agilysis

agilysis.co.uk

Evidence to remove the speed limit restrictions for ADR vehicle class on Romanian roads

Executive Summary

Romania has a poor road safety record in comparison to other EU member states, with the 2nd highest rate of deaths per million inhabitants and the highest number of deaths per million vehicles. There will be multiple contributors to the heightened risk on Romanian roads. This study sets out to explore the road safety implications of speed differentials between ADR and non-ADR HGVs, using a review of the scientific literature and data collected in a field study. ADR vehicles are those carrying dangerous goods, and in Romania, these are restricted to lower permitted speeds than other forms of HGVs. This is not the case for most other EU countries.

The scientific evidence reveals the following:

- ADR HGVs are regulated to drive in Romania at speeds comparable to slow-moving vehicles, and can be perceived as unusually slow by comparison, since HGVs with other types of loading do not fall under the same regulations; they are appointed to drive at speed limits similar with the limits for the oversized vehicles, which are, mostly, driving at speeds lower than the legal limits anyway, because of physics and road fitness reasons;
- Slow-moving vehicles are found to increase the rate of congestions on the roads;
- Slow-moving vehicles are found to determine driver stress and driver anger, which lead to aggressive behaviour and reckless driving;
- Slow-moving vehicles are increasing the number of large vehicles overtaking each other, which is demonstrated to be within the actions with the highest risk on the roads;
- Slow-moving vehicles are found to generate individual and public health consequences by increasing the congestion rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road.
- Slow-moving vehicles are found to generate significant economic consequences, by increasing the congestion rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road.

A field study measuring speed and traffic by vehicle length was undertaken at five locations along the 7D route in Romania. Sites were either subject to 50km/h or 90km/h speed limits. The study found that slower moving HGVs (ADR and heavy vehicles) created longer and more constant queues of traffic behind them compared to other HGVs. Given the findings from the scientific evidence review showing the risks created by slow-moving vehicles, these results suggest that the longer queues created by ADR vehicles in Romania are likely to influence driver stress and anger, stimulating aggressive behaviour and reckless driving; and lead to more frequent and more risky overtaking manoeuvres.

A comparative field study in Poland was undertaken at five locations on the DK50 route. This data also showed longer and more constant queues behind slower moving vehicles but when compared to Romania, there are significant differences, with the queues for Romanian slow vehicles being up to 80% longer than the Polish ones. Alongside the safety implications of this increased congestion, the Polish

data (where ADR HGVs are not restricted to lower speeds) reveals that traffic is more free-flowing in Poland, with fewer differences in speed, gaps or queues between vehicle categories.

Aside from Romania, only Bulgaria and Spain restrict the maximum speed of ADR transporters, with other countries focusing on driver training and safe packaging to limit the risks of transporting hazardous goods.

After analysing the body of evidence available within the literature, and the results of the field studies analysis, the authors would like to make the following recommendations:

1. The Romanian authorities responsible for road safety should eliminate the speed restrictions for ADR and set constant and consequent rules for all traffic participants. The present restrictions are creating big differences in speed between different traffic participants, traffic agglomeration and long queues. These are all creating anger, stress and frustration which are then increasing the likelihood of more drivers behaving aggressive and irresponsible, increasing the risk level on the roads;
2. The Romanian (and Polish) authorities should revise the speed limits and the methodologies of assigning speed limits, such way that the limits to be more credible;
3. After reviewing the speed limits, the Romanian (and Polish) authorities should put in place speed management systems to enforce the new limits;
4. Traffic rules and restrictions should be correlated with international practice, especially for HGVs, where the drivers are driving through multiple countries as their regular routine;
5. Any applicable rules (and especially restrictions) should be very visible on the relevant websites and updated on the EU websites (the ADR restrictions are not presented at the moment on the EU page detailing the limits in all EU countries, and therefore drivers who don't know the Romanian language can't find out about it).

George Ursachi, Tanya Fosdick, 2018

CONTENTS

THE CONTEXT

EXTENT OF THE PROBLEM

Romania is one of the worst performers in Road Safety in EU, managing to reduce, by 2016, only slightly over 20% of road deaths compared to 2001. The average reduction in the EU for the same period of time was 53%.

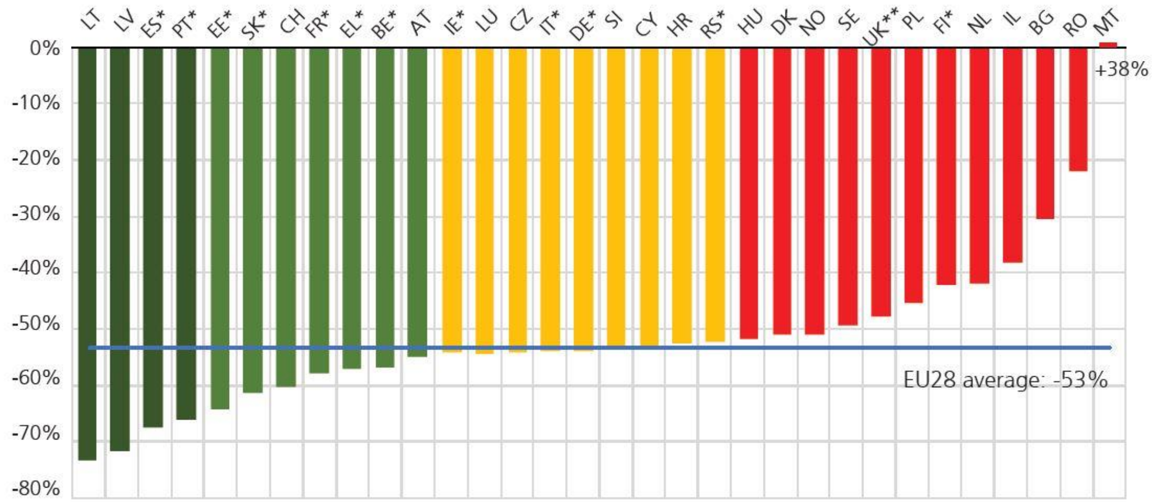

Fig.1: Relative change in road deaths (%) between 2001 and 2016

Source: ETSC 11th Road Safety Performance Index Report, June 2017, pp.15

The mortality rate (road deaths per million inhabitants) was the highest in the EU in 2010 and the second highest in 2016, with over 90 deaths per million inhabitants, compared to an EU28 average of 51 deaths per million inhabitants.

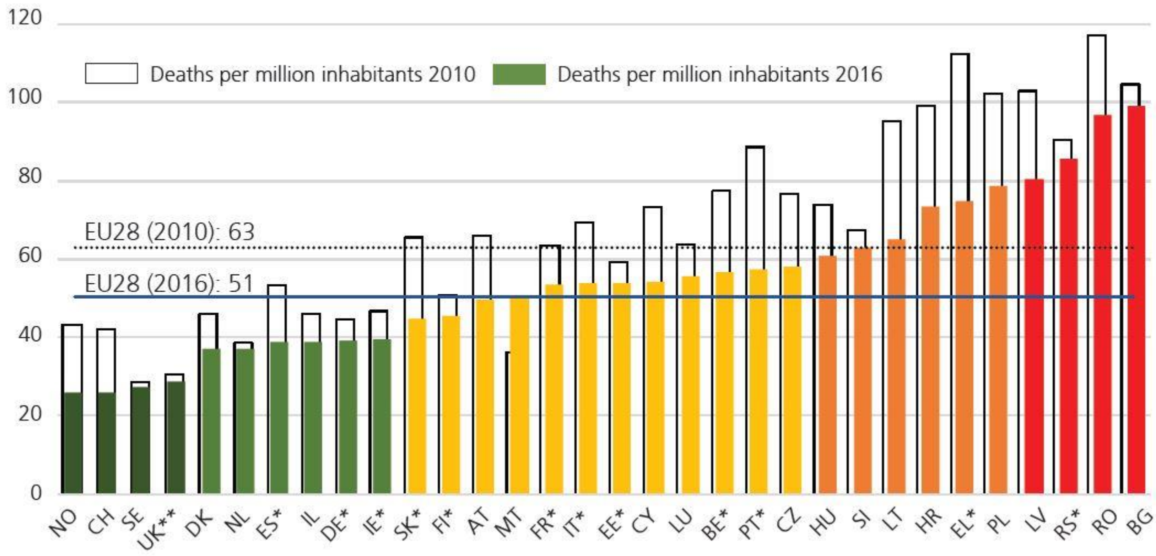

Fig.2: Mortality (road deaths per million inhabitants) in 2016, with mortality in 2010 for comparison

Source: ETSC 11th Road Safety Performance Index Report, June 2017, pp.16

The above rate does not take in to account the exposure (number of cars or million vehicle miles) which would transform the difference between Romania and the EU average into a much bigger one. The official statistics for 2015 show slightly over 5.15 million cars registered in Romania and slightly over 6.6 million vehicles registered in Romania, both on a growing trend (Source: The Annual Report of Road Safety for 2015, The General Inspectorate of Romanian Police, 2016, pp.16).

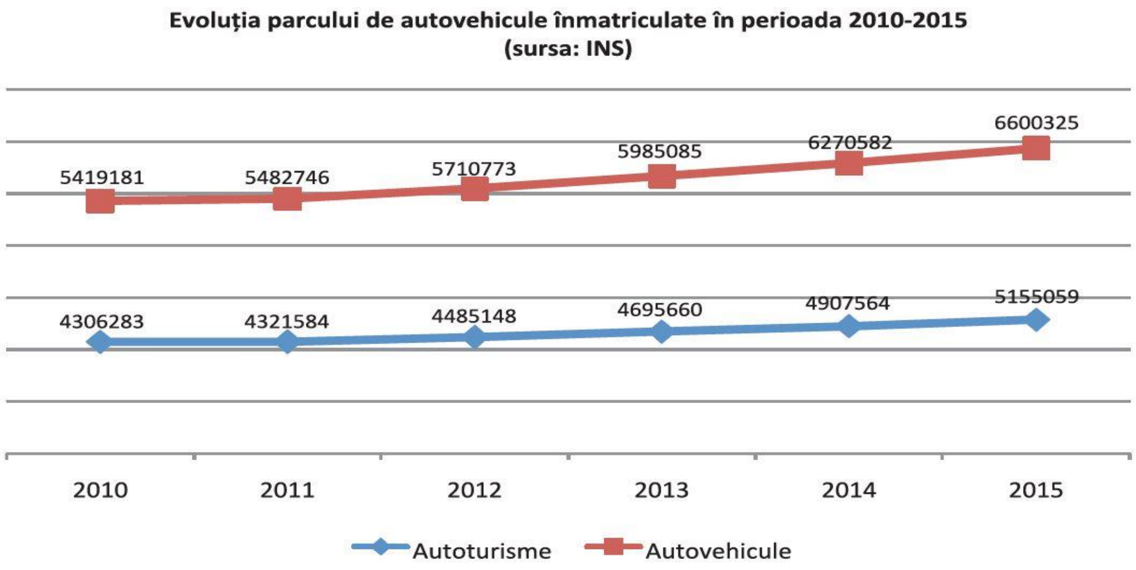

Fig.3: Evolution of the number of vehicles for 2010-2016, in Romania, blue = car, red = all
Source: The Annual Report of Road Safety for 2015, IGPR, 2016, pp.16

Therefore, for a population of around 22.2 million people, with about 80% over the legal age for driving (Source: Romanian population by localities, National Institute of Statistics, January 2016, pp. 13), the vehicle per capita in Romania is the lowest in EU, as can be seen in Fig. 4.

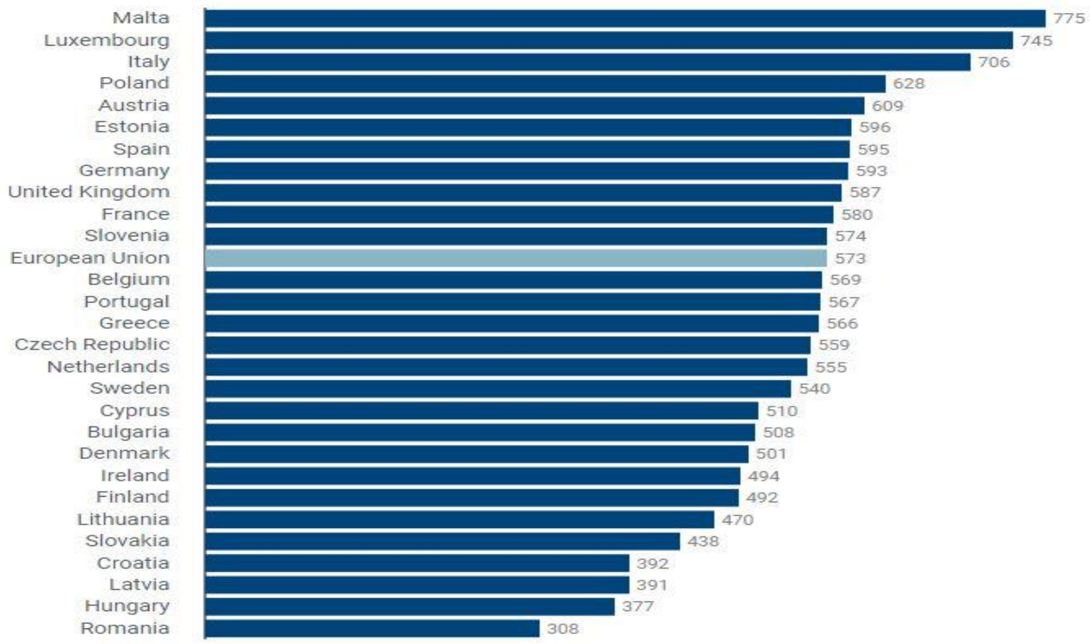

Fig.4: Number of vehicles per 1,000 inhabitants across EU (vehicle-per-capita by country)
Source: http://www.acea.be/statistics/article/vehicles-per-capita-by-country

Therefore, taking this exposure factor in to account as well, Romania has the highest number of deaths per million vehicles, and the difference between Romania and the EU average becomes at least of a ratio of 1:3.

With regards to the research subject, we can find from statistics that, in 2015, 1,644 HGVs were involved in severe collisions in Romania, with more than 78% of them being HGVs under 7.5 tonne mgw. The most frequent causes of collisions identified with an HGV driver at fault were: speed inappropriate for road conditions (140), not giving way to pedestrians (88), not giving way to other vehicles (73) and failing to maintain legal distance between vehicles. Collisions which occurred because of inappropriate speed for the road conditions resulted in 43 deaths and 129 severely injured casualties. Speed is the top contributory factor for all vehicle types as well, with 16.76% of total collisions being assigned to speed factors, and the highest proportion of road deaths which happened on national roads (54%). (Source: The Annual Report of Road Safety for 2015, IGPR, 2016, pp.16)

Since 2015, the situation in Romania got even worse, each year registering an increase of about 2% in the number of road deaths.

Table.1: Road safety statistics in Romania, 2001-2017

Source: https://www.politiaromana.ro/ro/structura-politiei-romane/unitati-centrale/directia-rutiera/statistici

Year	Collisions	Fatalities	Severely Injured
2001	7,300	2,451	6,072
2002	7,234	2,410	5,973
2003	6,689	2,229	5,585
2004	7,068	2,444	5,774
2005	7,211	2,629	5,885
2006	7,164	2,587	5,780
2007	8,505	2,800	7,091
2008	10,645	3,065	9,403
2009	10,214	2,797	9,097
2010	9,253	2,377	8,509
2011	9,290	2,018	8,768
2012	9,366	2,042	8,860
2013	8,555	1,861	8,158
2014	8,447	1,818	8,122
2015	9,380	1,892	9,057
2016	8,688	1,913	8,287
2017	8,624	1,951	8,172

Unfortunately, not much about the circumstances of these collisions (HGVs or other vehicles' speed related collisions) can be found in national statistics, but, anecdotally, the top factor of severe collisions is the engagement in dangerous actions when overtaking slow vehicles (slow dangerous goods HGVs or other slow vehicles) or when overtaking columns (queues) of cars formed behind slow vehicles. Some of the reasons assumed to be the cause of these dangerous behaviours lay in the accumulation of stress and anger while waiting and having to drive at low speeds behind slow vehicles. These hypotheses are sustained by international literature, as described in the following chapters, and are the hypotheses that will be tested in the data analysis section, through studying how large vehicles speeds' influence headway distance and overtaking speeds.

With regards to vehicles transporting dangerous goods, Romania is part of the ***European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)*** (ECE,2017), created at Geneva on 30 September 1957 under the auspices of the United Nations Economic Commission for Europe and entered into force on 29 January 1968. The Agreement itself was amended by the Protocol amending article 14 (3) at New York on 21st of August 1975, which entered into force on 19th of April 1985. The last version of the agreement entered into force on 1st of January 2017, and had at the time of publishing included the following Contracting Parties: Albania, Andorra, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, the Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Sweden, Switzerland, Tajikistan, the former Yugoslav Republic of Macedonia, Tunisia, Turkey, Ukraine and United Kingdom. ADR applies to transport operations performed on the territory of at least two of the above-mentioned Contracting Parties.

The structure of the agreement is consistent with that of the United Nations *Recommendations on the Transport of Dangerous Goods*, *Model Regulations*, the *International Maritime Dangerous Goods Code (IMDG Code)* and the *Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID)*. In broad lines, the Agreement specifies guidance for the following:

- Dangerous goods which are barred from international carriage;
- Dangerous goods which are authorised for international carriage and the conditions attached to them (including exemptions) particularly with regards to:
  - Classification of goods, including classification criteria and relevant test methods;
  - Use of packaging (including mixed packing);
  - Use of tanks (including filling);
  - Consignment procedures (including marking and labelling of packages and placarding and marking of means of transport as well as documentation and information required);
  - Provisions concerning the construction, testing and approval of packaging and tanks;
  - Use of means of transport (including loading, mixed loading and unloading).
- Conditions regarding the construction, equipment and operation of vehicles carrying dangerous goods authorised for carriage:
  - Requirements for vehicle crews, equipment, operations and documentation;
  - Requirements concerning the construction and approval of vehicles.

The provision of the ADR precedes the application of other standards required. The requirements of the standards that do not conflict with ADR shall be applied as specified, including the requirements of any other standard, or part of a standard, referenced within that standard as normative.

The Agreement does not specify standards, nor give recommendations, in regards of driving speed, differences in speed for vehicles carrying dangerous goods compared to similar vehicles or any suggestions on this matter, leaving these aspects at the judgement of the national responsible bodies. Most of the EU countries (as can be seen in the following section) adopted non-differential speed strategies between ADR HGVs and HGVs carrying other types of goods, therefore avoiding large differences of speed between the vehicles.

In Romania, in terms of driving speed, ADR HGVs are restricted to different speeds in comparison to other HGVs. These restrictions are stated in the Government Ordnance No 195/2002, Article 50, pp.21: (3). Maximum permitted speed for vehicles with overweight mass, or which transport dangerous goods is 40 km/h in localities and 70 km/h outside localities. This regulation is considering ADR transporters in the same category as the overweight mass vehicle, which, as mentioned before, is very unfamiliar across the EU. Another important aspect to mention is that, this regulation is not very visible, the document mentioned (which is part of the national traffic regulation) being only referred to by the traffic police web page, but not present or accounted for on the Romanian Road Authority web page or on the EU specific abroad transport pages (see the next section).

The regulated, unusually low, speeds for vehicles transporting dangerous goods, compared to other HGVs can be a key factor of danger or risk, especially when accounting for the state of the majority of the Romanian road network, which is single lane, single carriageway roads, with poor or restricted visibility ahead. In accordance with the international research, and giving the high death ratio per million inhabitants, and taking into account the circumstances, the research will focus on understanding the effect these different speeds regulated for ADR HGVs, have on another drivers' behaviour.

SITUATION ELSEWHERE

EU countries are Contracting Parties of the ADR Agreement, along with some other countries, enumerated in the previous section. As mentioned previously, the majority of the EU countries adopt non-differential speed policies for ADR HGVs and HGVs carrying other types of goods, with traffic restrictions similarly applicable to all HGVs or to all HGVs over a certain size (usually over 7.5 tonnes mgw). Traffic restrictions can be, in general, in one of the following forms:

- Lane restrictions (e.g. HGV prohibited from certain lanes on a multi-lane road);
- Speed restrictions (e.g. limited to certain speeds on specific roads);
- Overtaking restrictions (e.g. no overtaking on multi-lane roads);
- Peak time restrictions (e.g. lane use or overtaking restricted to peak times);
- Height restrictions (e.g. for low bridges).

From those types of restrictions, research has found that traffic (lane) restrictions can affect road safety in a positive way by potentially enabling an improved traffic flow and less overtaking by large vehicles, which can sometimes cause sudden braking in traffic and more lane movement, which can increase accident risk (Fitch, 2012).

One less common type of restriction is a speed restriction applied to vehicles carrying a specific load (e.g. dangerous goods). This type of restriction is applied in just a few countries, and varies from one to another in terms of specifics of the regulations. However, this type of regulation seems to work in the opposite way from the advantages identified by international research, of enabling an improved traffic flow and less overtaking by large vehicles. These regulations are more likely to be an obstacle for traffic flow, generating lower speeds, more lane movement and significantly more overtaking, by large or small vehicles. On single lane single carriageway roads (as a big part of the Romanian national roads are) these negative effects are even more powerful because of the lack of alternative for the other traffic participants, large or small vehicle, which will either form queues behind the slower (ADR) vehicles, or engage in overtakes.

Table 2 shows the situation of speed regulations across countries in the EU, highlighting (in red) where the ADR HGVs have different restrictions compared to HGVs carrying other categories of goods. Most countries require all HGVs, irrespective of their charge, to respect the same speed limits on different categories of roads. There are only three exceptions in the presented list from the European Council source: Spain, where the regulations oblige ADR HGV drivers to drive 10 km/h slower than other HGV driver on all roads; Bulgaria, where the regulations oblige ADR HGV drivers to drive 10 km/h slower than other HGV drivers on urban roads and on motorways and expressways, and 20 km/h or 30 km/h slower on non-urban roads; and Romania, where ADR HGV drivers are obliged to drive 10 Km/h slower than other HGV drivers on urban roads, 10 km/h or 20 km/h slower on non-urban roads, and 40 km/h on motorways or expressways. On motorways, this 40 km/h difference within the same mass category of vehicles is susceptible to create numerous large vehicle overtakings and is generating a huge speed differential in comparison to the other vehicles for which the legal speed limit is 130 km/h. These big speed differentials are found in international literature as being a very high-risk factor for collision rates and collision severity rates (described in the following chapters).

Table.2: Speed limits in EU for HGVs and ADR vehicles

Source: http://ec.europa.eu/transport/road_safety/going_abroad/index_en.htm

Country	HGVs (Km/h) - ADR vehicles		
	Urban Roads	**Non-urban Roads**	**Motorways/ expressways**
Austria	50 - 50	70 - 70	80 - 80
Belgium	20;30;50 – 20;30;50	70;90 – 70;90	90-90
Bulgaria	50 – **40**	80;70 – **50**	100;90 - **90**
Croatia	50 - 50	80 - 80	90 - 90
Cyprus	50 - 50	64 -64	80 – 80
Czech Republic	50 - 50	80 - 80	80 - 80
Denmark	50 - 50	70 - 70	80 - 80
Estonia	50 - 50	90 - 90	90 - 90
Finland	50 - 50	80 - 80	80 - 80
France	50 - 50	80;60 – 80;60	90;80 – 90;80
Germany	50 - 50	60;80 – 60;80	60;80 – 60;80
Greece	50 - 50	80;70 – 80;70	70;80;85 – 70;80;85
Hungary	50 - 50	70 - 70	80 - 80
Ireland	50 - 50	80 - 80	90 - 90
Italy	50 - 50	70;80 – 70;80	80;100 – 80;100
Latvia	50 - 50	80 - 80	80 - 80
Liechtenstein	50 - 50	80 - 80	N/A
Lithuania	50 - 50	70;80 – 70;80	80;90 – 80;90
Luxembourg	50 - 50	75 - 75	90 - 90
Malta	40 - 40	60 - 60	60 – 60
Netherlands	50 - 50	80 - 80	80 - 80
Norway	50 - 50	80 - 80	80 - 80
Poland	20;50;60 – 20;50;60	70 - 70	80 - 80
Portugal	50;40 – 50;40	80;70 – 80;70	90;80;70 – 90;80;70
Romania*	50 - **40**	80;90 - **70**	110 - **70**
Slovakia	50 - 50	90 - 90	90 - 90
Slovenia	50;30;10 – 50;30;10	80 - 80	80;90 – 80;90
Spain	50 - **40**	70;80 – **60;70**	80 - **70**
Sweden	50 - 50	70 - 70	80;90 – 80;90
Switzerland	50 - 50	80 - 80	80 - 80
United Kingdom	48 - 48	64;80 – 64;80	96 - 96

*The differences in speed limit for ADR HGVs are not presented in the referred source, they are taken from the national traffic regulation, Government Ordnance No 195/2002 regarding the traffic on public roads, republished, pp.21, Art.50.: (3) Maximum admitted speed for vehicles with overweight mass, or which transport dangerous goods is 40 km/h in localities and 70 km/h outside localities.

REVIEW OF SCIENTIFIC EVIDENCE

The review was undertaken using multiple sources and databases. For legislation and general rules and regulations, as well as for general traffic and road safety reports, the research mostly used, but was not limited to, the following sources:

- European Transport Safety Council (ETSC)
- European Commission
- Romania Traffic Police
- Romanian Road Authority
- Road Safety Observatory
- Safety Cube DSS

For specific research on the investigated topic and the connected topics, the search was undertaken on, although not limited to, the following databases/ search engines:

- Road Safety Observatory — http://www.roadsafetyobservatory.com/
- Safety Cube DSS — https://www.roadsafety-dss.eu/#/
- European Transport Safety Council (ETSC) — http://etsc.eu/
- Google Scholar — https://scholar.google.co.uk/

Since the two research subjects, speed differentials (dispersion), and the safety effect of speed limit changes (increase or decrease), are overlapping, the search and the evidence review was undertaken simultaneously. There were 19 Key Search Terms (KST) used in the methodology. On all investigated sources, the first 50 results, in order of relevance, for each KST, were investigated. An additional 10 Secondary Search Terms (SST) were also used, in combination with each of the KST. For each combination of "KST" AND "SST", the first 30 results, in order of relevance, were investigated. The key terms are:

Key Search Terms (KST)

- Traffic speed dispersion
- Traffic speed restrictions
- Traffic speed differential
- Slow traffic
- Slow vehicles
- Slow driving
- Speed limits increase
- Credible speed limits
- Close following
- Tailgating
- Dangerous overtaking
- ADR restrictions
- ADR vehicles
- ADR rules
- ADR speed
- Dangerous goods vehicle
- Low speed vehicles
- Restricted speed vehicles
- Headway distance

Secondary Search Terms (SST)

- Safety consequences
- Health consequences
- Flow consequences
- Economic consequences
- Psychological
- Anger
- Stress
- Driver behaviour
- Speed limits
- One lane roads

The methodology yielded over ***6,650 research evidences*** to investigate for relevance. Out of these, a number of ***208*** were selected as ***potentially relevant*** for the topic. The 208 were then reviewed thoroughly and a number of ***68*** were selected as ***relevant*** for the project. The 68 relevant research evidences are synthetized and can be found in Appendix I – Research evidence review. An additional ***25 policy reports*** and regulations documents, national and international, were used in constructing arguments and understanding the national and international contexts and are sometimes referred to. These documents will be attached in full to the final report, as a compressed archive.

Before getting into the more focused topics it is important for the reader, and for the researcher, to understand the context of the analysed topics. Therefore, the review begins with some widely debated topics in relation to speed limits in general and to differential speed limits. These topics are closely related to the target topics and are giving the readers the opportunity to understand the context and the relationships between several simple or more complex factors and mechanisms on the road.

One of the most debated topics when talking about speed limits is the Credibility of the Speed Limit. The credibility of the speed limit largely influences the behaviour of the drivers. Investigating how credibility of speed limits affects judgments of appropriate speed, ***Lee (2017)*** found that drivers choose speeds consistent with credible posted speed limits. Looking to develop a decision support instrument for setting safe and credible speed limits (SACREDSPEED), ***Aarts (2008)*** concluded that when operation speed is generally higher than the posted and/or safe speed limit, there is a speeding issue. One reason for speeding could be because the speed limit is not perceived as credible. A speed limit is credible when the limit in force conforms to what the road user considers to be reasonable for that particular road section. Drivers tend to better comply with speed limits when they are more credible. Later, also in the process of creating the decision support instrument, ***Aarts (2011)*** concluded that typically, when the speed limit lacks credibility, it is perceived as too low (although a speed limit that is perceived as too high is also possible) and people tend to speed. Incredible speed limits may also have an adverse effect on the speed limit system as a whole, and finally even on the acceptation of other traffic rules. Also looking at the adverse effect of (more or less) inadequate traffic rules, ***Havarneanu (2018)*** warned that a perfectly adequate traffic rule can turn ''perverse'' in situations when it does little to enhance road safety but seems – at least in the drivers' minds – directed primarily at punishing those who violate it. Rule violations depended on the usual deviant behaviour, perceived irrationality of the rule, little respect for the law and low risk perception.

Looking at results of studies conducted around the world on the effect of speed limits on speed and safety, ***Wilmot (1999)*** concluded that motorists do not adhere to speed limits but instead choose speeds they perceive as acceptably safe. Research shows that speed cannot be linked statistically to the incidence of accidents. The main benefits of increasing speed limits seem to be in improving their credibility with the public and regaining control of speed behaviour on highways. ***Navon (2003)*** also concluded that high speed limits can be beneficial through the reduction of the number of accident-prone interactions (APIs). ***Quimby (1999)*** found that, while there are a variety of interacting factors which determine an individual driver's choice of speed, the largest single influence was the site characteristics, which accounted for over half of the variation in speed. Sometimes, the driver is more susceptible to trust other systems as ISA (Intelligent Speed Assistance) than the posted speed limits. Investigating the potential of combining in-car speed assistance and speed credibility strategies, ***Van Nes (2008)*** reveals that drivers not using ISA appeared to be more susceptible to the speed limit credibility than those using ISA.

Therefore, the credibility of speed limits and of enforcement strategies are very important factors in determining drivers' behaviour with regards to the operation speed. Research ***(Aarts, 2010)*** had developed algorithms (the SACREDSPEED) which can check the credibility of the speed limit (current or ideal) and the enforcement situation (optional). Depending on the fit between the results of the assessments, the algorithms offer suggestions for adaptation consisting of:

- Speed limit adaptation (increase or decrease);
- Road design adaptation; or
- Additional adaptation in enforcement.

These suggestions can also take into account the road network function, the condition of the adjacent roads, the traffic volume, and the priorities the decision maker wants to set.

Another highly debated category of topics is related to **Close Following**, **Tailgating**, and **Overtaking**. Because all of these are commonly analysed in relation to slow vehicles or to large vehicles, some basic findings will help the reader understand the connection with previous and upcoming topics. The situational factors for these behaviours to manifest in a risky manner are relevant for understanding their relationship with posted or legal speed limits.

Aiming to reveal factors that govern car following under conditions of reduced visibility, ***Broughton (2007***) concluded that car following behaviour and the decision-making habits of drivers seem fundamental to understanding how to avoid rear-end crashes. Summarising the research on the risk of close following behaviour, ***Aigner-Breuss (2017)*** concluded that following situations occur when a driver arrives behind a vehicle at a lower speed and needs to react to this situation. In low traffic flow there might be sufficient opportunity for overtaking and maintaining the speed. If traffic flow is high, there might be reasons to follow but there might be an impact on the motivation and willingness to take risks. In a similar review of research, looking at summarising the research on the risk of the close following behaviour, ***Soteropoulos (2016)*** found the following situational factors for close following: traffic volume, traffic scenery or speed related factors, which appear to influence the frequency of risky overtaking.

In a study consisting of a vehicle headway analysis and a questionnaire survey aimed at identifying the causes of tailgating and to find effective means of tailgating treatments, ***Wang (2009)*** found the following top causes for tailgating:

- Heavy traffic;
- Slow car ahead;
- In a hurry;
- Poor visibility;
- Distraction;
- Weather conditions; and
- Hypermiling.

Among the few different tailgating treatments, the most preferred one was where equal-distanced horizontal bars were used as reference markings.

In the complex environment of driving there are multiple factors that influence the tendency of close following, tailgating, and risky overtaking situations. ***Hegeman (2004)***, looking at overtaking frequencies on roads with opposing traffic, concluded that the total risk of overtaking is a multiplication of frequency of overtaking times the risk of each overtaking action. If overtaking frequency increases, the total risk of overtaking will only increase if the risk per overtaking action remains the same or increases as well. Therefore, more overtaking opportunities create the ground for increased risk of overtaking. Looking to assess the speed differential threshold at which drivers decide to pass a lead vehicle, ***Bar-Gera (2005)*** found that the tendency to pass appears to be related to the drivers' own speed variability:

the more variable the driver's speed the more likely he or she was to pass the vehicle ahead even when its speed was greater than their average speed. In the same time, drivers are frequently inaccurate in deciding whether it is safe to overtake in front of an oncoming vehicle ***(Gray, 2005)*** and the size of the gap a driver would accept varies based on the amount of time a driver has already been waiting; the longer this interval is, the more likely that the driver would accept a shorter gap ***(Elefteriadou, 2014)***.

There are more possible reasons for close following, tailgating or dangerous overtaking behaviours, but there are no simple or straightforward relationships and links. ***Kinnear (2015)***, examining the impact of various factors associated with driving on 'A-class' roads in the United Kingdom (specifically length of platoon, proportion of heavy goods vehicles (HGVs), speed and opportunities for overtaking) on self-reported frustration and overtaking intentions, concluded that the links between traffic variables such as speed and platoon length, and behaviourally-relevant variables such as frustration and overtaking intentions, are not simple. Although there are broad and predictable effects of speed and platoon length (lower speeds and longer platoons leading to greater frustration) these are mediated by other variables, and it is not always the case that more frustration leads to more intention to overtake. Analysis of driver attitudes identified three clusters (low, medium and high-risk drivers) and suggests that higher risk drivers' levels of frustration are more affected by situational changes than those of lower risk drivers. In another study, headway was found to change according to the type of vehicle being followed (i.e. subjects followed closer to trucks than to cars) ***(Brackstone, 2009)***. Examining the effect of the time-saving bias on drivers' choice of speed, ***Peer (2010)*** found that drivers overestimate the time saved when increasing from an already relatively high speed and underestimate the time saved when increasing from a relatively low speed. Time-saving bias may help explain why drivers, in some situations, prefer an overly high speed and violate the legal speed limit. ***Rajalin (1997)*** found hurry or desire to overtake the car ahead as the justification for close-following in the majority of cases.

Therefore, at the very first glance at the evidence we can understand how slow vehicles (and more over when they are slower in comparison to other similar vehicles), can induce or augment elements which can then be triggers of risky behaviour, such as close following, tailgating, followed usually by risky overtaking. The following paragraphs will go even deeper, revealing several literature findings in relation to **Driving Behaviour in Congestions**, **Driver Anger**, and **Driver Stress**.

It is widely known and accepted that state anger affects driving behaviour by increasing risk taking ***(Abdu, 2012)*** and that driving stress is related to driving conditions ***(Gulian, 1990)***, altering driving abilities and capabilities, through determination of feelings and actions such as anxiety, fear, lack of reaction, delayed responses etc. In terms of causes, research had identified several factors with a high probability to trigger stress and/or anger while driving. Aiming to test a model for a relationship between drivers' irritation and aggressive behaviour, ***Bjorklund (2008)*** found three main sources of driver irritation: progress impeded, reckless driving, and direct hostility. The tested model also suggested a positive relationship between the amount of driver irritation and frequency of aggressive actions for all three sources of irritation. In a simulator study, ***Roidl (2014)*** shows that the fact that the participant had to wait (regardless of length of time) was sufficient to elicit measurable anger levels. The experience of anger in arrival and safety related goals could be explained as due to near accidents caused by another driver eliciting an anger reaction. The study also shows that anger, anxiety and fright had significant influence on several aspects of driving performance in various simulated traffic situations. Results indicate that anger leads to stronger acceleration and higher speeds even for 2 km beyond the emotion-eliciting event. Anxiety and contempt yielded similar but weaker effects yet showed the same negative and dangerous driving pattern as anger. Fright correlated with stronger braking momentum and lower speeds directly after the critical event. Waiting time and congestion are commonly found to correlate with increasing levels of driving anger and stress. In an observational study, ***Shinar (2004)*** found there was a strong linear association between congestion and the frequency of aggressive behaviours. Even if the relationship was thought to be due to the number of drivers on the road, when the value of time was high (as in rush hours), the likelihood of aggressive driving—after adjusting for the number of drivers on the road—was higher than when the value of time was low (during the non-rush weekday or weekend hours). ***Underwood (1999)*** also reported that, on a journey by journey basis, drivers are more likely to report anger when congestion is present. Their study found a strong association between the number of near accidents and occasions of anger a person experiences while driving. Aiming to discover how angry, if at all, a range of situations on the road make drivers, ***Parker (2002)*** found, among others, the following factors related to driver anger: (i) someone is driving too slowly in the outside lane and holding up the traffic; and (ii) someone is driving more slowly than is reasonable for the traffic flow. ***Deffenbacher (1994)*** found that men are more angered by police presence and slow driving whereas women are more angered by illegal behaviour and traffic obstructions, but differences compensated so there were no gender differences on total score.

Time pressure and time urgency are also a significant factor in determining driving anger. ***Hennessy (2000)*** found that time urgency made a significant positive contribution to state driver stress at both congestion levels. State driver stress is influenced by a combination of situational and personal factors, including factors external to the driving context. Earlier, the same author ***(Hennessy, 1999)*** found that in low congestion, time urgency predicted state driver stress, while aggression predicted driver stress in high congestion, and that reports of aggressive behaviours showed the greatest increase from low to high congestion ***(Hennessy, 1997)***. Lastly, but not least important, anger is triggered different depending on the status of the perpetrator. ***Stephens (2014)*** found reliable differences in subjective anger ratings and behaviour suggesting that anger experienced and expressed depends not just on the actions of the perpetrator but on the perceived status of that perpetrator. Higher status vehicles appear to be forgiven their indiscretions more readily even when there are no extenuating circumstances, whilst lower status drivers are likely to be blamed more readily for circumstances beyond their control.

In terms of effects, investigating in a laboratory experiment, the influence of time pressure on the perception of speed and duration in driving situations, ***Coeugnet (2013)*** found that time pressure promotes fast driving and may induce an underestimation of speed and trip-related durations. Looking at improving the system performance of urban expressways by reducing congestion and crash risk, ***Shi (2015)*** identified congestion indicator effects, both indirect (peak hour, higher volume and lower speed upstream of crash locations) and direct (higher congestion index downstream to crash locations) which confirmed the significant impact of congestion on rear-end crash likelihood.

In a study investigating the interference of negative emotions with information processing and the management of attentional resources while driving, ***Jallais (2014)*** concluded that participants induced in anger were slower to locate road elements than participants induced in sadness and in neutral mood. Drivers exposed to anger could be slower to detect atypical hazards. Exploring the effects of specific emotions on subjective judgement, driving performance, and perceived workload, ***Jeon (2014)*** concluded that anger clearly showed negative effects on subjective safety levels and led to degraded driving performance compared to neutral and fear emotions. In a study for the development of a measure of expressing anger while driving, ***Deffenbacher (2002)*** identified four ways people express their anger when driving, three aggressive and one adaptive/constructive:

- Verbal Aggressive Expression (α=0.88) assesses verbally aggressive expression of anger (e.g., yelling or cursing at another driver);
- Personal Physical Aggressive Expression (α=0.81), the ways the person uses him/herself to express anger (e.g., trying to get out and tell off or have a physical fight with another driver);

- Use of the Vehicle to Express Anger (α=0.86), the ways the person uses his/her vehicle to express anger (e.g., flashing lights at or cutting another driver off in anger); and
- Adaptive/Constructive Expression (α=0.90), the ways the person copes positively with anger (e.g., focuses on safe driving or tries to relax).

Aggressive forms of anger expression correlated positively with driving related anger, aggression, and risky behaviour; adaptive/constructive expression tended to correlate negatively with these variables.

Another very important aspect of speed limits, traffic and congestions is related to the Costs of Traffic and the Optimal Speeds to minimise costs. In a research aimed to assess the positive and the negative consequences of higher speeds, ***Box (2012)*** concluded that there are undoubtedly some tangible and positive benefits to increasing the average speed of traffic. For individuals, this includes reduced journey times and enhanced mobility and access options. If car journey speeds were increased by 10% then the area that could be accessed by the average journey would increase from 55 square miles to 67 square miles. There are also benefits for the economy with regard to reducing the time associated with transporting goods and with journeys in the course of work. In the UK's economic productivity, growth and stability, the author concluded, eliminating existing congestion on the road network would be worth some £7–8 billion of GDP per year.

In a meta-analysis of studies for setting speed limits, ***Elvik (2014)*** identified five principles for setting speed limits:

1. Adapting speed limits to actual driving speed, such as the 85th percentile of the speed distribution, to ensure that the limits seem reasonable from motorists' point of view and are not too widely disregarded;

2. Setting speed limits according to roadway geometry (low speed limits on narrow and winding roads, high speed limits on straight and wide roads);

3. Setting speed limits according to the type and level of roadside development (low speed limits in residential and commercial areas, high speed limits in rural areas);

4. Setting speed limits according to human tolerance for biomechanical energy, in order to ensure that nobody is killed or permanently injured (Vision Zero speed limits);

5. Setting speed limits so as to minimize the total societal costs of transport. Speed limits set this way are generally referred to as optimal speed limits.

The author also offers guidance for setting optimal speed limits. Optimal speed limits are those that minimize the total costs to society of transport. The following impacts of speed are normally included in these costs when optimal speed limits are estimated, considers the author:

- Costs of travel time;
- Vehicle operating costs;
- Road accident costs;
- Costs of traffic noise;
- Costs of air pollution; and possibly
- Costs of road maintenance, as these depend on speed.

Congestion costs, which often occur when having slow vehicles traveling on single carriageway roads should be also minimised. A widely accepted and used method of calculating congestion costs is suggested by ***Goodwin (2004)*** and define the Economic cost of congestion = Total congestion delays *

Value of time. Therefore, by reducing congestion delays the economic burden is also reduced. ***Barth (2008)*** is also suggesting three different strategies that could reduce CO_2 emissions by up to almost 20%:

- congestion mitigation strategies that reduce severe congestion, allowing traffic to flow at better speeds;
- speed management techniques that reduce excessively high free-flow speeds to more moderate conditions;
- and shock wave suppression techniques that eliminate the acceleration and deceleration events associated with the stop-and-go traffic that exists during congested conditions.

The first and the last ones can be improved by reducing the speed differential between vehicles and implementing higher, reasonable speed limits for all vehicle categories (where safety conditions are fulfilled).

There is little research on the topic of **Differential Speed Limits applicable for HGVs or categories of HGVs**, due to the very few cases where these types of restrictions (unrelated to the vehicle category but to the nature of the loading) are applied. Most of the rules related to the category of loading are concerned with safety and training regulations, and very few relate to speed restrictions. When undertaken with the focus on speed, research is usually focused on slow moving vehicles or for agricultural vehicles. ***Singh (2018)*** identified slow moving vehicles (SMVs) as the crucial factor responsible for traffic problems and congestion, affecting transport networks. ***Dey (2008)*** observed that the capacity of a two-lane road decreases as the proportion of tractor or heavy vehicles increases in the traffic stream. With regards to the benefits of the traffic restrictions research ***(Fitch, 2012)*** has found that HGV traffic (lane) restrictions can affect road safety in a positive way by potentially enabling an improved traffic flow and less overtaking by large vehicles, which can sometimes cause sudden braking in traffic and more lane movement, which can increase accident risk. On the other hand, speed restrictions applicable to specific categories of HGVs, especially for single lane roads, can have the opposite effect: the affected vehicles acting as obstacles for the traffic flow, inducing more overtaking and more large vehicle overtaking; inducing more sudden braking; more lane movement; and more disobeying of the rules, creating stress and anger, and therefore increasing the accident risk for all categories of traffic participants. Other research ***(Garber, 2003)***, aiming to compare the safety effects of a uniform speed limit (USL) for all vehicles as opposed to a differential speed limit (DSL) for cars and heavy trucks found no consistent safety effects of DSL as opposed to USL were observed. The mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the ten-year period, regardless of whether a DSL or USL limit was employed.

REVIEW OF SCIENTIFIC EVIDENCE RELATED TO SPEED DIFFERENTIALS (SPEED DISPERSION)

Safety consequences – psychological/physical

Speed dispersion is a very important factor to influence the risk of collision and the effects of its magnitude on crash rate have been largely debated and analysed. In a paper discussing the most important empirical studies into speed and the relationship between speed and the risk of being involved in crashes, ***Aarts (2006)*** found evidence that speed dispersion is an important factor in determining crash rate; larger differences in speed between vehicles being related to a higher crash rate. Looking at the relationship between average speeds, speed variations, and accident rates, ***Quddus (2013)*** found that average speeds are not associated with accident rates when controlling for other factors affecting accidents such as traffic volume, road geometry (e.g., grade and curvature), and number of lanes. Speed variation, however, is found to be statistically and positively associated with accident rates. A 1% increase in speed variation is associated with a 0.3% increase in accident rates, ceteris paribus (all other things being equal). Comparing the 'speed kills' and the 'variance kills, not speed' paradigms with the help of empirical tests, ***Rodriguez (1990)*** found a positive and significant relationship between the variance of the speed distribution and the fatality rate. Therefore, there is enough research evidence to demonstrate the risk of high speed differentials in traffic.

Researchers also looked at the safety effect of strategies for differential speed limits between trucks and cars and found no evidence of significant safety effect. Aiming to compare the safety effects of a uniform speed limit (USL) for all vehicles as opposed to a differential speed limit (DSL) for cars and heavy trucks, ***Garber (2003, 2014)*** found no consistent safety effects of DSL as opposed to USL within the scope of the study. They studied crash, speed, and volume data obtained from ten states for rural interstate highways for the period 1991 to 2000. These states were divided into four policy groups based on the type of speed limit employed during the period: maintenance of a uniform limit only, maintenance of a differential limit only, a change from a uniform to a differential limit, and a change from a differential to a uniform limit. The mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the ten-year period, regardless of whether a DSL or USL limit was employed. When all sites within a state were analysed, temporal differences in these variables were often not significant; however, in several cases, significance was observed if one then excluded sites with unusually high or low traffic volumes from the data set. Further examination suggests that while these data do not show a distinction between DSL and USL safety impacts, the relationship between crashes and traffic volume cannot be generalized but instead varies by site within a single state. In another study on the same data, the same author ***(Garber, 2006)*** found the crash frequency increasing in time regardless of whether a state changed from DSL to USL, changed from USL to DSL, maintained USL, or maintained DSL, leading one to conclude that speed limit policy has no consistent impact on safety. This is probably coming back to speed limit credibility, where over time roads are improving constantly and their appearance becomes one of 'safer' roads more than before.

Analysing two different types of speed control strategies, with the aim of assessing the safety implications of car-truck speed limits for two-lane highways, ***Ghods (2012)*** concluded that, on two-lane highways, speed control can have a significant effect on vehicle interactions. Estimating vehicle interactions affecting safety through the application of a calibrated microscopic traffic simulation model to a 6 Km straight segment of two-lane highway, and using three overtaking-related indicators (number of vehicles overtaking, percentage of time spent in 'desire to overtake mode', and average time-to-collision with the oncoming vehicle prior to returning to the original lane), the authors concluded that, although differential speed strategies (DSL and MSL) were observed to have a minimal increase in the total number of overtake manoeuvres in comparison to a uniform strategy (USL), the effect on the nature of the overtakes i.e. car-car versus car-truck, was significant. Differential speed strategies increased the number and rate of car-truck overtakes over the range of volumes considered in the analysis.

Other authors looked at situational factors and effects directly and indirectly influenced by differential speed limits, through the determination of lower following speeds, of more overtaking situations, lower gaps between cars or other similar factors. In an analysis of driver behaviour, on data from three European cities: Oslo (Norway), Paris (France) and Southampton (UK), ***Piao (2003)*** found that both the time gaps and their standard deviations decreased as the following speed increased, however, such changes were much more obvious when at low speeds than those when at high speeds. For speeds lower than 10 km/h, the research observed large time gaps and large standard deviations; for speeds between 10 km/h and 60 km/h the research observed clear trends of time gaps and standard deviations decreasing as speed increases; and for speeds above 60 km/h the research observed relatively stable time gaps and standard deviations. The inability of human drivers to accurately estimate longitudinal distance to the car in front might be one of the main reasons for this. One of the main effects of speed differential, especially on single-lane roads is that the affected vehicles will act as slow vehicles in traffic, which are a significant factor to determine close following ***(Soteropoulos, 2016)***. ***Aigner-Breuss (2016)*** also concluded that following situations occur when a driver arrives behind a vehicle at a lower speed and needs to react to this situation. In low traffic flow there might be sufficient opportunity for overtaking and maintaining the speed. If traffic flow is high, there might be reasons to follow but there might be an impact on the motivation and willingness to take risks. Close following and queuing behind slow vehicles induce anger and stress to the traffic participant. ***Roidl (2014)*** found that the fact that the participant had to wait (regardless of length of time) was sufficient to elicit measurable anger levels. The experience of anger in arrival and safety related goals could be explained as due to near accidents caused by another driver eliciting an anger reaction.

The evidence presented in this subchapter suggests that there is a lack of evidence for safety effects of differential speed limit strategies. Moreover, the evidence suggests that these strategies are susceptible to increasing crash risk and crash rates through the increase of close following, tailgating and dangerous overtaking situations and through the increase of stress and anger level for traffic participants.

Traffic flow consequences

From a traffic flow perspective, differential speed limit strategies are transforming the affected vehicles into vehicles similar to the slow-moving vehicles. Research has been investigating the effect of slow-moving vehicles on traffic and also some related effects. Analysing the capacity of two-lane roads for different split options, ***Chandra (2001)*** found that the capacity of two-lane roads decreases as the proportion of slow-moving vehicles in the traffic stream increases. Collecting data at several locations of two-lane roads in different parts of India and studying the speed, placement, arrival, acceleration, and overtaking characteristics of different types of vehicles, with the aim of determining the capacity of two-lane roads and to study the effect of traffic mix on capacity and speed, ***Dey (2008)*** observed that the capacity of a two-lane road decreases as the proportion of tractors or heavy vehicles increases in the traffic stream.

Working on a conceptual model for passing bays, ***Jaarsma (2006)*** concluded that slow-moving vehicles, including agricultural vehicles, on arterial highways can cause serious delays to other traffic as well as posing an extra safety risk. In an experiment – phase diagram, ***Masukura (2009)*** also concluded that slow vehicles induce traffic jams (congestions) on multi-lane highways. Finally, in a paper reviewing the current practices to minimise congestion due to slow moving vehicles through traffic-regulation techniques, street vendors policies and parking management, ***Singh (2018)*** found that slow-moving vehicles (SMV) are one of the crucial factors responsible for traffic problems and congestion affecting transport network.

As described in earlier chapters, slow-moving vehicles can influence other drivers' behaviour and affect traffic safety in different ways. In a driving field experiment used to investigate lane changes in which a slow vehicle was present, ***Olsen (2003)*** observed that 37.2% of lane changes are slow lead vehicle lane changes, with a mean completion time of 6.3 s. Investigating factors affecting the car following process in the UK, on different types of high speed roads, ***Brackstone (2009)*** found that headway changes according to the type of vehicle being followed (i.e. subjects followed closer to trucks than to cars). Little variation was found with changes in overall traffic flow, little correlation with road type, and a distinct day-to-day variation in individual behaviour was observed. The car following behaviour and the following distance are very important, ***Broughton (2007)*** considered that car following behaviour and the decision-making habits of drivers are fundamental to understanding how to avoid rear-end crashes.

Having in mind the negative effects slow-moving vehicles are generating to traffic, research and practice is looking for solutions to mitigate theses effects. One of the most common interventions in this respect is represented by slow-vehicle turnouts (or bays). Analysing slow-vehicle bays' performance, ***Koorey (2007)*** concluded that their effect on vehicle following was generally not substantial, but the short-term benefits are probably reducing driver frustration. In another study, looking at the efficacy of slow vehicle turnouts (SVT) for operational improvements, on a rural highway in Alaska, ***Bowie (2016)*** observed that the trend suggests that SVTs are being used by some lead vehicles and that the result is an overall reduction in the percentage of vehicles that are impeded by a slow vehicle in front of them. The effect was greater just downstream of a SVT than it was for locations further away from the SVT.

Again, the presented evidence indicates that slow-moving vehicles represent in general a challenge for traffic planners, being partially responsible for congestions and increasing factors which elicit dangerous behaviours. Policies to decrease the number of slow-moving vehicles or vehicles which act or are being perceived similarly in traffic, are therefore, welcomed.

Health consequences (drivers and public health)

The health consequences of differential speed limit strategies derive firstly from the determination of lower general average and individual speeds, and from the creation of congestion. These consequences, although not widely investigated, can be regarded from two points of view: individual (driver) health consequences and social (public) health consequences.

From an individual perspective, driving conditions are affecting driving stress and anger, as previously evidenced in the paragraphs dedicated to Driving Behaviour in Congestions, Driving Stress and Driving Anger. Stress and anger not only alter driving capabilities, but they also negatively affect the general health condition of the driver, leading to heart or brain affections or conditions. ***Novaco (1979)***, investigating sources of psychological stress as they affect the physiology, task performance, and mood of commuters, shows that the distance and speed of the commute to work were found to account for significant proportions of variation in blood pressure. The research did not look at confounding factors, but we can assume that the distance of commute is correlated with the probability of events such as congestions or slow driving, which were previously shown to be related to driver stress and anger. In a different study, analysing the negative effects resulting from exposure to road traffic noise on people's wellbeing, as reviewed in light of the latest published findings, ***Ouis (2001)*** concludes that exposure of people to road traffic noise leads to suffering from various kinds of discomfort.

From a broader perspective of public health, in a study evaluating 83 individual urban areas with the aim to quantify the public health impacts of traffic congestion, or to determine how these impacts compare in magnitude to the economic costs, ***Levy (2001)*** revealed that that the public health impacts of congestion may be significant enough in magnitude, at least in some urban areas, to be considered in evaluations of the benefits of policies to mitigate congestion.

Logistics costs and CO_2 emissions are two of the most important aspects of public health identified by the literature, when talking about low speeds and congestions. ***Panis (2006)*** considers that, for the differential speed limit settings, the frequent acceleration and deceleration movements in the network are significantly reducing the effect of the reduced average speed on emissions. ***De Vlieger (2000)***, studying a small test fleet aiming to reveal the driving behaviour and traffic condition effects on fuel consumption, found that fuel consumption increased by up to 40% for aggressive driving compared to normal driving. This increase has a proportional effect on CO_2 emissions and is often triggered by congested or slow traffic conditions. ***Figliozzi (2011)*** found that increased congestion during peak morning and afternoon periods in urban areas is increasing logistics costs. The impacts of congestion or speed limits on commercial vehicle emissions are significant but difficult to predict since it is shown that it is possible to construct instances where total route distance or duration increases but emissions decrease. The author also suggested that environmental, social, and political pressures to limit the impacts associated with CO_2 emissions are mounting rapidly.

Using detailed energy and emission models, and linking them to real-world driving patterns and traffic conditions, ***Barth (2008)*** suggested three different strategies to reduce CO_2 emissions by up to 20%:

- congestion mitigation strategies that *reduce severe congestion*, allowing traffic to flow at better speeds;
- speed management techniques that reduce excessively high free-flow speeds to more moderate conditions;
- and shock wave suppression techniques that *eliminate the acceleration and deceleration events associated with the stop-and-go traffic that exists during congested conditions*.

Therefore, no matter what point of view we take, individual or public health, there is a consistent body of evidence encouraging strategies to mitigate congestion and slow driving (where appropriate). Differential speed limits strategies aren't supported from the health perspective either and require additional measures to mitigate their shortcomings.

Economic consequences

The subject of economic consequences related to differential speed limit strategies is not directly treated in the literature, due to the reduced spread of the phenomenon, in general. There are economic implications considered when looking at economic costs of congestions ***(Goodwin, 2004)*** or at strategies for optimal speed limits ***(Elvik, 2014)***. These subjects are mostly treated in previous chapters, or better related to speed limit increase strategies and, therefore, subject for the following chapter. Also, the health and public health issues and challenges presented in the previous chapter, are strictly related to, and generate individual and public (social) costs.

REVIEW OF SCIENTIFIC EVIDENCE RELATED TO INCREASING (OR NOT) SPEED LIMITS (FOR A SPECIFIC CLASS OF VEHICLES)

A considerable body of the evidence related to speed in general and to speed differential in particular is overlapping with the evidence for increasing speed limits for a specific class of vehicles. Therefore, in this chapter the reader can often find reference to evidence already presented in the speed differential chapter, in order to avoid repetition. However, some already discussed evidence might reoccur where there is scope of underlying a different perspective of the research, closer to the analysed topic.

Another aspect to mention is that most of the evidence related to slow vehicles and their effect on the network are valid for this chapter as well, since increasing speed limits for a specific class of vehicles (which, on low speeds might act or be perceived as slow vehicles) would help mitigate those effects and challenges.

Safety consequences – psychological/physical

The safety consequences of increasing speed limits for specific classes of vehicles or for all vehicles, where the situation allows it, are starting to be explored and analysed lately around the world. In Israel, the speed limits on highways were increased on some segments in 2011 and 2013, with 10 km/h, 15 km/h or 20 km/h. ***Harari (2017)*** used three methods to explore the change in safety resulting from this action: (1) a simple before-and-after approach; (2) a before-and-after study with a comparison group; and (3) before-and-after studies with traffic flow correction, using the empirical Bayes method. All the methods showed decreases in the number of crashes after the speed limit change. The finding suggests an increase in safety after the increase in the speed limits to more credible limits.

In April 2015, new national speed limits came into force for heavy goods vehicles (HGVs) over 7.5 tonnes on single carriageway and dual carriageway roads in England and Wales ***(Department for Transport, UK, 2017)***. The new limits are:

- 50 mph (up from 40 mph) on single carriageway roads;
- 60 mph (up from 50 mph) on dual carriageway roads.

The methodology for analysis had focused on two types of variables: traffic speeds and flows. Data from April to December 2014 were used for understanding the baseline situation (before the speed limit changes). Data from April to December 2015 were used for the analysis of the initial impact of the speed limit changes; and collision data (STATS19) for the period from January 2005 to September 2015 were used. There was therefore approximately 10 years of pre-change data and only 6 months of post-change data available. The 2016 analyses are therefore initial findings and should not be interpreted as robust evidence of change.

The initial analysis of traffic speeds and flows found that:

- speeds for HGVs over 7.5 tonnes on single carriageway roads had increased between 2014 and 2015 by more than 1 mph, on average, across a range of flow conditions;
- the equivalent figure for dual carriageways was an increase of less than 0.5 mph.

The initial analysis of safety data between 2005 and 2015 identified that:

- historically, up to 17% of all reported collisions in England and Wales have taken place on single (50 mph and 60 mph speed limit) and dual carriageway (60 mph and 70 mph speed limit) roads - 7.6% of the total collisions on these roads were reported to involve HGVs;

- prior to the introduction of the new speed limits there had already been a trend of collisions reducing on these roads, though the rate of reduction had slowed in recent years;
- in the period following the introduction of the new speed limits there is preliminary evidence of a reduction in HGV collisions estimated to be between 10% and 36%, however, it is not possible to attribute this directly to the speed limit changes.

Therefore, although preliminary, the analysis estimates positive safety effects of the implementation of the new speed limits for HGVs, estimated between 10% and 36% decrease of collisions involving HGVs.

For many situations, where the conditions allow, increasing the speed limits for a class of vehicles in order to align it to the rest of the traffic or to minimise the differences in speed, appear as a reasonable path to follow. Since differential speed limits for cars and heavy trucks were not found to have significant safety effects ***(Garber, 2014)***, and moreover, they were found to increase the number and rate of car-truck overtakes, increasing traffic risk ***(Ghods, 2012)***, the application of these strategies for safety reasons might have, in some cases, contrary effects. HGV restrictions were found to have positive effects when applied as line restrictions, by potentially enabling an improved traffic flow and less overtaking by large vehicles, which can sometimes cause sudden braking in traffic and more lane movement, which can increase accident risk ***(Fitch, 2012)***. Class speed restrictions produce opposite effects to line restrictions.

Other arguments for increasing speed limits for a vehicle class are offered by ***Quimby (1999)*** who concludes that the apparently strong 'cross-sectional' association between speed and accidents does not necessarily imply a causal link between the two, and it cannot be assumed that reductions in speed by particular drivers (a 'within driver' effect) will necessarily result in accident reductions of a size predicted by this association; by ***Piao (2003)***, who found that time gaps and standard deviations are relatively stable at speeds over 70 km/h; by ***Wang (2009)*** who identified 'slow car ahead' as a top cause for tailgating; by ***Aigner-Breuss (2016)*** or by ***Soteropoulos (2016)*** who identified that close following situations occur when a driver arrives behind a vehicle at a lower speed and needs to react to this situation, low-speed vehicles being one of the most common situational factors for the behaviour.

Therefore, there is sufficient evidence to suggest that speeds limits on roads should be set in such a way to assure more homogeneous speeds, at least between vehicles of the same category. Having different traffic restrictions with regards to traffic speed limits for vehicles of the same category, based on the nature of their loading (accounting that there are plenty of rules and regulations for the safety of the loading, of the packing, and for supplementary driver training) seems to be contrary to a traffic safety perspective, when looking at the whole system and at the effects these special regulations create to the network and to other drivers.

Traffic flow consequences

The most important traffic flow consequences of increasing the speed limit to a class of vehicle would be given by the consequences of those vehicles not acting or not being perceived anymore as slow-moving vehicles. Therefore, some slow-moving vehicles challenges, identified and presented previously, would be mitigated:

- the capacity of the roads could increase with the decrease of slow-moving vehicles in the traffic stream ***(Chandra, 2001)***;
- the amount of traffic problems and congestions could be reduced, as a consequence of a decrease in the number of slow-moving vehicles ***(Singh, 2018; Masukura, 2009)***;

- the amount of delays can be reduced, and the safety risk can be decreased as well as a consequence of less slow-moving vehicles ***(Jaarsma, 2006)***;
- the rate of slow lead vehicle lane changes can be reduced as a consequence of fewer slow-moving vehicles on the network ***(Olsen, 2003)***;
- the size of gap drivers could accept can increase if the waiting time intervals would decrease as a consequence of the assumptions revealed above ***(Elefteriadou, 2014)***;
- time gaps and standard deviations could become more stable for speeds over 70 km/h ***(Piao, 2003)***.

The new (increased) speed limits can be more credible but they can also be a better representation of the actual operation speeds. ***Alemazkoor (2014)***, on a study to evaluate the speed distribution before and after a speed limit increased on a freeway in Texas, from 70 mph to 75 mph, found that the 75 mph speed limit is a better representation of the 85th percentile speed than the 70 mph speed limit. The results also indicate that, when the speed limit on a high-speed road is increased, there may not be a similar magnitude of increase in the 85th percentile speed.

Therefore, there is sufficient evidence to suggest that an increase in speed limit, especially when it is for a class of vehicles which are restricted to low speed limits, has the potential to improve traffic safety through the mitigation of the issues that a high number of slow-moving vehicles are raising to traffic and moreover, the new (higher) speed limits might be a better representation of the actual operation speed and eliminate the large speed differentials from the network.

Health consequences (drivers and public health)

The health consequences of increasing the speed limit for a class of vehicles derive as well from the decrease in the number of slow-moving vehicles and congestions and relate both to driver health and to public health. For driver health, decreasing the rate of slow-moving vehicles may have positive effects:

- fewer slow-moving vehicles could mean fewer congestions and fewer occasions for driver stress and driver anger accumulation ***(Bjorklund, 2008; Deffenbacher, 1994; Hennessy, 1997, 1999; Parker, 2002; Underwood, 1999; Shinar, 2004)***;
- fewer slow-moving vehicles could reduce the time urgency feeling and drivers could therefore feel less pressed by time and speed, and close follow, tailgate and overtake less ***(Coeugnet, 2013; Hennessy, 2000; Roidl, 2014)***;
- less anger and stress accumulation could lead to less aggressive behaviour, less hostility, less reckless driving and fewer rear-end crashes ***(Abdu, 2012; Bjorklund, 2008; Deffenbacher, 2002; Shi, 2015; Shinar, 2004)***.

The public health consequences are mostly related to the CO and CO_2 emissions and were reported in the health consequences chapter for the speed differentials topic. They widely concern:

- the increased fuel consumption generated by aggressive driving ***(De Vlieger, 2000)*** or by frequent acceleration and deceleration ***(Panis, 2006)***. These could decrease with the decrease in the number of slow-moving vehicles and congestions;
- congestion mitigation strategies to improve traffic flow, decrease CO_2 emissions, and decrease exposure of people to road traffic noise ***(Barth, 2008; Levy, 2001; Ouis, 2001)***, for which a strategy to decrease the rate of slow-moving vehicles would be beneficial.

Additionally, in an examination of the various means of driving speed investigators, fundamental for emissions estimations and inventories, ***Andre (2000)*** found that CO and CO_2 emissions generally are high at low speeds, decrease up to 60-80 km/h and then increase again. Therefore, large vehicles (which are the largest emitters of CO and CO_2) should avoid traveling at very low speeds, from this perspective.

Economic consequences

The general consequences generated by the economic cost of congestions ***(Goodwin, 2004)*** and the costs that should be accounted for when setting optimal speed limits ***(Elvik, 2014)*** were reported in the economic consequences chapter of the speed differential topic and are as valid for this topic, as well.

Of highest relevance to the topic of increasing speed limits for a class of vehicle are Box's conclusions ***(Box, 2012)***: "There are undoubtedly some tangible and positive benefits to increasing the average speed of traffic. For individuals this includes reduced journey times and enhanced mobility and access options. If car journey speeds were increased by 10% then the area that could be accessed by the average journey would increase from 55 square miles to 67 square miles. There are also benefits for the economy with regard to reducing the time associated with transporting goods and with journeys in the course of work."

In a study of safety and other impacts of speed limit changes on high-speed roads, ***Kockelman (2006)*** also concluded that the higher speeds resulting from a speed limit increase lead to travel time savings that have an economic value. The vehicles most likely to experience such savings are those making long distance trips primarily in rural areas, where vehicle speeds are not significantly constrained by congestion.

REVIEW OF SCIENTIFIC EVIDENCE – CONCLUSIONS

After reporting and analysing all this body of evidence, the authors consider that there is enough evidence to show the following:

- ADR HGVs are regulated to drive in Romania at speeds comparable to slow-moving vehicles, and can be perceived as unusually slow by comparison, since HGVs with other types of loading do not fall under the same regulations; they are appointed to drive at speed limits similar with the limits for the oversized vehicles, which are, mostly, driving at speeds lower than the legal limits anyway, because of physics and road fitness reasons;
- Slow-moving vehicles are found to increase the rate of congestions on the roads;
- Slow-moving vehicles are found to determine driver stress and driver anger, which lead to aggressive behaviour and reckless driving;
- Slow-moving vehicles are increasing the number of large vehicles overtaking each other, which is demonstrated to be within the actions with the highest risk on the roads;
- Slow-moving vehicles are found to generate individual and public health consequences by increasing the congestion rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road;
- Slow-moving vehicles are found to generate significant economic consequences, by increasing the congestions rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road;

The authors also suggest a field study to investigate speeds, gap, headway distance, and time gap of traffic participants when following large vehicles at different speeds under distinct circumstances: inside and outside localities, on portions of road with clear view and on portions of road with very limited visibility (curves). Such a study would give an even clearer image about the effect of the slow-moving vehicles on other traffic participants.

FIELD STUDY - ROMANIA

As suggested at the end of the previous chapter, a field study was deployed, on 5 locations in Romania, analysing speeds, gaps and queue length for a large number of vehicles. The locations were chosen in such a way as to vary in terms of rural/urban, curvature, or length of the straight line. This chapter describes the study and the results of the analysis.

DATA COLLECTION

Locations

Data collection was done with an SDR Traffic+ radar device, a versatile and reliable traffic classifier using an inbuilt microwave (radar) sensor to measure traffic at one or two lane (opposite direction) road layouts. The data collected for each record was: Speed, Lane, Time, Date, and Length. From the recorded variables the project team could accurately compute Headway and Gap, in seconds and metres. Other variables and indices were also calculated and are discussed in the Data Analysis section.

The collection (627,204 vehicles recorded in total) was undertaken in 5 distinct locations on road 7D in Romania between 16/03/2018 and 28/04/2018, as follows:

1. Aldesti – urban road

   GPS: Lat 45°3.731'N, Lon 24°25.235'E, 121° E-SE

   Speed limit: 50km/h

   Collection time: 16/03/2018, 08:00 – 29/03/2018, 10:59

2. Balota – rural road

   GPS: Lat 45°25.259'N, Lon 24°17.418'E, 25° N-NE

   Speed limit: 90km/h

   Collection time: 29/03/2018, 12:00 – 05/04/2018, 10:59

3. Lotrisor – rural road

   GPS: Lat 45°18'16" N, Lon 24°17'10" E, 242° S-SW

   Speed limit: 90km/h

   Collection time: 05/04/2018, 12:00 – 14/04/2018, 10:59

4. Brezoi – urban road

   GPS: Lat 45°20'2" N, Lon 24°17'8" E, 242° S-SW

   Speed limit: 50km/h

   Collection time: 14/04/2018, 12:00 – 21/04/2018, 09:59

5. Goranu – urban road

   GPS: Lat 45°6'45" N, Lon 24°23'12" E, 184° S-SW

   Speed limit: 50km/h

   Collection time: 21/04/2018, 12:00 – 28/04/2018, 08:59

DATA ANALYSIS

The data collected was grouped in an Excel workbook and analysed from different perspectives. The following charts are presenting the most important and/or relevant findings in relation to the analysed topic. For some of the findings, different indices were computed, and they are explained for each case.

Traffic distribution

To understand the findings and to give the reader the opportunity to get a grasp of the context, firstly some traffic distribution analysis was undertaken.

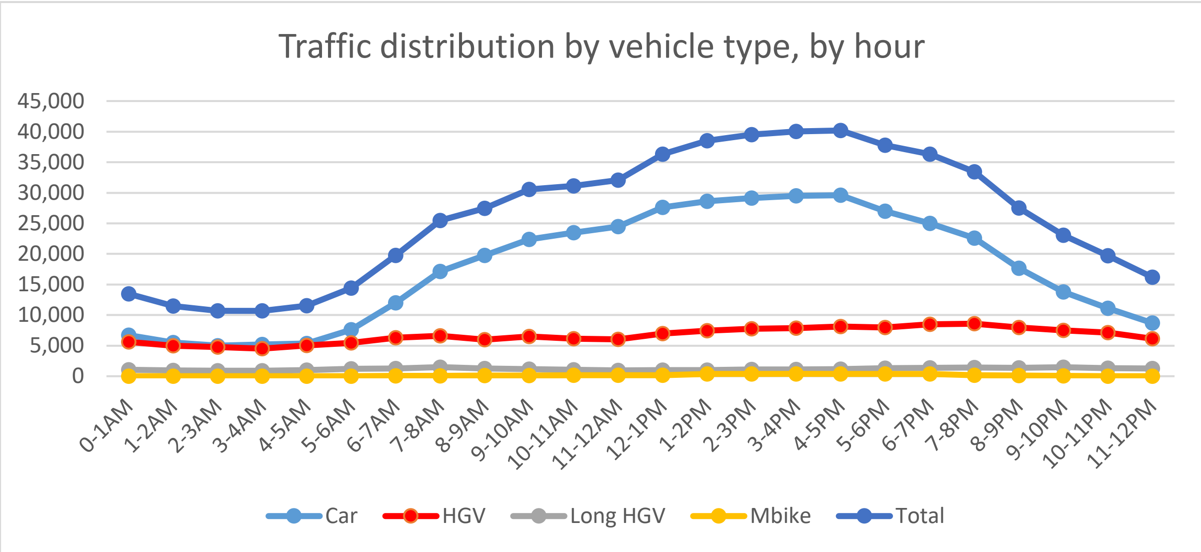

Fig.5: Traffic distribution by vehicle type, by hour

As can be observed from the Figure 5 above, and from Table 3, we can see that the traffic on the location of the data collections presents several characteristics:

- During the night hours HGV traffic is similar with the car traffic (in numbers);
- HGV traffic doesn't vary to much between day and night, whereas the car traffic is varying to a scale of 1:6;
- The peak hours for all vehicles and for cars especially is between 12AM and 8PM, slightly unusual compared to western countries where the peak hours are around the commute times;
- The motorbike proportion is around 1% of the traffic;
- There is a significant share (up to 3%) of unusual vehicles (either under 2.1m long, the length of a motorcycle, which can be scooters, bicycles, or small trailers detected separately, either unclassifiable, which can mean that they are for instance carried by animals).

Table.3: Traffic distribution by vehicle type, by hour

Hour	Car	HGV	Long HGV	Motorbike	Unclassified	Total
0-1AM	6,691	5,614	1,084	24	52	13,465
1-2AM	5,516	4,979	937	11	28	11,471
2-3AM	5,005	4,766	905	9	34	10,719
3-4AM	5,184	4,514	921	19	50	10,688
4-5AM	5,330	5,046	1,032	18	110	11,536
5-6AM	7,581	5,475	1,222	26	90	14,394
6-7AM	11,986	6,298	1,287	44	125	19,740

Hour	Car	HGV	Long HGV	Motorbike	Unclassified	Total
7-8AM	17,153	6,593	1,497	59	176	25,478
8-9AM	19,772	5,989	1,252	104	349	27,466
9-10AM	22,396	6,509	1,157	107	372	30,541
10-11AM	23,453	6,128	1,044	142	379	31,146
11-12AM	24,458	6,048	969	159	423	32,057
12-1PM	27,638	6,975	999	187	490	36,289
1-2PM	28,604	7,427	1,015	390	1,053	38,489
2-3PM	29,111	7,746	1,113	389	1,172	39,531
3-4PM	29,522	7,881	1,124	391	1,092	40,010
4-5PM	29,601	8,105	1,142	364	972	40,184
5-6PM	27,011	7,959	1,313	362	1,110	37,755
6-7PM	25,014	8,473	1,347	368	1,102	36,304
7-8PM	22,612	8,590	1,450	182	601	33,435
8-9PM	17,682	7,951	1,380	140	380	27,533
9-10PM	13,786	7,491	1,468	75	234	23,054
10-11PM	11,125	7,143	1,336	25	101	19,730
11-12PM	8,699	6,161	1,248	26	55	16,189
Total:	**424,930**	**159,861**	**28,242**	**3,621**	**10,550**	**627,204**

Presented on time of day intervals, the image is even clearer. From Figure 6 and Table 4, we can easily see that the volume of HGV traffic is relatively constant during the entire day (24 hours) whereas the car traffic volume has a high variance with a peak in the afternoon.

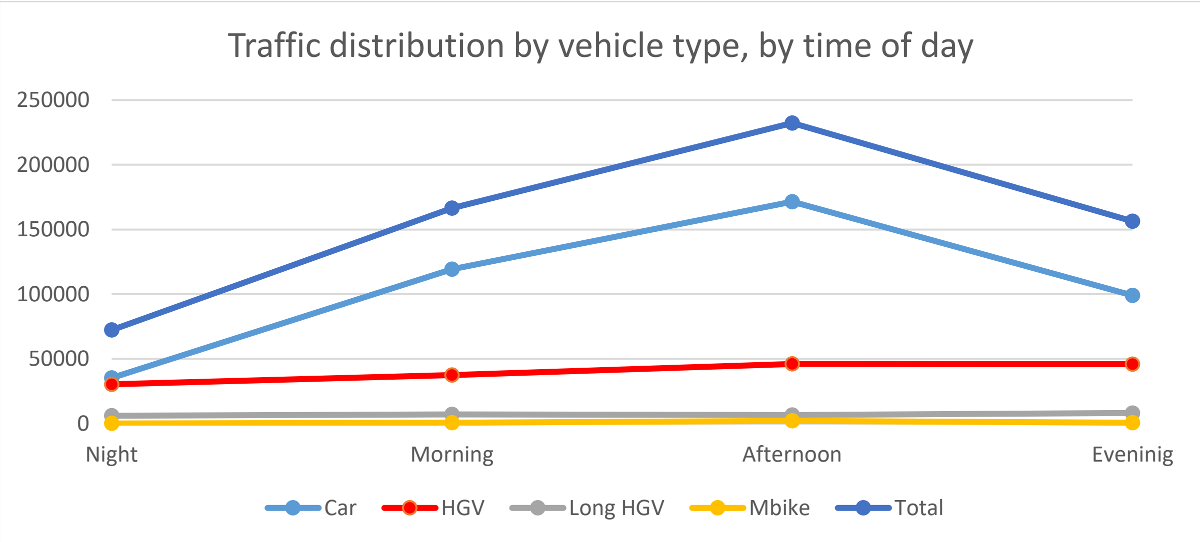

Fig.6: Traffic distribution by vehicle type, by time of day

Table.4: Traffic distribution by vehicle type, by time of day

Time of day	Car	HGV	Long HGV	Motorbike	Unclassified	Total
Night	35,307	30,394	6,101	107	364	72,273
Morning	119,218	37,565	7,206	615	1,824	166,428
Afternoon	171,487	46,093	6,706	2,083	5,889	232,258
Evening	98,918	45,809	8,229	816	2,437	156,245
Total:	**424,930**	**159,861**	**28,242**	**3,621**	**10,550**	**627,204**

When splitting the data by the speed limit at the locations where the data was collected, the distribution for 50km/h roads and for 90km/h roads does not differ significantly, as can be seen from Figures 7 and 8 below.

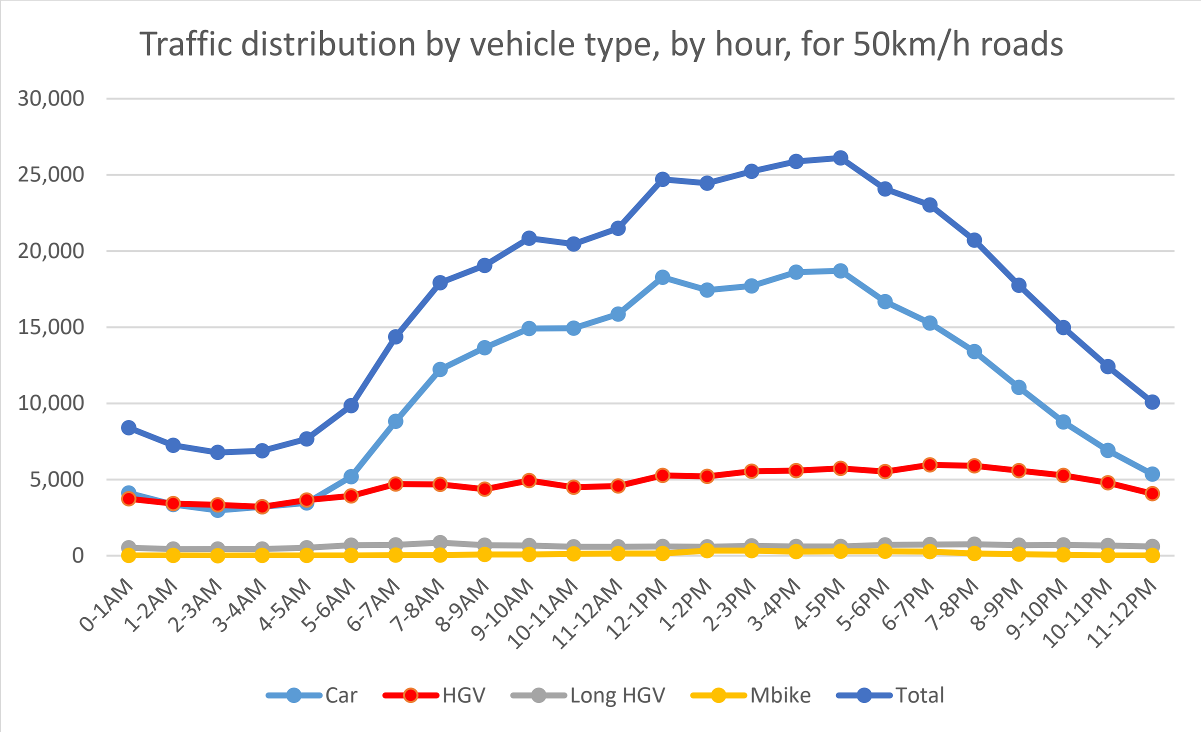

Fig.7: Traffic distribution by vehicle type, by hour, for 50km/h roads

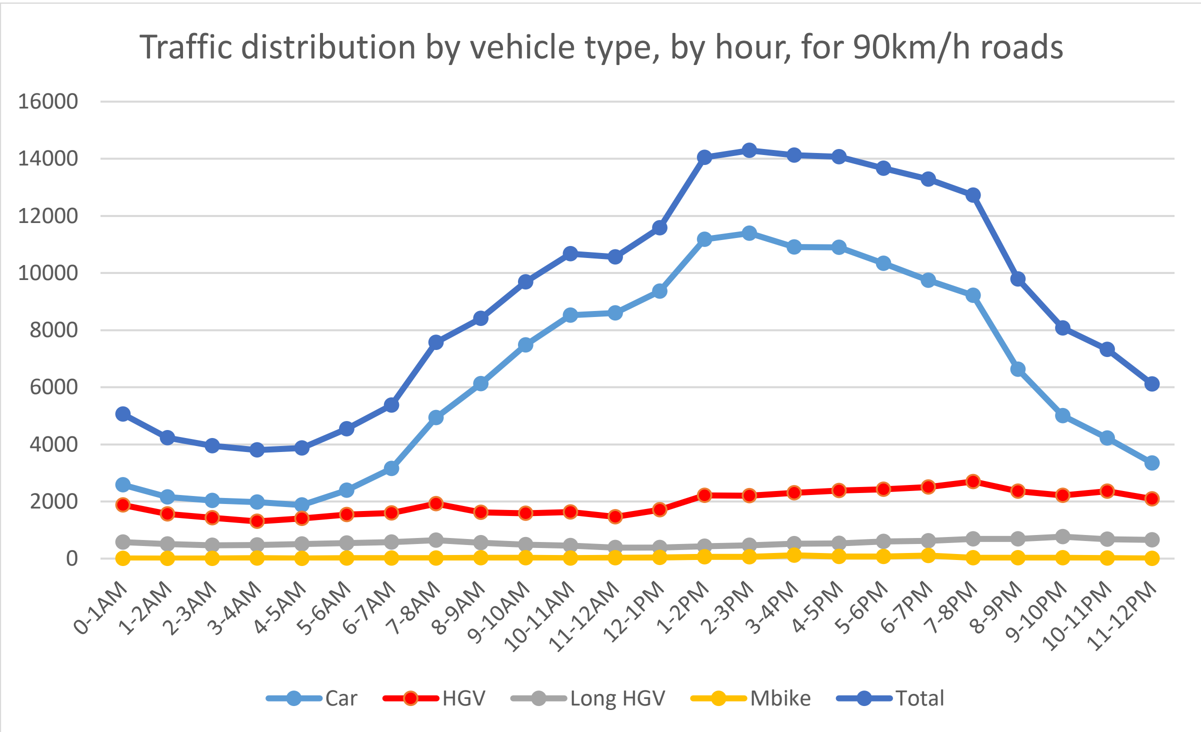

Fig.8: Traffic distribution by vehicle type, by hour, for 90km/h roads

Traffic speeds

The next section is analysing the speeds that different vehicle categories are traveling at, for each category of roads (50km/h roads and 90km/h roads), looking at percentage of vehicles traveling within legal speeds or 10km/h above, percentage of vehicles traveling within distinct speed bands and cumulative percentages.

Table.5: Traffic distribution by speed bands, by vehicle type, for 50km/h roads

Speed band	%Car	%HGV	%Long HGV	%Motorbike	%Unclassified	%Total	Cumulative Total
<20km/h	0.2%	0.2%	0.2%	0.5%	1.1%	0.2%	0.2%
20-30km/h	0.6%	0.8%	1.3%	1.3%	1.6%	0.7%	1.0%
30-40km/h	2.0%	2.4%	2.5%	2.3%	3.3%	2.2%	3.2%
40-50km/h	9.4%	12.7%	7.1%	11.4%	12.4%	10.3%	13.4%
50-60km/h	29.0%	29.6%	19.7%	33.9%	35.7%	29.0%	42.4%
60-70km/h	35.7%	36.5%	40.9%	34.9%	32.7%	36.1%	78.5%
70-80km/h	16.5%	15.3%	24.1%	12.3%	10.5%	16.3%	94.8%
80-90km/h	4.7%	2.2%	3.8%	2.4%	2.1%	3.9%	98.7%
90-100km/h	1.3%	0.3%	0.3%	0.7%	0.4%	0.9%	99.6%
100-110km/h	0.4%	0.0%	0.0%	0.2%	0.2%	0.3%	99.9%
110-120km/h	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	100.0%
>120km/h	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Total:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

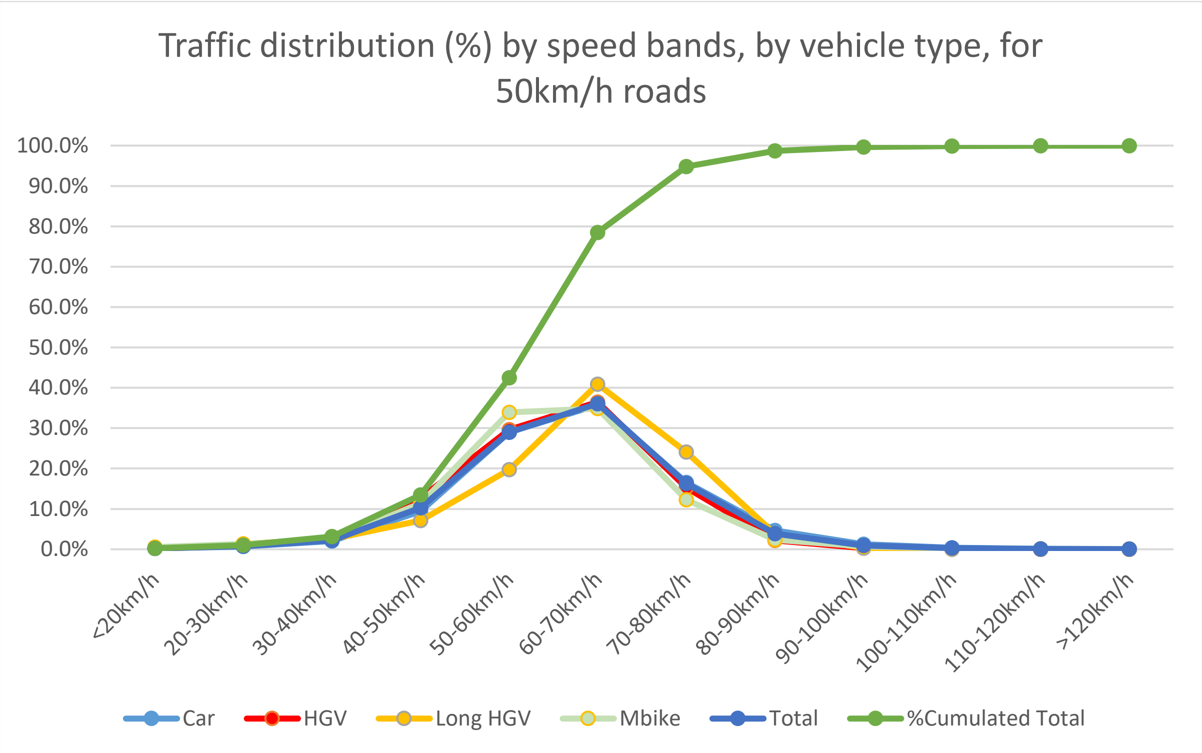

Figure.9: Traffic distribution by speed bands, by vehicle type, for 50km/h roads

The next figure, Figure 10, is showing basically the same information, for total vehicles, cars and HGVs, using a visualisation solution which makes it easier to differentiate between the three categories. As can be observed, for 50km/h roads the distribution is pretty similar for all three chosen categories.

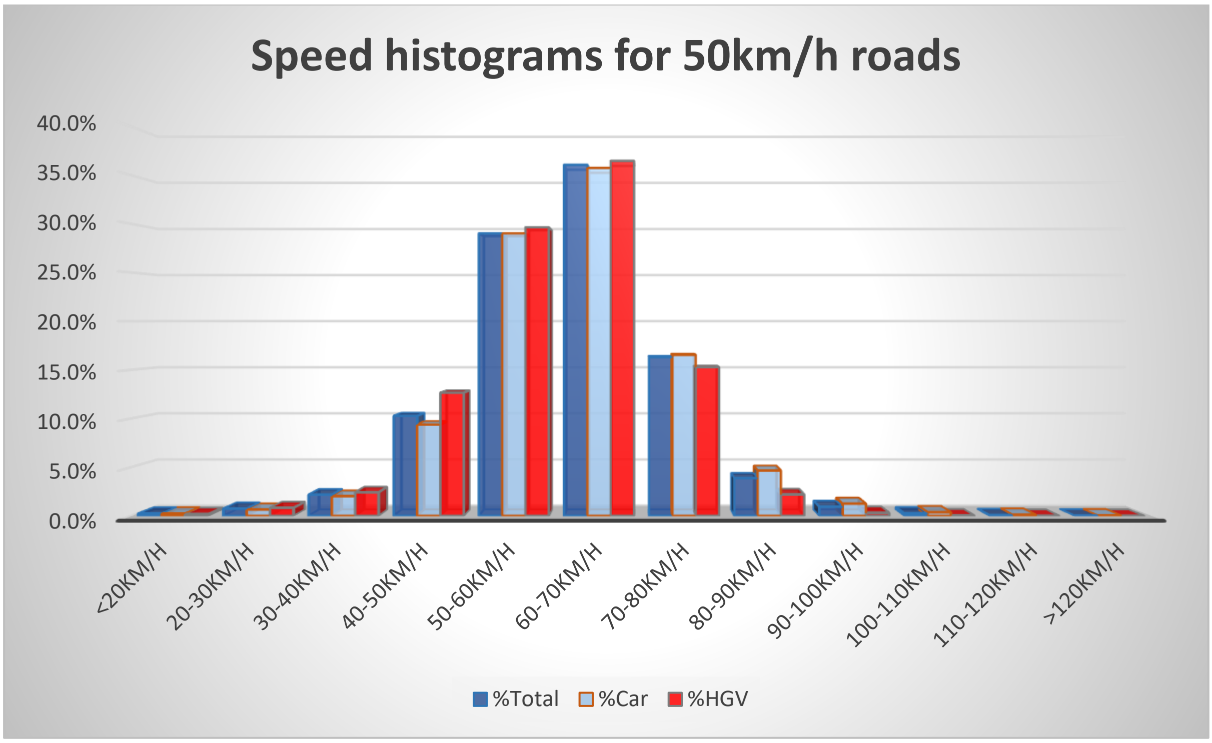

Figure.10: Speed histograms by speed bands, by vehicle type, for 50km/h roads

Although the legal limit is 50km/h we can see that the biggest proportion of vehicles are travelling with speed between 60km/h and 70km/h (36.1% of the total vehicles, 35.7% of cars, and 36.5% of the HGVs). Only 13.4% of total vehicles are traveling within legal limits. For cars, the percentage is even lower, of 12.3%, whereas for HGVs this percent is 16.1%. However, in Romania, anecdotally, drivers 'know' that they will not receive a fine for up to 10km/h above the limit. But, even so, only 42.4% of total vehicles are traveling within the 'popular' limit, with 41.3% of the cars and 45.7% of the HGVs. These percentages are pointing towards at least two important warning messages: (1) the speed limits seem not to be in accordance with the real traffic, therefore not credible, and (2) the speed management system, if any, is not efficient.

For the 90km/h roads (reduced to 70km/h for a few hundred metres just before and after any locality), the situation is not as bad (if we consider 90km/h the limit and not 70km/h), but is still far from ideal, as can be observed from Fig 10 and from Table 6.

Table.6: Traffic distribution by speed bands, by vehicle type, for 90km/h roads

Speed band	%Car	%HGV	%Long HGV	%Motorbike	%Unclassified	%Total	Cumulative Total
<20km/h	0.4%	0.2%	0.1%	1.3%	2.7%	0.3%	0.3%
20-30km/h	0.6%	0.3%	0.2%	1.8%	2.3%	0.6%	0.9%
30-40km/h	1.7%	1.1%	0.2%	3.2%	4.1%	1.5%	2.4%
40-50km/h	9.7%	9.5%	0.3%	15.3%	13.9%	9.2%	11.5%
50-60km/h	24.0%	29.6%	1.2%	18.9%	15.9%	23.7%	35.3%
60-70km/h	21.5%	14.8%	4.1%	11.0%	12.9%	18.9%	54.2%
70-80km/h	12.6%	13.8%	24.5%	13.8%	14.1%	13.6%	67.8%
80-90km/h	12.5%	19.1%	47.0%	16.2%	19.0%	16.1%	83.9%
90-100km/h	8.7%	8.7%	20.8%	10.5%	8.7%	9.4%	93.3%
100-110km/h	4.6%	2.2%	1.7%	4.5%	3.5%	3.9%	97.2%
110-120km/h	2.2%	0.4%	0.0%	2.7%	1.7%	1.7%	98.9%
>120km/h	1.5%	0.1%	0.0%	0.7%	1.2%	1.1%	100.0%
Total:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

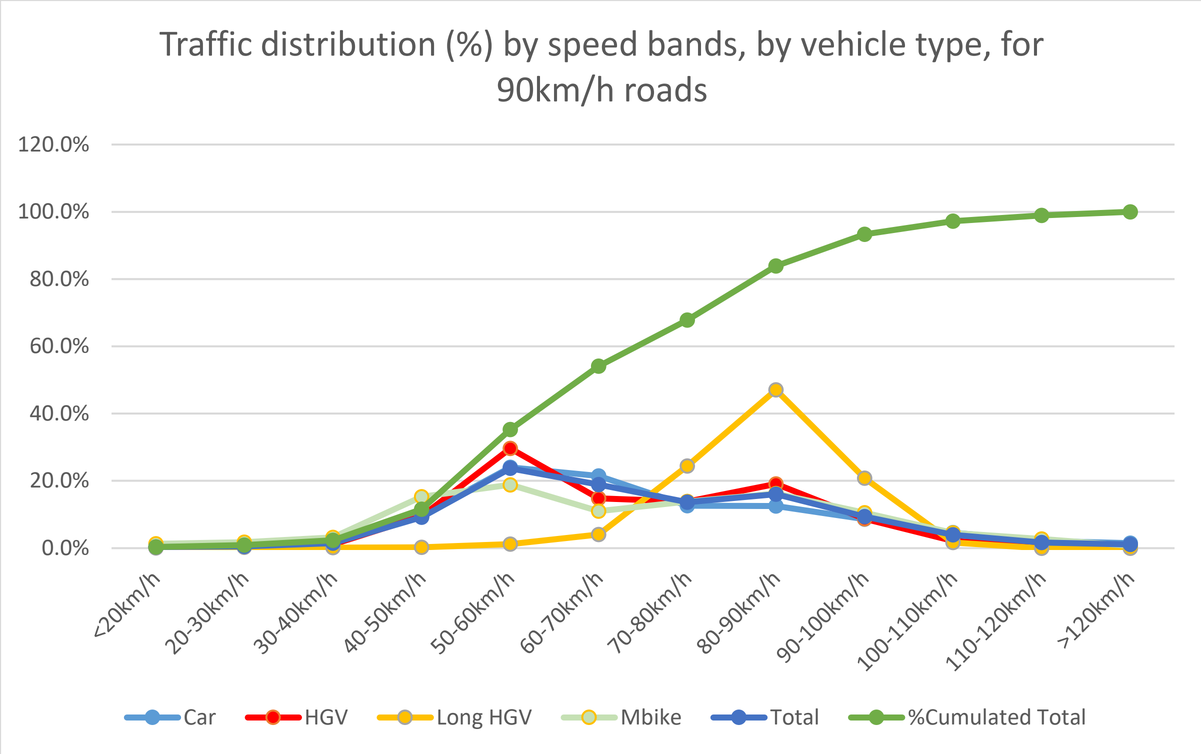

Figure.11: Traffic distribution by speed bands, by vehicle type, for 90km/h roads

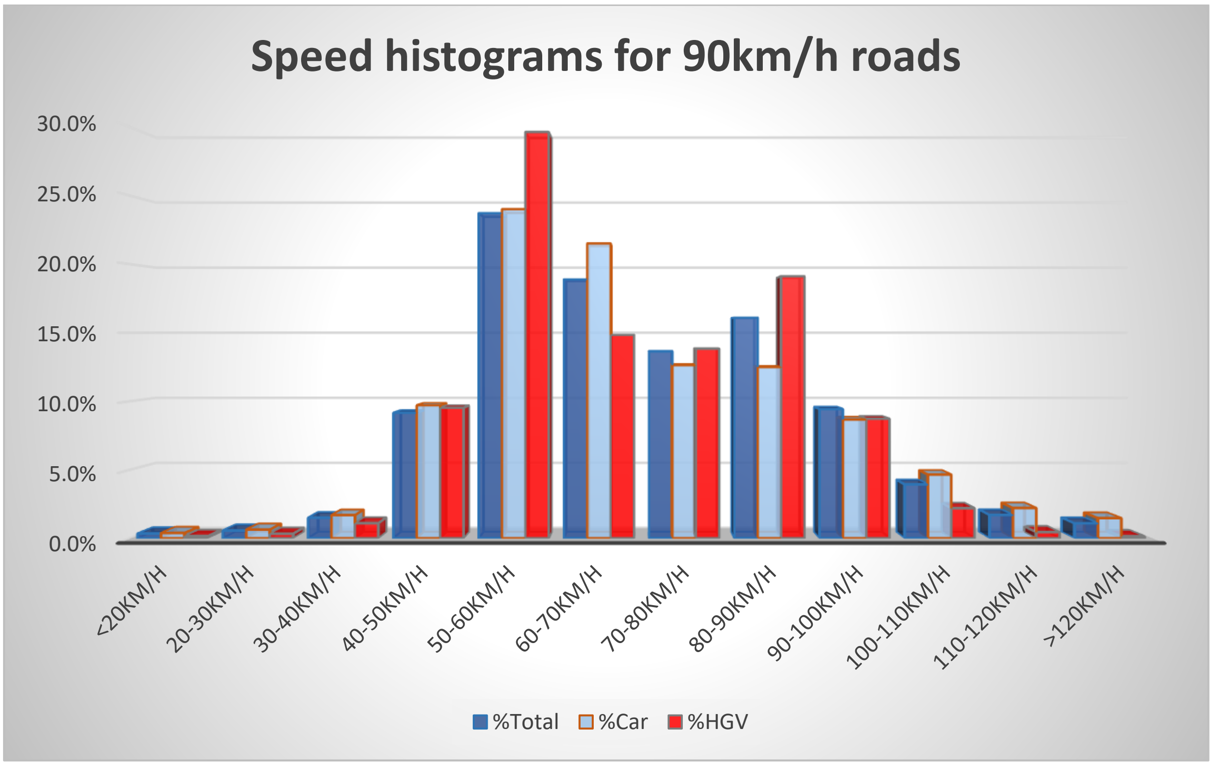

Figure.12: Speed histograms by speed bands, by vehicle type, for 90km/h roads

Although it is a different speed limit (a higher one), in most of the cases we can see that the highest proportion of vehicles are traveling at lower speeds, between 50km/h and 60km/h (23.7% of the total vehicles, 24% of cars, and 29.6% of the HGVs). Even if we consider 70km/h as being the speed limit, the chosen speed is still 10km/h below.

Cumulative, 83.9% of the vehicles are traveling within the legal limit, and 93.3% within the 'popular' limit. 83% of the cars and 88.5% of the HGVs are traveling within legal limits, and 91.7% of the cars and 97.2% of the HGVs are traveling within the 'popular' limit. At a first glance it looks like the speed limit is more appropriate than in the previous case but, the big percentage of vehicles traveling at speeds considerably below the speed limit indicates that, in this case, the speed limit might be too high for the conditions and therefore, inappropriate again.

Analysing the percentage of distinct categories of vehicles traveling within the legal speed limits (or the popular speed limits), we can see that there are not big differences between categories of vehicles, most of them following a similar path during the day.

Table.7: Percentage of vehicles traveling with up to 50km/h and up to 60km/h, by time of day and vehicle type, on 50km/h limit roads

Time of day	%50-Car	%60-Car	%50-HGV	%60-HGV	%50-Total	%60-Total
Night	11.9%	30.9%	17.1%	39.8%	14.1%	34.4%
Morning	11.5%	39.7%	15.2%	43.9%	12.4%	40.6%
Afternoon	11.6%	42.9%	13.7%	46.0%	12.2%	43.8%
Evening	14.7%	44.4%	18.7%	50.9%	16.1%	46.4%
Total	**33,261**	**111,866**	**18,245**	**51,876**	**55,123**	**174,200**

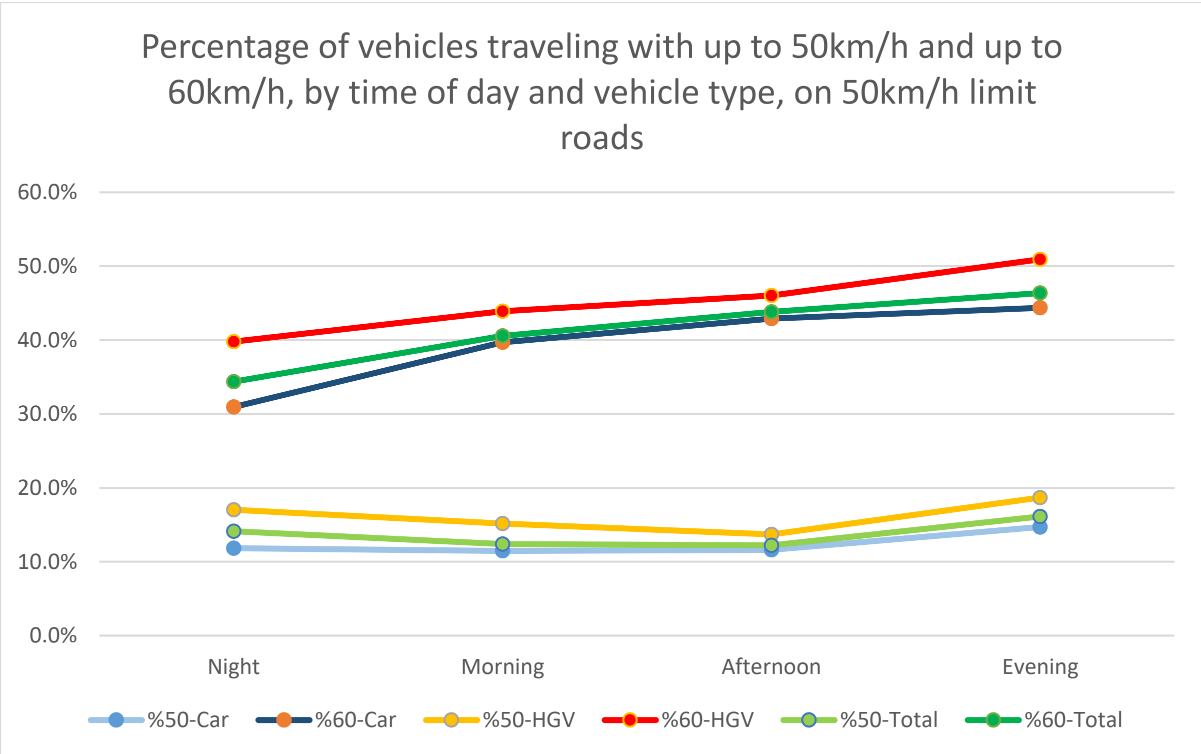

Figure.13: Percentage of vehicles traveling with up to 50km/h and up to 60km/h, by time of day and vehicle type, on 50km/h limit roads

On 50km/h roads, only between 12.2% and 16.1% of all vehicles travel within the legal speed limit, cars varying from 11.5% to 14.7%, and HGVs varying between 15.2% and 18.7%. For the 'popular' speed limit (60km/h), there are between 34.4% and 46.4% of all vehicles, between 30.9% and 44.9% of cars, and between 39.8% and 50.9% of HGVs. HGVs 'compliance' rates are slightly higher than for other categories in all analysed cases. For all vehicle categories, in both cases, the highest percentage of 'compliance' was found in the evening.

On the 90km/h limit roads the situation looks a lot better, with a very high proportion of vehicles traveling within legal limits.

Table.8: Percentage of vehicles traveling with up to 90km/h and up to 100km/h, by time of day and vehicle type, on 90km/h limit roads

Time of day	%90-Car	%100-Car	%90-HGV	%100-HGV	%90-Total	%100-Total
Night	80.3%	89.2%	88.7%	96.7%	83.2%	93.0%
Morning	80.8%	90.0%	85.1%	96.2%	81.2%	91.7%
Afternoon	83.9%	92.6%	87.4%	97.4%	84.2%	93.6%
Evening	84.7%	92.6%	91.8%	98.2%	86.2%	94.4%
Total	**127,912**	**141,253**	**41,057**	**45,100**	**181,878**	**202,303**

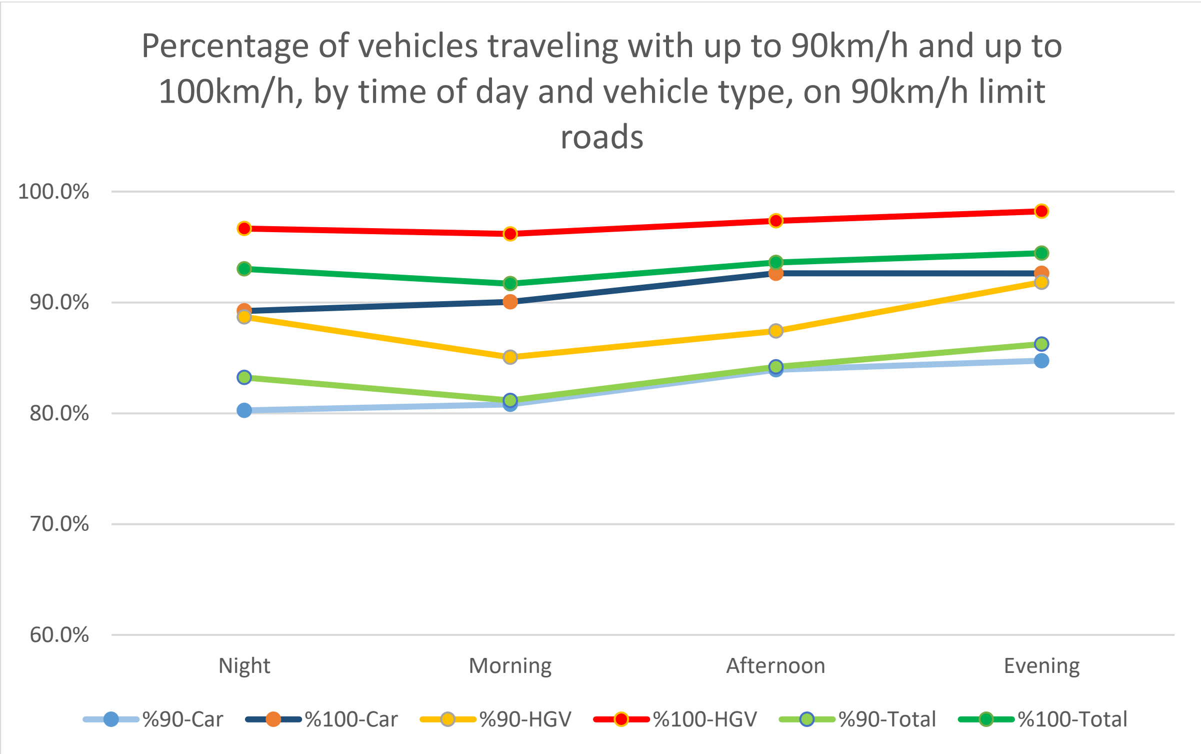

Figure.14: Percentage of vehicles traveling with up to 90km/h and up to 100km/h, by time of day and vehicle type, on 90km/h limit roads

Again, HGVs 'compliance' rate is slightly higher than the other vehicles categories' rates, varying between 85.1% and 91.8% for the legal limit and between 96.2% and 98.2% for the 'popular' speed limit. For all vehicle types, the higher rates are during the evening hours.

Gap behind and queue length

To understand the traffic conditions more and how traffic is behaving at different speeds, two indices were calculated, as follows:

(1) The average gap behind until a gap bigger than 5s is met – A formula was developed to calculate, for each record, the average gap behind each vehicle for queues. The formula is looking at each vehicle and averages the gap between the vehicles behind, until a gap of 5s (an interval for which the vehicles are not considered as being part of the same queue anymore) is met. This index, although somehow useful, has the shortcoming of not being able to differentiate between the queue leader and the vehicles following (therefore, for example, in a queue of 15 cars with an average gap of 2.5s between the cars, the leading vehicle will have an average of 2.5s, of the 14 vehicles behind, but the second vehicle, first in the queue, will have a similar average gap, of the 13 vehicles behind, and so on). Because of this shortcoming, the index is not showing significant differences between categories of vehicles and is more likely to show differences between vehicles travelling at different speeds.

(2) Average number of vehicles behind (average queue length) – A new formula, similar to the one described previously was used, but this time the index is recording the number of vehicles queueing behind for each record, again until a gap bigger than 5s is met. In this case, even if the shortcoming described for the previous index is still influencing the analysis, the leading vehicle would get at least one point more than any other following vehicle, and therefore we should be able to see significant differences between categories of vehicles if they exist in traffic.

The following several charts and tables will be focusing on the two indices described, allowing for a better understanding of the traffic.

Table.9: Average gap behind (s) until a gap bigger than 5s is met

Time of day	Total (50)	Total (90)	Car (50)	Car (90)	HGV (50)	HGV (90)
Night	2.45	2.16	2.40	2.02	2.47	2.32
Morning	2.35	1.97	2.34	1.95	2.36	2.07
Afternoon	2.26	1.97	2.25	1.96	2.27	2.00
Evening	2.33	2.02	2.30	1.97	2.36	2.14

There are several aspects that can be mentioned from this analysis, although the differences aren't very big:

- ✓ The smallest gap averages can be found behind cars;
- ✓ The biggest gap averages can be found behind HGVs;
- ✓ For all vehicle categories the gap averages are bigger on 50km/h roads;
- ✓ On 90km/h roads, the difference in gap averages between HGVs and cars or other vehicles is more significant;
- ✓ In general, the biggest gap averages are found during night time and the smallest gap averages are found in the afternoon;

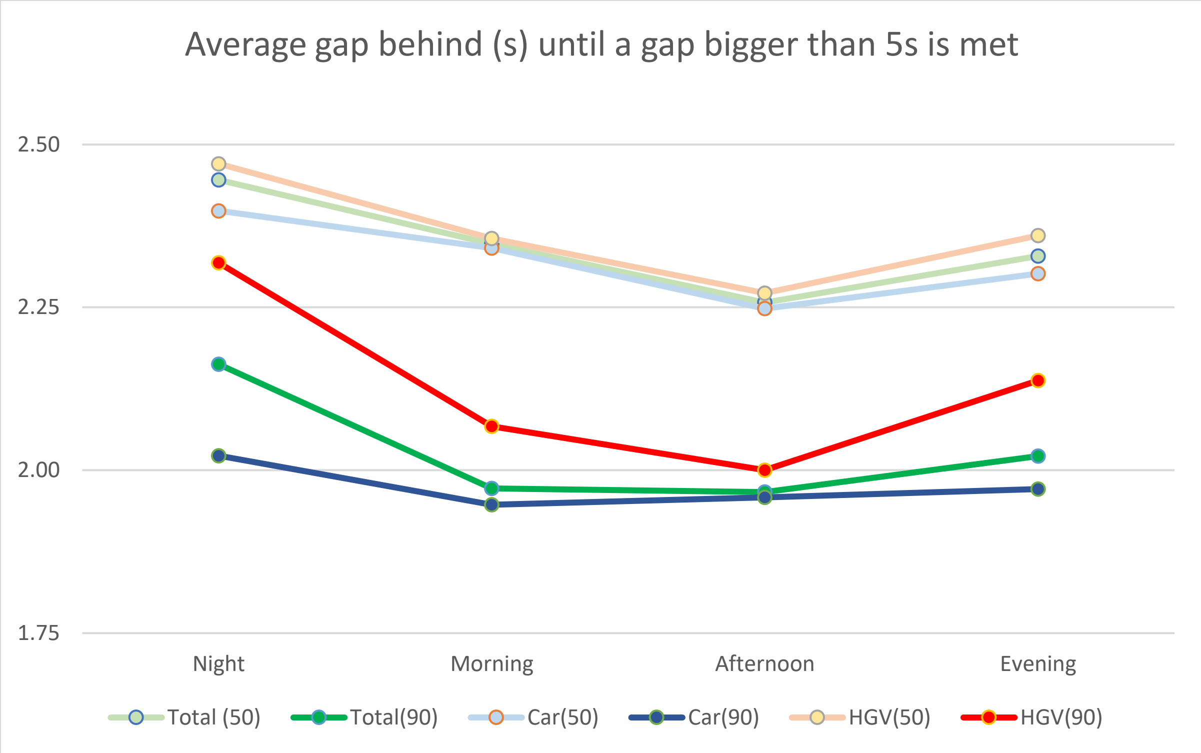

Figure.15: Average gap behind (s) until a gap bigger than 5s is met

The next charts and tables are looking at the difference between gap averages between HGVs travelling at different speeds, both for 50km/h roads and for 90km/h roads.

Table 10 and Figure 16 are presenting the gap averages for HGVs traveling on 50km/h roads, looking at the differences between gap averages behind HGVs travelling at:

- Any speed;
- Up to 40km/h (presumably where ADR and overweight transporters fall into);
- Between 40km/h and 50km/h (legal limit);
- Between 50km/h and 60km/h (above legal limit but inside the 'popular' limit)

The main points to mention here are:

- ✓ HGVs travelling up to 40 km/h show significantly higher gap averages than all other HGVs (possibly because of their size – affecting visibility, or they might be accompanied by traffic management vehicles – decrease the willingness to close follow);
- ✓ Except HGVs travelling at speeds up to 40km/h, the rest of the HGVs follow very similar patterns during the day, with regards to gap averages.

Table.10: Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Time of day	HGV total (50)	HGV up to 40km/h (50)	HGV 40 to 50km/h (50)	HGV 50 to 60km/h (50)
Night	2.47	2.86	2.46	2.42
Morning	2.38	2.65	2.31	2.34
Afternoon	2.30	2.41	2.24	2.27
Evening	2.38	2.57	2.32	2.36

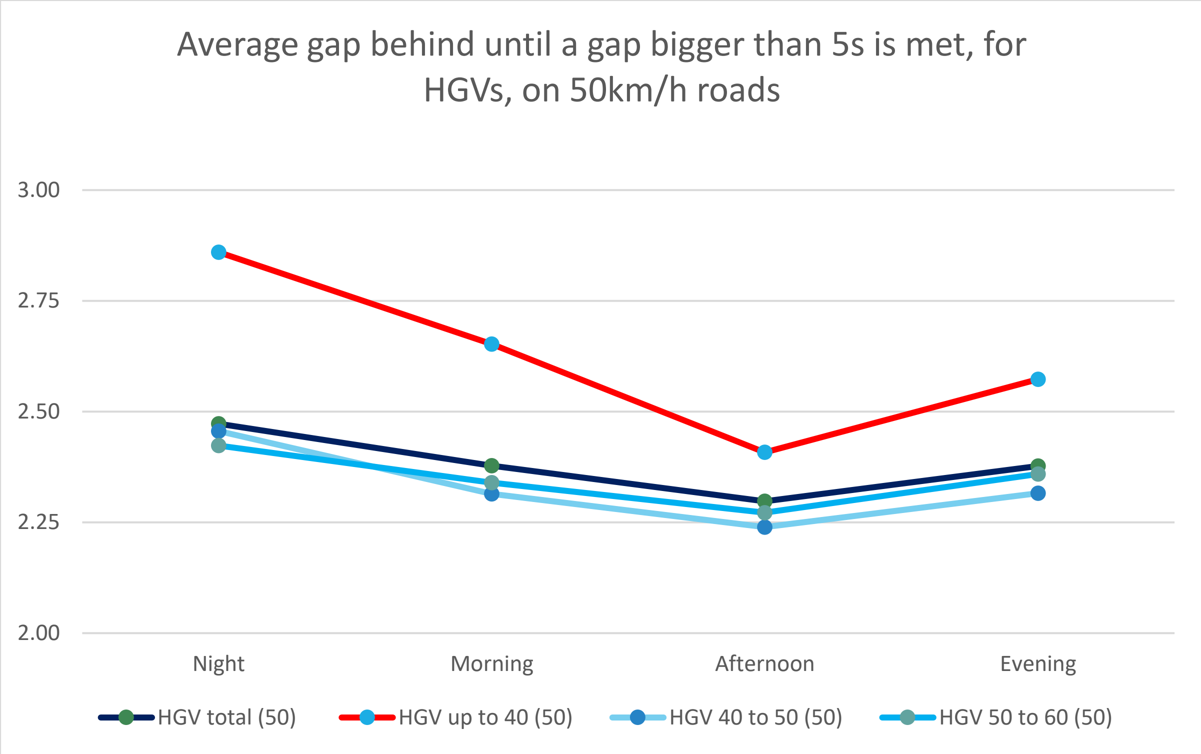

Figure.16: Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Similar to the previous analysis, Table 11 and Figure 17 are presenting the gap averages for HGVs travelling on 90km/h roads, looking at the differences between gap averages behind HGVs travelling at:

- Any speed;
- Up to 70km/h (again, presumably where ADR and overweight transporters fall into);
- Between 70km/h and 90km/h (legal limit);
- Between 90km/h and 100km/h (above legal limit but inside the 'popular' limit)

Relevant mentions:

✓ In this case HGVs travelling up to 70 km/h don't show significantly higher gap averages than the other HGVs but the HGVs travelling at speeds between 90km/h and 100km/h show slightly lower gap averages than all the rest, especially in the evenings;

✓ All HGVs follow very similar patterns during the day, with significantly higher gap averages during night time and with the smallest averages during afternoon hours.

Table.11: Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Time of day	HGV total (90)	HGV up to 70km/h (90)	HGV 70 to 90km/h (90)	HGV 90 to 100km/h (90)
Night	2.30	2.30	2.31	2.28
Morning	2.08	2.08	2.08	2.06
Afternoon	2.00	2.01	1.98	1.97
Evening	2.13	2.15	2.11	2.03

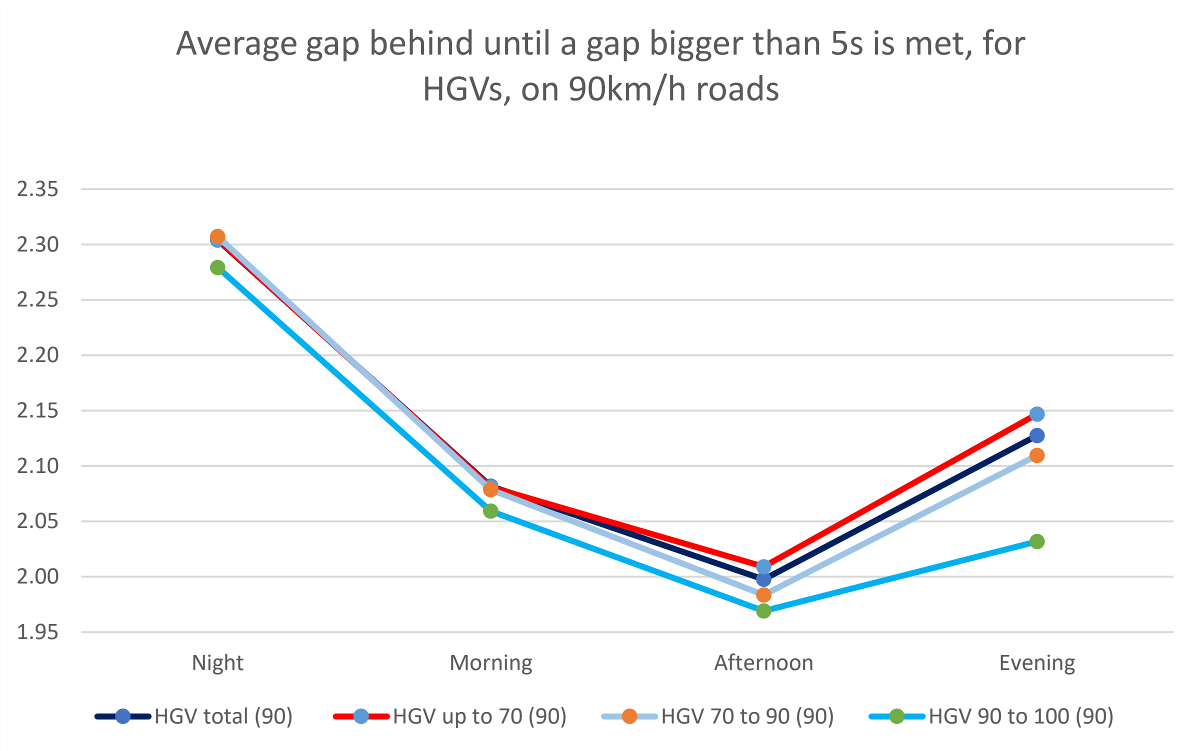

Figure.17: Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 90km/h roads

The next set of charts and tables are analysing the queues behind vehicles, counting the number of vehicles queuing, for 50km/h roads and for 90km/h roads.

Table 12 and Figure 18 are presenting queue length for HGVs travelling on 50km/h roads, for the same categories as before, traveling at:

- Any speed;
- Up to 40km/h (presumably where ADR and overweight transporters fall into);
- Between 40km/h and 50km/h (legal limit);
- Between 50km/h and 60km/h (above legal limit but inside the 'popular' limit)

Relevant mentions:

- ✓ The length of the queue is the smallest during the night and the biggest during the afternoon hours, for HGVs travelling at any speed;
- ✓ All categories analysed are following similar patterns during the day, with the highest difference showing between HGV total and HGV up to 40km/h in the afternoon hours (4.53 vehicles for HGV total and 5.43 vehicles for HGV up to 40km/h). The fact that the slower vehicles are susceptible to produce longer queues during busy hours is in line with the literature and with the research objectives.

