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DESTINATION Project: Data Analysis Relating to the Transport of Dangerous Substances by Road in 2015

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One of the activities included in the DESTINATION project - DangErous tranSport To New prevenTive Instruments, related to the safety of dangerous goods transport by road, concerns the analysis of data from the monitoring network implemented on the project area.
The monitoring network consists of more than 30 cameras - gates able to detect the orange plate (reading the letters and numbers KEMLER and UN code) positioned on vehicles used to transport hazardous substances; the cameras were installed in the 5 regions involved in the project.
At the end of the first year of the monitoring system operation (2015), an analysis of the acquired data was performed in order to know the type and quantity of substances passing through the roads of the project area.
Due to the lack of thorough statistical data about this type of transport, the proposed study can represent a valid database for carrying out quantitative risk analysis associated with the transport of dangerous goods by road. The statistical elaborations carried out are articulated on several levels: hourly, daily, weekly, monthly and by substance.
The proposed work involves two kinds of analysis: general analysis (aggregated) and detailed analysis (disaggregated); aggregated analysis considers the average values referred to the whole project area while the disaggregated ones allow to analyse the information related to each single camera (gate).

1. The DESTINATION Project

The data analysis is part of the DESTINATION Interregional Strategic Project, aimed at understanding the risk related to the transport of dangerous substances by road (Borghetti et al., 2016, Giacone et al., 2012).
The project involves the territory of the Lombardy Region, the Piedmont Region, Valle d'Aosta, the Autonomous Province of Bolzano and the Canton of Ticino (CH) and also involves the participation, as technical partners, of Politecnico di Milano, Lombardia Informatica SpA, CSI Piemonte and 5T Srl.
The main objective of the project was to develop and implement the GIIS - Global Integrated Information System - as a useful tool for public and private subjects for a more effective and efficient management of the activities related to the different phases of the DGT - Dangerous Goods Transport - such as planning and prevention, on-trip assistance, emergency management in case of accident.
Furthermore, to increase the knowledge concerning the transport of dangerous goods in the project territory, a network for data acquisition and analysis about the transport of dangerous substances was implemented, composed of electronic gates installed on the main roads and highways. This was allowed thanks to the collaboration with the road operators that joined the project.
The GIIS is configured as an instrument for planning and a decision support tool, able to collect and process traffic data coming from the monitoring network as well as from databases of institutional partners. Through a model of risk analysis of DGT, which allows to estimate and analyse the effects of accidental events on human and environmental targets, it is possible to carry out elaborations and simulations aimed at the implementation of thematic maps for management/mitigation of the risk.

2. Aim and features of the analysis

The analysis developed in the project and briefly presented in the paper, allows to process statistics on the data coming from the monitoring network - gate, in order to estimate and know the type and quantity of dangerous substances that transit within the project area. The current availability of statistical data about DGT by road is limited and the information is too aggregated (Ministry of Transport and Infrastructures, 2005) to be considered significant for detailed territorial analysis. In particular, analytical tools such as the GIIS can benefit from the availability of information about DGT strictly related to the territorial contexts considered.

The data acquired in a disaggregated form by the monitoring network can be used by analytical models for the risk analysis associated with the DGT by road (Bubbico et al., 2006, Conca et al., 2016). These models also represent Decision Support Systems - DSS that can support decision-making processes aimed at orienting infrastructural and/or management measures designed to mitigate risk. In some recent studies (Hao, 2017, Li, 2017) road routes have been evaluated to optimize social risk according to specific origin-destination pairs.

For the analysis carried out in DESTINATION, the reference time interval considered is between 1st January 2015 and 31st December 2015. Two types of analysis have been defined: general or aggregated analysis and detailed or disaggregated analysis; in the first case the average values referred to the entire project area were considered while in the second one it is possible to evaluate the values recorded and processed by each single gate.The statistical elaborations of the two analyses are articulated on several levels: hourly, daily, weekly, monthly and by substance.

3. The monitoring network implemented

The monitoring network consists of 32 gates located on road sections within the project territory. Each gate is made by three elements: a support structure (eg VMS - Variable Message Sign), a camera, able to read the orange panel and a shelter for data processing and transmission to the control centre as illustrated in Figure 1. The cameras, equipped with OCR technology - Optical Character Recognition, can read the alphanumeric characters of the KEMLER and UN numbers of the orange panel.

