number of analysed data	1251	1251
Horizontal DRMS (m)	4.22	2.71
Vertical DRMS (m)	6.01	3.69
	Date (dd/mm/yyyy): 06/04/2017	
Number of analysed data	1243	1243
Horizontal DRMS (m)	4.11	2.63
Vertical DRMS (m)	5.94	3.43

In the case of use of GPS + EGNOS with position data compliant with CWA 16390 revision, it is possible to have, in addition to the coordinates and time, also an attribute called Protection Level (PL) indicating the relevant information guarantee.
KPI 3 Position Information Guarantee is considered as the % of positions for which the PL is available, calculated only in the case of use of GPS + EGNOS with position data compliant with CWA 16390.
In order to make a reliable analysis, the evaluation of this KPI has been done on the same data sample (two days of static data) used for DRMS calculation/KPI 2 Position Information Accuracy evaluation.
Next figure shows the availability of the PL representing an indicator for KPI 3 Position Information Guarantee. The obtained availability of the PL results is > 96%, that well matches the target value identified for the KPI.

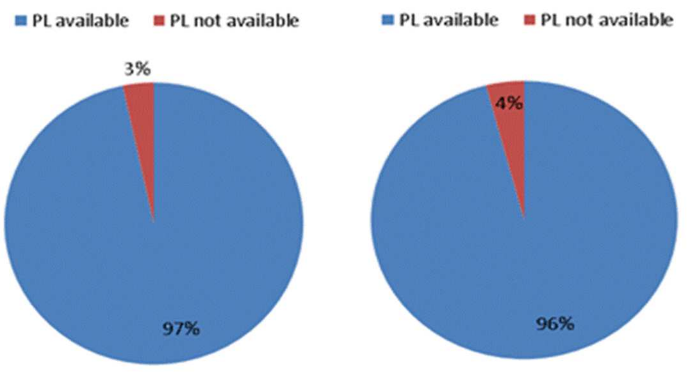

Fig. 2 PLs' availability (related to day 1 - 03/04/2017 – and day 2 - 06/04/2017 – respectively) representing an indicator for KPI 3 Position Information Guarantee

These results show that CORE tracking & tracing solution complies with the targets for KPI 2 & KPI 3 - Position Information Accuracy & Position Information Guarantee. Moreover, that the position information measured by using GPS + EGNOS with position data compliant with CWA 16390 revision is more accurate and allows to have an additional information, the PL, that is an indicator of position information guarantee, fully satisfying the expected performances.

7.2. KPI 9 - Social benefits

KPI 9 - social benefits is the indicator showing the advantages of the tracking & tracing solution when it is in

operations, from the business authorities' perspective. For the evaluation of this KPI, a survey has been conducted in order to collect/gather the necessary feedbacks/inputs.
The purpose of the survey is to evaluate the advantages and impacts generated by the use of telematics systems in the emergency intervention/operations thanks to a higher availability of data/information related to the dangerous goods transport/flows and transiting through gates (e.g. the transport document in digital form in addition and/or instead of paper form, real-time position and status of the goods).
The survey has been implemented through an on-line questionnaire, and including questions aimed at a comparison of the following situations:

- CASE 0 - no adoption of telematics systems/no availability of data and information related to the dangerous goods transport (e.g. digital transport document in addition to the paper form);
- CASE 1 - adoption of telematics systems by the transport operator allowing the digital transport document in addition to the paper form;
- CASE 2 - adoption of telematics systems that in addition to the digital transport document (i.e. CASE 1), provide information about the transiting of the vehicles transporting dangerous goods through fixed gates located along the road stretches;
- CASE 3 - adoption of telematics systems that in addition to the digital transport document (i.e. CASE 1), and to the provision of information about the transiting of the vehicles transporting dangerous goods through fixed gates (i.e. CASE 2), foresee tracking & tracing devices installed on board the vehicles/containers transporting dangerous goods allowing real-time information about the positions and status of the goods (including the detection of anomalous events and alarm conditions).

The survey has been oriented to selected[18] public entities/bodies involved in the territory monitoring/law enforcement, organisation/management of emergency intervention/operations primarily in the Italian Piemonte and Lombardia regions that are interested by the CORE use/business case.

8. Conclusions

The evaluation of KPIs will be completed on the basis of the data/parameters and feedbacks/inputs collected during the demonstration. The difference between target and measured values will be analysed in order to assess the developed solution in terms of benefits/advantages, needs for improvements/modifications, ideas for possible commercialisation and operational adoption. Preliminary results have been presented in this paper.
From the business stakeholders' perspective, the analysis will also consider the capability to be extended to other business cases.
From the authorities' perspective, the advantages deriving from the large adoption of telematics (GNSS based) solutions for tracking & tracing the carriage of dangerous goods are linked to the real-time knowledge of transport flows, possibly combined with other relevant information (such as geographical information on sensitive and/or populated areas, real-time information on traffic, weather, etc.). The result is improved risk assessment functions that are beneficial to authorities as they allow them to:

- Opportunely plan/optimise the traffic flows;
- Increase law enforcement;
- Minimise the hazards related to the carriage;
- Reduce the risk of incidents and relevant consequences in terms of human lives and environmental damages;
- Guarantee an effective response (thanks to a better knowledge about the incident prior that allows to better organise a response) and reduce emergency response time;
- Support the introduction of electronic (digitalised) transport documents (transport e-documents), to cope with ADR[19]/RID[20]/ADN[21] regulations. In fact, current regulations envisage paper form documents for the purposes of transport operations, law enforcement and accidents (retrieved by police and emergency services). Telematics solutions for the transport of dangerous goods gather in electronic form most of the information required in the paper transport documents, which results in enhanced efficiency, safety and security.
- Enhance/enrich statistics;
- Deliver value added services built on the collected information (possibly integrated with other relevant information and with policy/measures), that could support the set-up of robust incentive models in order to foster the involvement of business actors and stakeholders and eventually convince them to share their data (such as "green lanes", "secure lanes" or facilitations).

[18] Invited to participate in the survey
[19] European Agreement concerning the International Carriage of Dangerous Goods by Road
[20] Regulations concerning the International Carriage of Dangerous Goods by Rail
[21] European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways