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Monitoring Dangerous Goods Transport on Highways: The Experience of Autovie Venete S.p.A.

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The safety of the transport of dangerous goods can highly benefit from an increased awareness of this activity. In particular, quantitative information about the amount of substances transported and their features can support further research and operative activities. This paper describes the approach of monitoring activities adopted by the Motorway Concessionaire Autovie Venete S.p.A. on the A4 highways Venezia-Trieste, in the northeast of Italy.
Firstly, the paper briefly describes the architecture of the system, currently based on 24 on-line DGT monitoring gantries, and its functionalities. Some samples of the possible extractions of the collected data are presented. Then, an overview about how the Concessionaire uses the data collected are is provided. Besides the relevant aim of data collection for a better knowledge about DGT on the highway, the system implemented is intended to support the Road Operator in its strategy to increase safety. Data allowed, and the process is still ongoing, the fine-tuning of procedures, measures and actions for the effective management of DGT. Final consideration about the possible future scenarios is provided.

1. Introduction

Currently, few information about the transport of dangerous goods (DGT) is available for research, planning and management purposes. This condition is particularly questioning as well as penalizing, considering the relevance of this activity for whatever need of society and for its safety and security implications.
Available data are mainly referred to a statistic description of the topic, both at European level, with information processed by Eurostat, and at national level. In Italy, the reference is represented by the “Conto Nazionale Trasporti” that periodically provides information about the amount of DG moved in the Country, organized in large categories of substances. Shippers and carriers in charge of the transport are instead in possession of very detailed information; however, the information is inaccessible to the other subjects and stakeholders.
This partial lack of knowledge has negative impacts on the effectiveness of projects, studies and methods dealing with the topic of DGT that can be investigated with reference to many approaches. Among them it is possible to mention the risk assessment, examples are Orso Giacone et al (2012) and Conca et al (2016), the management of emergency, as discussed by Hemmratian et al. (2017), the identification of optimum paths and routes, as presented by Li (2017), Hao (2017) and AlRukaibi et al(2018) or the statistical analysis about hazardous materials accidents, considered by Liu et al (2020), Oggero et al (2006) and Yang et al (2010).
To fill this lack of knowledge on this topic, many initiatives and projects were employed or are currently ongoing. Among them, it is possible to mention Interreg projects such as Lose+ and Destination, which specifically for this purpose used a monitoring network on the territory involved; details of this are provided by Borghetti et al (2018). Besides these institutional approaches, private companies are also trying to increase knowledge and awareness about DGT, for what pertains their missions. This paper briefly describes one of these private initiatives presenting the monitoring system for DGT developed by the Motorway Concessionaire Autovie Venete S.p.A. on the highways A4 Venezia-Trieste, in the northeast of Italy.

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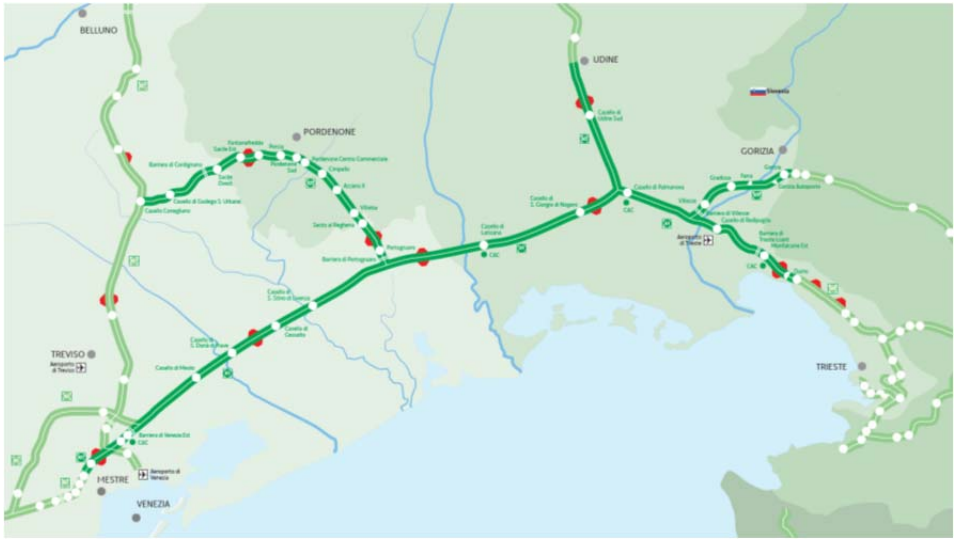

Figure 1: Highway network managed by Autovie Venete S.p.A.

2. Monitoring network

The system for monitoring Dangerous Goods Transport (DGT) was implemented in 2008. Four remote monitoring gates were firstly installed and other 23 gantries were added in 2010. Currently, the system is operational with 24 on-line DGT detection points. However, some of the installed gates are temporarily out of service due to the road works for the construction of the third lanes of the A4 motorway.
Since 2018 and due to a specific request from Polizia di Stato, the National Police Department, the system has been improved, with the involvement of an interfacing between the Central System managed by Autovie Venete S.p.A. and its counterpart managed by the National Police called SCNTT (i.e. Sistema Centralizzato Nazionale Targhe e Transiti). This connection allows the real time data and images of transits of vehicles to be forwarded to the National Police Department for crime prevention and investigation purposes. The system involves remote monitoring gates connected to the Central System, intended for data collection and elaboration.

2.1 The remote monitoring gates

The road side monitoring gates read all the vehicles plates. Thus, the system is able to record the passage of all the vehicles, including motorbikes. The gates are also able to detect the passage of dangerous goods transports. They automatically read the orange plates and the identification number of the hazardous material transported, which are placed in the rear part of the trucks. This information is joined with the data of the license plate of the trucks. Moreover, each transit data is completed with the transit time information.
The identification of both the ordinary and DG plates is developed through the continuous video processing in the infrared spectrum and through a software OCR - Optical Character Recognition. The system uses two sensors, each consisting of an optical lens with specific focal length, and both contained in a single camera body, one for each controlled highway lane. These sensors are equipped with infrared illuminator. The system has been deeply analyzed regarding its function of plate recognition. This allowed a fine-tuning of the sensors, increasing its effectiveness even in unfavorable conditions (low light, backlight, adverse weather conditions).
The on-ground concentrator PC acquires the overall data and sends it to the control center on TCP-IP protocol.

2.2 The Central System

The Central System acquires and records the transits detected by the remote monitoring gates, storing them in servers, currently located in the Centro Elaborazione Dati (CED) of the Road Operator in Palmanova (UD). The remote monitoring gates already distinguish transits in transits of vehicles with dangerous goods and indistinct transits. The Central System collects from each remote monitoring gate the transits of vehicles with dangerous goods in real time. Indistinct transits data are instead collected every 5 minutes. Transits of dangerous goods are recorded in the system and kept for 168 hours (7 days). Their images are then discarded, storing only the transit data for possible processing and statistics. Indistinct transits data are recorded, kept for 72 hours (3 days) and then deleted, respecting the provisions of the GDPR 2016. Statistics

about the total number of transits are also saved every minute, organized by substances for each monitoring gate. Qualified users, organized through profiling, can remotely connect from their workstations and access the recorded data, consistently with the access prerogatives guaranteed by their profiling and always in compliance with the Privacy regulation.

3. Application

The system is currently used by the TCC (Traffic Control Center) of Autovie Venete S.p.A. to monitor the alarms transits of vehicle with dangerous goods along the extended motorway managed. In addition to the internal offices of Autovie Venete S.p.A., the system is accessible to other stakeholders such as Traffic Police (SCNTT), and Fire fighters of Mestre (VE).

3.1 Data collection and analysis

Firstly, the use of the system by Autovie Venete S.p.A. allowed taking a representative picture of the volumes of dangerous goods transiting within the motorway sections, with limited inaccuracies due to intrinsic system gaps (transport in packages, UN recognition errors). Figure 2 shows an example of possible data extraction, reporting overall transits recorded by gates at each section. The reference year for this data, as well as for the followings, is 2016, the most recent year with all the gates active on the road network managed by the concessionaire.

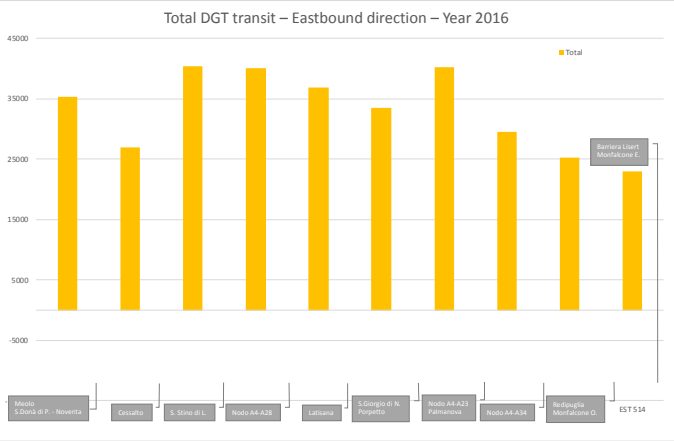

Figure 2: Total DGT transit – Eastbound direction – Year 2016

Besides recording the overall number of transits at gates, the system automatically provides the variations of transits at each gate. This allows observations on the typical fruition of the motorway by DGT, as reported for example in Figure 3, but even its real time monitoring by operators of TCC.

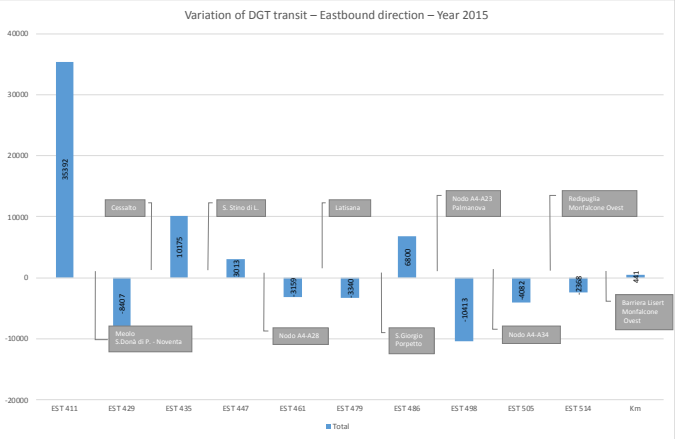

Figure 3: Variation of DGT transit – Eastbound direction – Year 2015

The analysis of the transits with reference to the materials carried, reported in Figure 4, shows that the majority of hazardous materials transported is represented by flammable substances The three main substances transported, that represent more than 50% of the transits in 2016, are diesel oil (ONU number 1202), gasoline (ONU number 1203) and LPG (ONU number 1965). These are respectively featured by the dangers “flammable liquids”, “highly flammable liquids” and “flammable gas”.

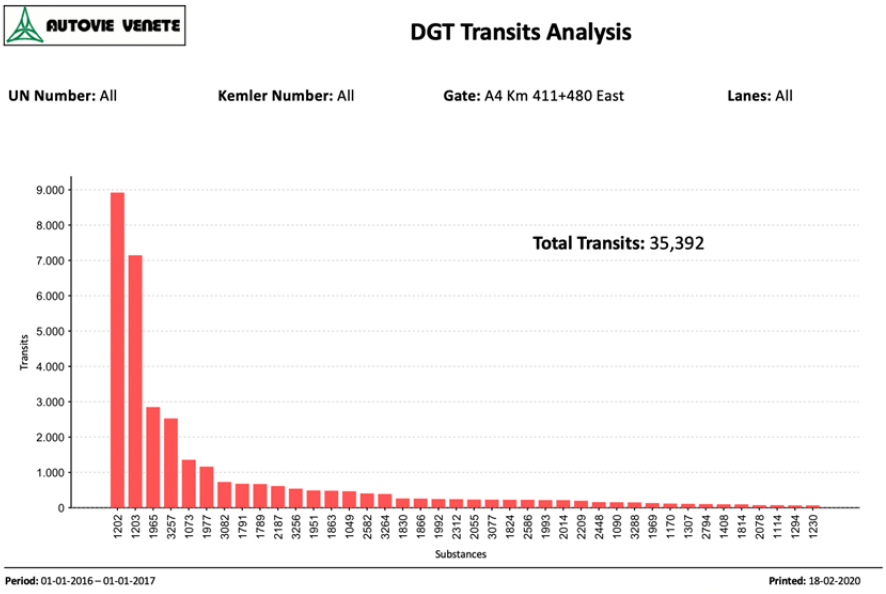

Figure 4: Yearly transits for each substance recorded by gate at km 411+480 – Eastbound direction– Year 2016

The system also allows queries about transits of a specific substances or class of substances, as reported for example in Figure 5 for ADR Class 6.

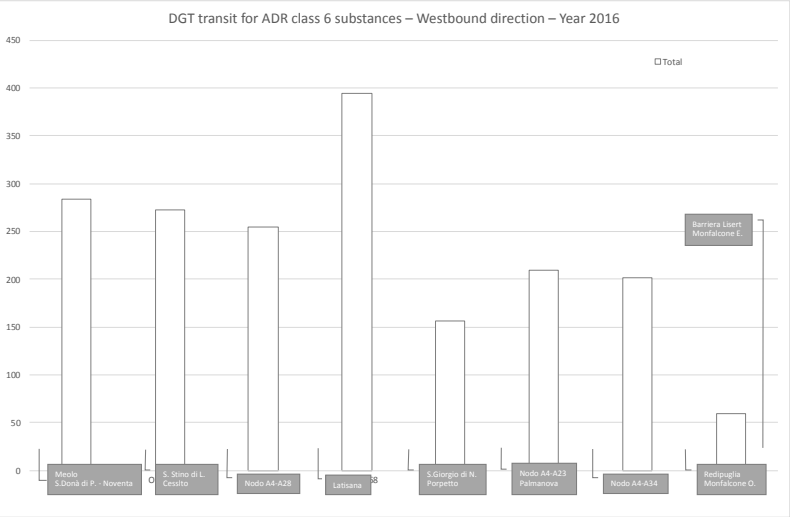

Figure 5: DGT transit for ADR class 6 substances – Westbound direction – Year 2016

3.2 The use of data collected to improve safety

The predominance of these substances firstly led the Company to adopt targeted prevention measures on this type of products:

- at the infrastructural level: the evaluation and application of interception and containment systems of the run-off waters of the highway specifically calibrated on the case of hydrocarbons;

- at the procedural level: the improvement of communication procedures with the subjects in charge of the intervention (internal staff, fire fighters, traffic police, health personnel, mechanical assistance);
- at the operational level: the elaboration of protocols and intervention actions in an emergency synergistic with the intervention of the fire fighters. These will be used by the company staff, with its own vehicles and equipment, and by the suppliers of ecological emergency services.

Figure 6: accident with DGT involved on the A4 (courtesy of Autovie Venete S.p.A. and Vigili del Fuoco)

A phase of specific training of the staff operating on the motorway about the risks associated with DGT followed the first measures previously listed. In particular, basic knowledge of:

- the emergency identification of dangerous goods and their intrinsic danger;
- the identification of dangerous conditions due to breakdowns or malfunctions of vehicles used for transport or due to accidents;
- effective communication of the danger scenario;
- the adoption of safety measures for people present within the area of potential danger.

3.3 Ongoing activities

Currently, the definition of an approach for risk analysis is under development, with reference to four potential targets: users, population in proximity of the infrastructure, environment and infrastructure.
It is necessary to define the safety distance to be respected by users. This is done according to macro categories of substances and according to the boundary conditions (planimetry, physical barriers, preferential propagation directions for gases and liquids.This could lead to a more precise definition of the intervention procedures or the adoption of visual systems for users and rescue teams for the identification of the best path to safe points. Concerning the population in proximity of the infrastructure, the potential impact to be analyzed is mainly connected to gaseous substances and to the transport routes depending on the boundary conditions and wind direction. This analysis aims to identify the origins and destinations of DGT involving these substances and the inhabited neighboring towns potentially affected. Given the recorded limited quantity and the multiplicity of these hazardous materials, the possibility of a single intervention procedure will be evaluated and eventually shared with the relevant authorities. This is intended to timely and effectively communicate the event to the subjects involved and interested by a possible preventive evacuation. The possibility of ordinances that affect specific substances and that provide restrictions of transit times on the highway or the presence of escorts/safety car will also be assessed.
A review of the historical data about the safety measures carried out in the last 15 years will address the environmental target. The current procedures, indicating the possibility of expected containment in the case of hydrocarbons and according to the lithology, will be refined. A highway map of the potential propagation of pollutants will be defined, with lithological and geotechnical tests and analysis, conducted in particular during the construction phase of the third lanes of the A4 motorway. Moreover, a study on the propagation of pollutants over time along watercourses will be developed to define in advance the intervention links as a function of time. The identification of the most vulnerable or exposed elements such as viaducts, power lines, aqueducts, gas pipelines and railways will help face the risk for infrastructures. In this case, the technical-economic feasibility of interventions for risk mitigation will be assessed. In addition, the definition and implementation of procedures for communication will be shared with authorities.

4. Conclusions

The monitoring system implemented at Autovie Venete S.p.A. proved in its operating years to provide a picture of the activity of DGT in the highway section covered by gates. Considering the technological issues, the system granted effectiveness and reliability in the correct identification of the transits.
In terms of increasing the knowledge and awareness of this topic, the system, despite the unavoidable and intrinsic gaps connected to the punctual monitoring of the transits, provides useful and interesting information.
The data collected through the monitoring network allowed a quantitative measure of the activity of DGT, with details about the substances transported. The presence of gates, continuously on each highway section, made considerations about the exit/entrance tollgate more interested by movements of hazardous materials possible. This increased knowledge overcame the boundary of the activity of data collection, determining impacts on the management of safety issues connected to DGT. It oriented the efforts of the Company in this field, defining improvement activities at the infrastructural, procedural and organizational level. Moreover, the information collected profits to the ongoing activities developed within the Company, mainly aimed to the definition of an approach for risk analysis.
For the future, an evolution of the types and volumes of DGT is expected. The electrification of mobility, for example, should decrease the need for hydrocarbon supply. Meanwhile, the increase in transits of trucks carrying batteries is predictable, developing different types of danger as compared to the current ones. The possible development of industrial batteries assembly centers potentially connected by Autovie Venete S.p.A. would also lead to the transport of further chemical compounds currently not transiting the motorway. Then, flexibility will be required to face upcoming risks properly, probably overlapping to the current ones.
In the short term, an evaluation of the benefits in relation to the costs to be incurred for the improvement of the instrument currently in operation should be developed concerning:

- the implementation of a camera for the lateral vision of vehicles, necessary for the identification of transports in packages that cannot currently be monitored;
- the increase of the number of monitoring gates, with particular regard to the highways A28 (Portogruaro-Pordenone-Conegliano) and A34 (Villesse Gorizia), managed by the Company.

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