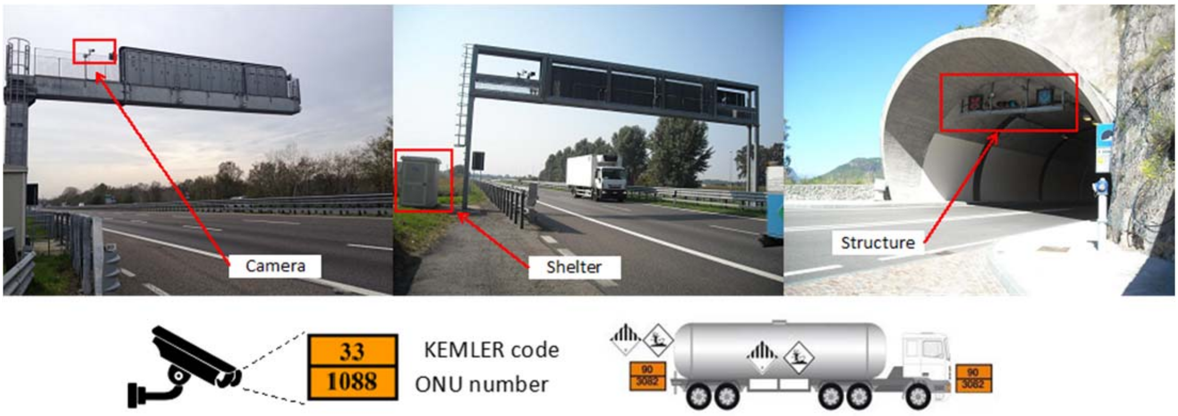

Figure 1: Example of gate consisting of support structure, camera and shelter. The OCR camera is able to detect the passage of a vehicle and read the alphanumeric codes of the orange panel

Each camera is able to monitor two lanes of a carriageway, also detecting the passage of other non-DGT vehicles. If the carriageway is made by 3 lanes, the camera detects the transit only in the two slowest lanes, where it is more probable that heavy vehicles, especially those carrying DGT, travel. Thus, in this configuration, it is not possible to know the number of vehicles traveling on the fastest lane, leading to an underestimation of the total vehicles detected.

For each detected transit the following data are recorded, stored and transmitted:

- characters of the orange panel of the vehicle
- identification data for the gate and the lane
- transit time of the vehicle
-

The choice for the location of the gates on the project area was made based on the following criteria:

- coverage of roads notoriously interested by DGT

- availability of support structure/installation (eg VMS) equipped with electricity and, possibly, of a data connection, to limit installation costs and maximize the number of gates in relation to the budget allocated for this issue
- coverage of path connecting companies classified as “major accident hazard companies”
- coverage of regional exchanges
- coverage of different roads categories (eg motorways, main suburban and extra-urban secondary roads)

Figure 2 shows the location and the number of installed cameras divided by region involved in DESTINATION

Figure 2: Location and number of cameras installed within the DESTINATION project area

4. Data analysis for year 2015

The following is a summary of the analyses carried out considering the data acquired during 2015.

4.1 Percentage of DGT vehicles on the overall traffic

For some gates of the monitoring network, the percentage of vehicles used to transport hazardous goods was evaluated compared to the total vehicles detected. It arose that the DGT vehicles represent, for the 16 directions analysed, the 0.62 % of the total transits detected (light and heavy vehicles). Rounding the value to the unit, to stay on a safe side, it can be concluded that the vehicles used for the DGT represent about 1 % of the overall traffic. In general, assuming a distribution of vehicles in which about 80 % is represented by light vehicles and 20 % by heavy vehicles, it can be deduced that DGT vehicles represent around the 5 % of heavy vehicles. Data are summarized and reported in Table 1.

Table 1: Percentage of vehicles used to transport dangerous goods (DGT) compared to the total vehicles detected. The percentage refers to 16 gates

Gate ID	Gate Description	Total vehicles	DGT vehicles	DGT/total
1	AT01 - Muggiano dir A1 Bologna	14,371,015	55,631	0.39 %
2	AT02 - S. Giuliano M. dir A8 Laghi	8,346,688	31,179	0.37 %
3	BP1 - Sirmione dir Padova	6,896,569	36,665	0.53 %
4	BP2 - Brescia Centro dir Brescia	9,644,584	45,191	0.47 %
5	MG1 - Bereguardo dir Genova	7,777,446	29,660	0.38 %
6	MG2 - Bereguardo dir Milano	6,263,768	33,544	0.54 %
7	PB1 - Cremona dir Brescia	5,307,762	46,804	0.88 %
8	PB2 - Cremona dir Piacenza	3,568,364	32,091	0.90 %
9	SS1 - Trecate/Cerano dir Cerano	1,447,816	73,452	5.07 %
10	SS1 - Trecate/Cerano dir Trecate	1,465,696	91,332	6.23 %
11	TM1 - Borgo d'Ale dir Milano	4,534,123	20,790	0.46 %
12	TM2 - Marcallo Mesero dir Milano	5,548,019	14,039	0.25 %
13	TM3 - Novara Ovest dir Torino	7,395,054	25,052	0.34 %
14	TM4 - Borgo d'Ale dir Torino	5,053,192	21,324	0.42 %
15	TP1 - Alessandria Est dir Piacenza	4,538,921	19,975	0.44 %
16	TP2 - Alessandria Ovest dir Torino	3,871,417	20,022	0.52 %

4.2 Total number of transits of the 10 most transported hazardous substances

Figure 3 illustrates the total number of records on the entire project area for the 10 most transported substances. For each substance the UN number and the KEMLER code are reported. Petrol, diesel and LPG hold the first three positions in terms of transits recorded. The transits sum of the 10 most transported substances (542,203) represents about 80 % of the total transit recorded by all the gates within the project area (673,810) in year 2015.

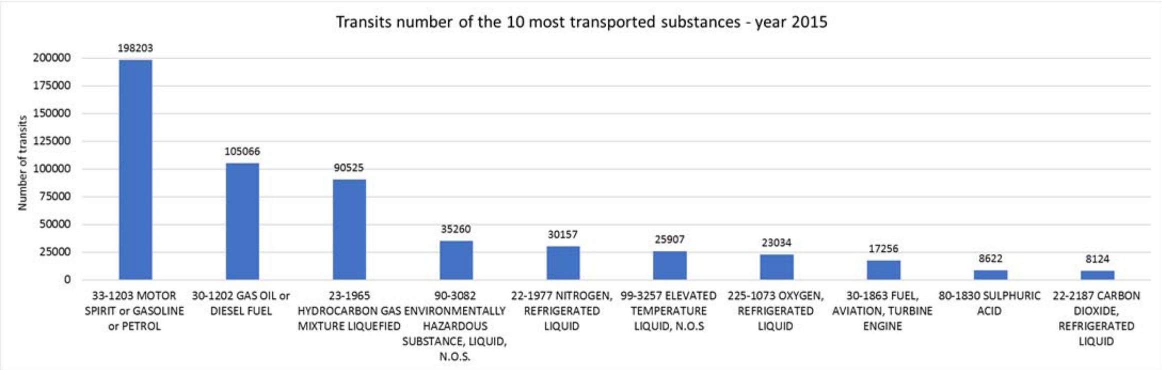

Figure 3: Recorded transits of the 10 most transported substances - year 2015

4.3 Average distribution of hazardous substance transits on monthly basis

Figure 4 shows the average monthly transits recorded within the DESTINATION area referring to the year 2015. The maximum values are observed during the summer except for the month of August in which there is a reduction in transits. The peak value is associated with the month of September.

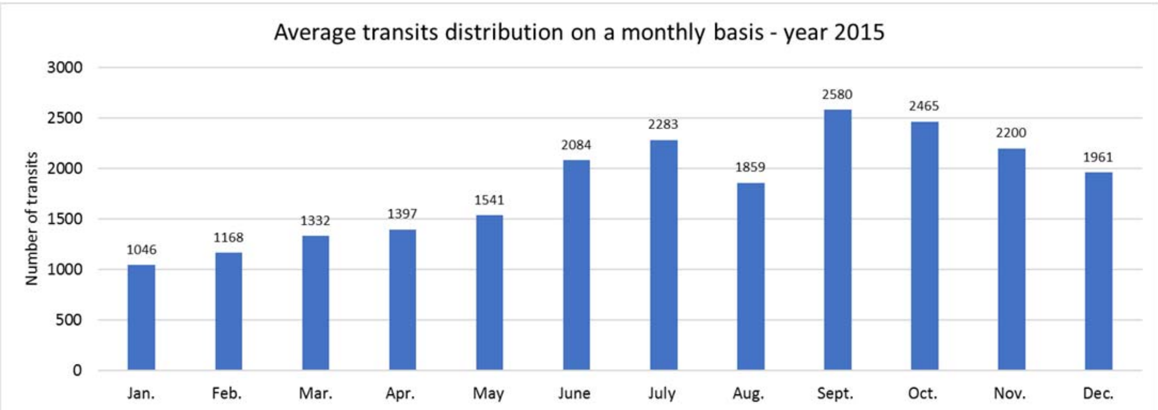

Figure 4: Average transits distribution on a monthly basis - year 2015

4.4 Average distribution of hazardous substance transits on daily basis

Figure 5 illustrates the number of average records for each day of the week over the entire project area. From Monday to Friday the average transits are almost stationary, while on the weekend there is a contraction that is further prominent on Sunday.

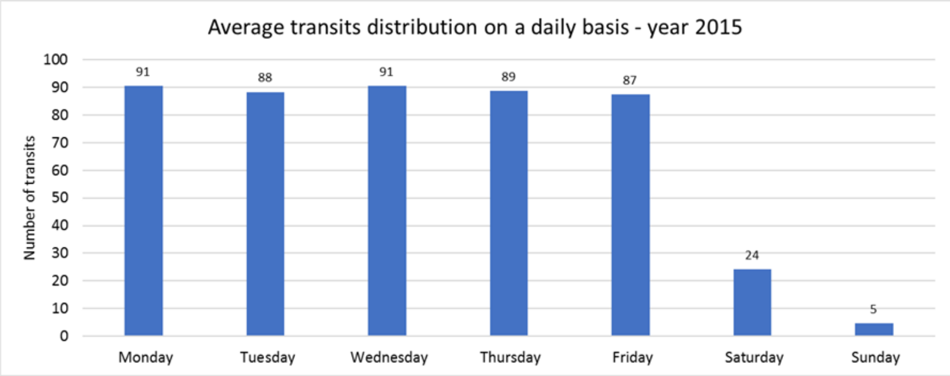

Figure 5: Average transits distribution on a daily basis - year 2015

4.5 Average distribution of hazardous substance transits on hourly basis

Figure 6 illustrates the number of average records for each hour of the day over the entire project area.
The greatest number of transits occurs between 5 AM and 5 PM, with a peak between 6 and 7 in the morning.
During the night and evening hours there is reduction in transits.

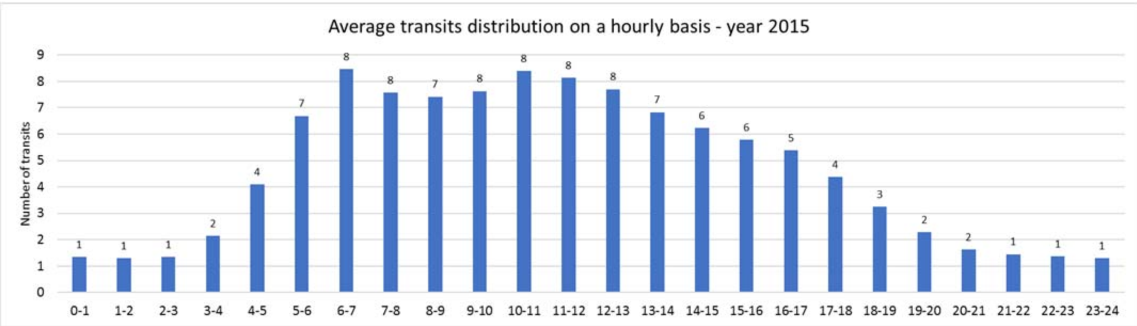

Figure 6: Average transits distribution on an hourly basis - year 2015

4.6 Total number of transits of the 10 most transported hazardous substances for gate BZ2 – Vipiteno dir. Bolzano

Figure 7 illustrates, as example, the total number of gate detections for the 10 most transited substances for the specific gate BZ2.
Differently from the general analysis, LPG, potassium hydroxide in solution and resin in solution respectively hold the first three positions in terms of transits recorded.

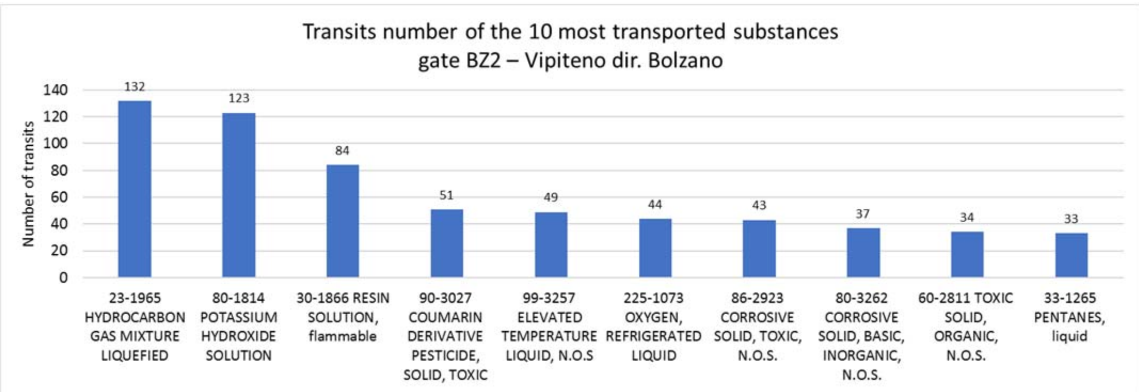

Figure 7: Transits number of the 10 most transported substances gate BZ2 – Vipiteno dir. Bolzano

4.7 Total number of transits of the 10 most transported hazardous substances for gate BP1 – Sirmione dir. Padova

Figure 8 illustrates, as example, the total number of gate detections for the 10 most transited substances for the specific gate BP1. Unlike the general situation, petrol, LPG and refrigerated liquid oxygen respectively hold the first three positions in terms of transits.

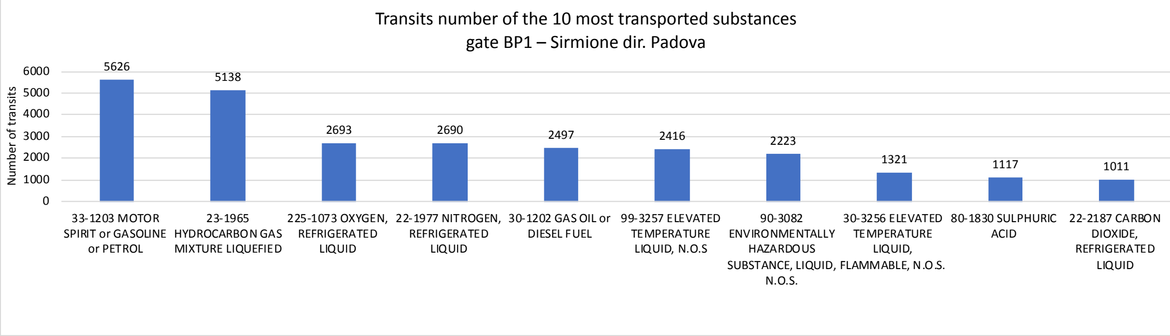

Figure 8: Transits number of the 10 most transported substances gate BP1 – Sirmione dir. Padova

5. Conclusions

The data analysis conducted in 2015 on the first twelve months of operation of the cameras installed within the DESTINATION project area allowed to provide indications about the type and quantity of hazardous substances transited and detected. Although the number of installed cameras is not able to fully monitor the entire road network of the project regions, it is believed that the data acquired and processed constitute, however, some useful information for the knowledge of the phenomenon in the absence of more complete data. The methodological approach involved two types of analyses: general and detailed. The first one allowed to develop an overall picture by analysing average values of the entire project area while during the second one was carried out a disaggregated evaluation in which it was possible to know the traffic of dangerous substances detected by each camera. The result of both types of analysis, carried out on an hourly, daily, weekly, monthly and by substance basis, can be managed and displayed using a dashboard. The frequency of records of the main substances is repeated fairly consistently in most gates; exceptions are some gates that are characterized by their proximity to attractors/generators of specific substances. August and December are the months in which there are fewer transits. About the weekly transits the trends are the same for all gates: on the days from Monday to Friday the passages are fundamentally constant. On Saturday there is a notable reduction, while on Sundays the transits are almost null. With regard to hourly transits it's not possible to identify a common trend for all gates, because it is highly depending by the specific territorial context. Trends can be observed with a single peak or with two peaks throughout the day. In any case, a very low traffic of dangerous substances during the night is recorded. The peaks, single or double, are frequently recorded in the early morning hours (6 AM-7 AM) and in the later morning (10 AM-12 AM).

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