Table.12: Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Time of day	HGV total (50)	HGV up to 40km/h (50)	HGV 40 to 50km/h (50)	HGV 50 to 60km/h (50)
Night	2.55	2.77	3.25	2.63
Morning	3.77	4.05	4.18	3.98
Afternoon	4.53	5.43	5.23	4.82
Evening	3.50	4.08	4.07	3.66

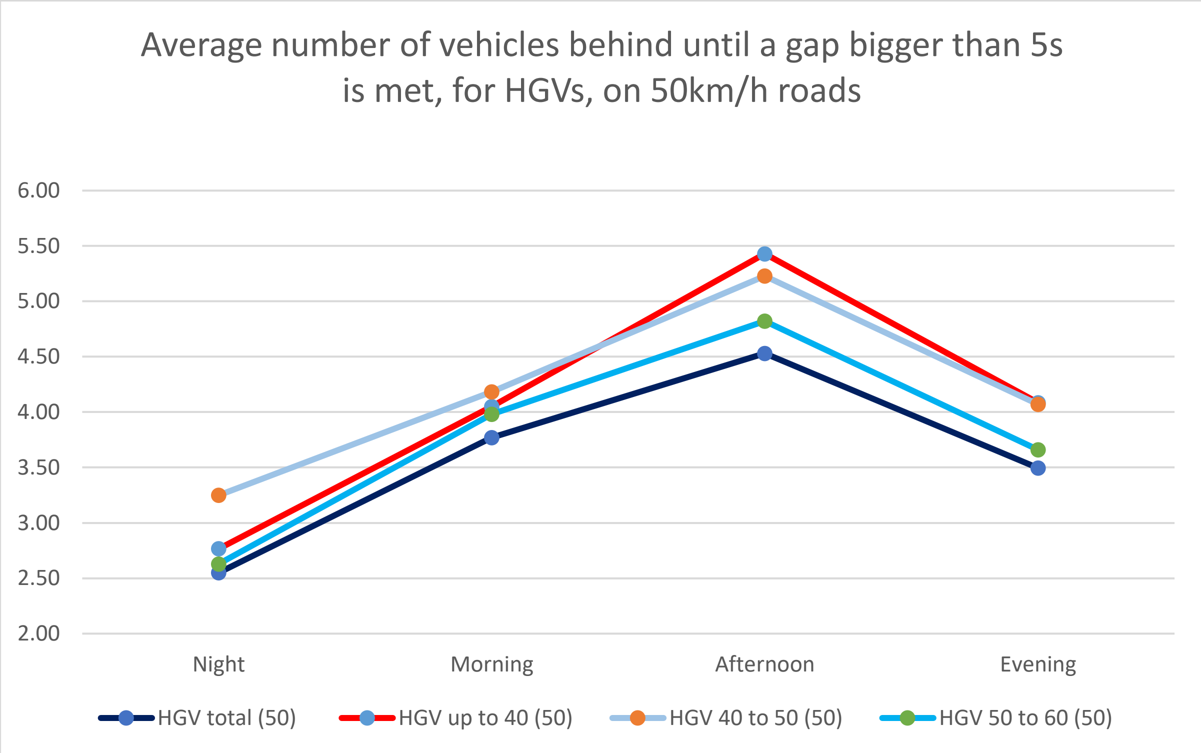

Figure.18: Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Table 13 and Figure 15 are presenting queue length for HGVs travelling on 90km/h roads, travelling at:

- Any speed;
- Up to 70km/h (again, presumably where ADR and overweight transporters fall into);
- Between 70km/h and 90km/h (legal limit);
- Between 90km/h and 100km/h (above legal limit but inside the 'popular' limit)

Relevant mentions:

✓ In this case the length of the queues varies significantly, from night time to afternoon hours but also between HGVs travelling at different speeds. During peak hours, in the afternoon, smallest queues average is behind fast HGVs (travelling between 90km/h and 100km/h), with an average of 4.21 vehicles behind, whereas the slow HGVs have an average queue of 6.49 vehicles, for the same time periods. These findings are again consistent with the literature and in lines with the research objectives, showing that slow HGVs are responsible for longer queues (up to 55% longer than faster HGVs). These longer queues are then responsible for putting more people in stress and anger, with all the connected consequences (dangerous behaviour, nervousness, health issues, environmental issues);

Table.13: Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Time of day	HGV total (90)	HGV up to 70km/h (90)	HGV 70 to 90km/h (90)	HGV 90 to 100km/h (90)
Night	3.00	3.20	2.81	2.22
Morning	4.60	5.00	4.42	3.40
Afternoon	5.87	6.49	5.36	4.21
Evening	4.65	4.94	4.30	3.63

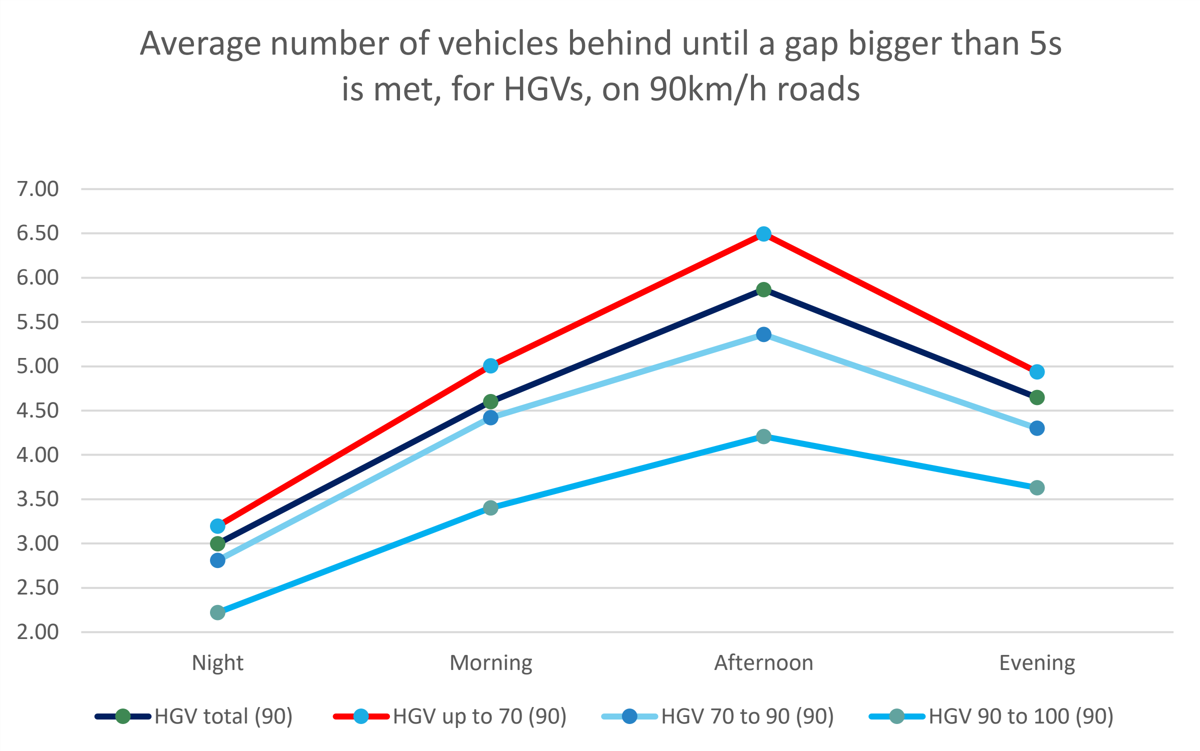

Figure.19: Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 90km/h roads

The next two sets of tables and charts are looking at the comparison between slow HGVs (the category where HGVs transporting ADR fall into), the majority of the HGV traffic, and the majority of all traffic, to see if and how speed or vehicle category are affecting the length of the queue.

Table 14 and Figure 20 are analysing traffic on 50km/h limit roads:

Table.14: Average number of vehicles behind, by vehicle category, on 50km/h roads

Time of day	All (40-60km/h)	HGV (up to 40km/h)	HGV (40-60km/h)
Night	2.80	2.77	2.88
Morning	3.83	4.05	4.04
Afternoon	4.65	5.43	4.93
Evening	3.68	4.08	3.80

Relevant mentions:

- ✓ On 50km/h, all three studied categories have very similar queues behind during night time or in the morning. In the afternoon and evenings, HGVs travelling at speed lower than 40km/h determine significantly longer queues, up to 20% longer than the other two categories analysed (the majority of the traffic and the majority of HGV traffic);
- ✓ HGVs in general produce slightly longer queues behind, when compared to the rest of the traffic.

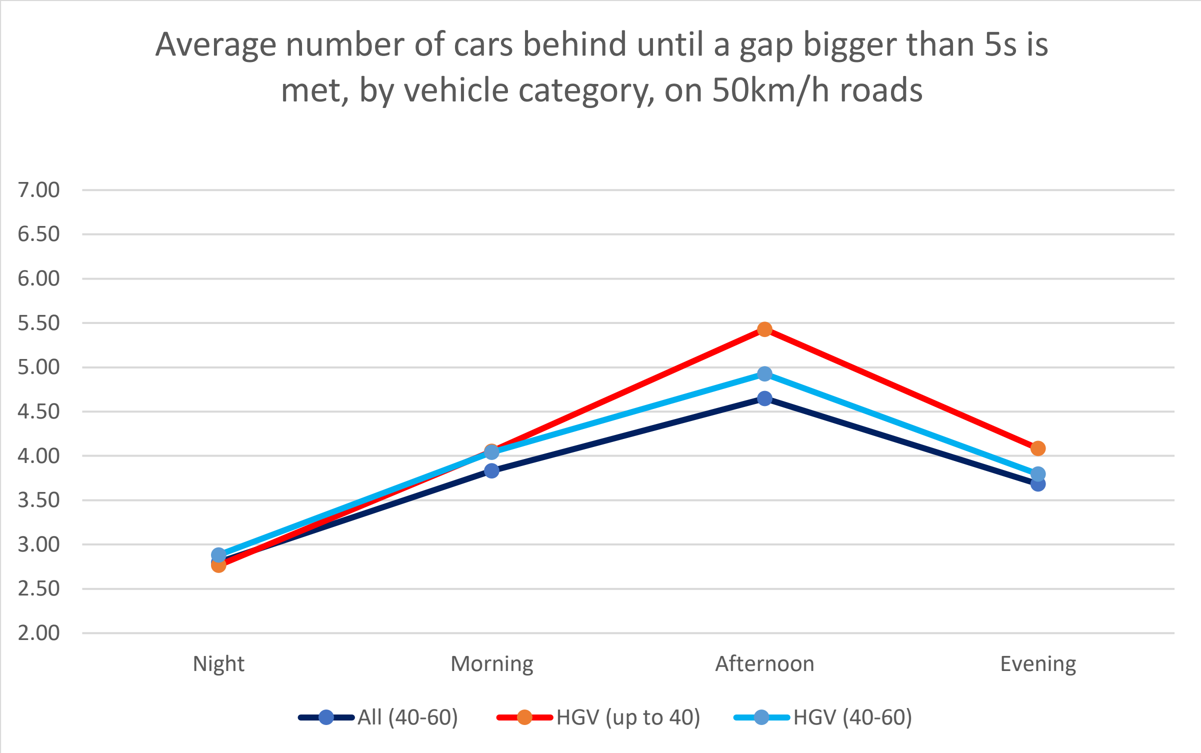

Figure.20: Average number of vehicles behind, by vehicle category, on 50km/h roads

Table 15 and Figure 21 are analysing traffic on 90km/h limit roads:

Table.15: Average number of vehicles behind, by vehicle category, on 50km/h roads

Time of day	All (70-90km/h)	HGV (up to 70km/h)	HGV (70-90km/h)
Night	2.79	3.20	2.81
Morning	4.11	5.00	4.42
Afternoon	5.10	6.49	5.36
Evening	4.23	4.94	4.30

Relevant mentions:

- ✓ On 90km/h roads, slow HGVs are constantly showing queues longer than the other two analysed categories (the majority of the traffic and the majority of the HGV traffic), with up to 30% longer;
- ✓ The longest queues for the slow HGVs are shown in the peak afternoon hours, with an average of 6.49 vehicles behind.

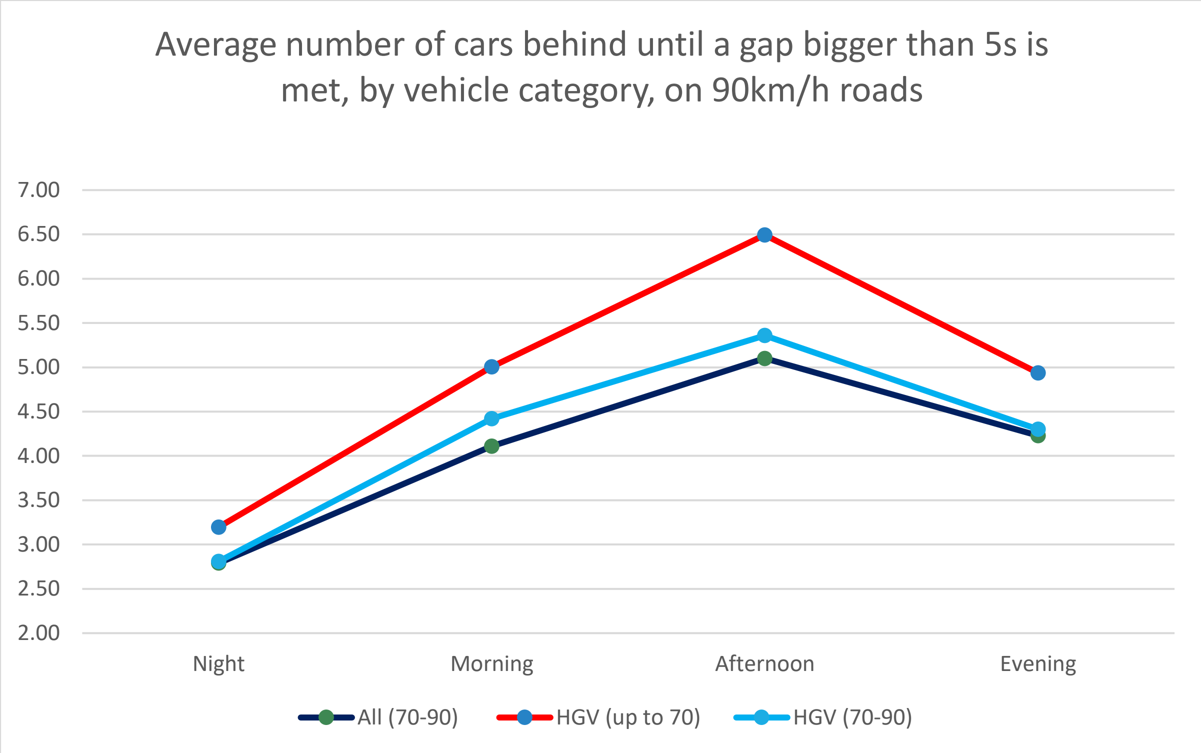

Figure.21: Average number of vehicles behind, by vehicle category, on 90km/h roads

If we consider the shortcomings that are presented in the description of the indices we can assume that the real differences, if we would be assessing only the queues leaders (determinative), are a lot bigger and more pronounced. Anyway, the results are clearly presenting significantly bigger queues behind slow HGVs, even when working with all the shortcomings.

FIELD STUDY – ROMANIA – CONCLUSIONS

The main (and relevant) findings are:

- ✓ HGV traffic represents between 19% (during peak afternoon hours) and 45% (during night time) of the total traffic at the analysed locations;
- ✓ Over 35% of the total traffic happens in the afternoon. The distribution of the traffic in Romania (at the selected locations) presents a peak period from 12AM to 7PM. This distribution is very different from western countries, where the peak hours are around the work commute hours, equally in the mornings and afternoons;
- ✓ The HGV traffic is quite constant during the entire day, varying less than 100% from the lowest to the highest hour (compared to cars which are varying by up to 600%);
- ✓ On 50km/h speed limit roads, the 'compliance' levels are very low: about 12% for cars, about 16% for HGVs and about 14% for total traffic. This indicates a very big issue around the credibility (and suitability) of the speed limit, and another, maybe bigger issue around the efficiency of the speed management strategies (if any);
- ✓ On 90km/h speed limit roads, the levels of compliance are significantly higher, over 80%. But, here there is again a question of suitability of the limit, since more than half of the vehicles choose to travel on speeds significantly lower than the limit;

- ✓ There is no substantial difference between categories of vehicles with regards to speed limit compliance or to speed bands of which they choose to travel;
- ✓ There is no significant variation between distinct time of day with regards to speed bands or speed compliance, regardless of the vehicle category or the type of road (limit);
- ✓ The average gap distance of the vehicles queueing does not differ significantly between vehicle categories, with averages around 2-2.5s;
- ✓ HGVs travelling at lower speeds (ADR and heavy vehicles) show a slightly higher gap average when compared to other HGVs or to other vehicle categories;
- ✓ The length of the queue behind is constantly and significantly higher for slow HGVs when compared to other to HGVs travelling at higher speeds or to other vehicle categories. For 90 km/h speed limit roads these differences can be an average of 3 cars (85%), and they tend to remain higher in any condition and compared to any other category. These differences are assumed to be even higher because vehicles in the queue have a queue behind, but they are not leading (causing) the queue.
- ✓ These findings are very relevant in relation to the research objectives, because, they are showing that the slow HGVs are representing an increased danger for the roads, through the creation of long queues which will then determine dangerous consequences for the traffic participants.

FIELD STUDY – POLAND - COMPARISON TO THE ROMANIAN STUDY

In order to better understand the effect of the speed restrictions applied to HGVs transporting ADR goods, a field study in a country with similar traffic conditions was recommended. Therefore, upon availability, Poland was chosen as the comparator country. The specifications for radar device installation were similar to those for Romania. The present section will detail the data collection and analysis for Poland, as well as, where appropriate, comparison with the Romanian data analysis.

DATA COLLECTION

Locations

Data collection was done with an SDR Traffic+ radar device, a versatile and reliable traffic classifier using and inbuilt microwave (radar) sensor to measure traffic at one or two lane (opposite direction) road layout. The data collected for each record was: Speed, Lane, Time, Date, and Length. From the recorded variables the project team could accurately compute Headway and Gap, in seconds and metres. Other variables and indices were also calculated and are discussed in the Data Analysis section.

The collection (472,810 vehicles recorded in total) was undertaken in 5 distinct locations on road DK50 in Poland between 25/05/2018 and 26/06/2018, as follows:

1. **Grojec1** – urban road

   Speed limit: 50km/h

   Position: Straight

   Collection time: 08/06/2018, 12:00 – 15/06/2018, 14:59

2. **Grojec2** – urban road

   Speed limit: 50km/h

   Position: Curve

   Collection time: 19/06/2018, 12:00 – 26/06/2018, 11:59

3. **Droga** – rural road

   Speed limit: 90km/h

   Position: Straight

   Collection time: 25/05/2018, 12:00 – 04/06/2018, 13:59

4. **Zalukiem** – rural road

   Speed limit: 90km/h

   Position: Curve

   Collection time: 08/06/2018, 13:00 – 15/06/2018, 14:59

5. **Stanislawow** – rural road

   Speed limit: 90km/h

   Position: Straight

   Collection time: 19/06/2018, 11:00 – 26/06/2018, 11:59

DATA ANALYSIS

Similar to the approach taken with the Romanian data, the data collected was grouped in an Excel workbook and analysed from different perspectives. The following charts are presenting the most important and/or relevant findings in relation to the analysed topic, and follow, on most of the cases, a similar approach as for the Romanian data. For some of the findings, different indices were computed, and they are explained for each case. Where relevant, comparison charts between Romania and Poland are also presented and discussed. Moreover, in some cases Poland has its particularities (for example there are different speed limits at different hours) and slightly different analyses were also included.

Traffic distribution

To understand the findings and to give the reader the opportunity to get a grasp of the context, firstly some traffic distribution analysis was undertaken.

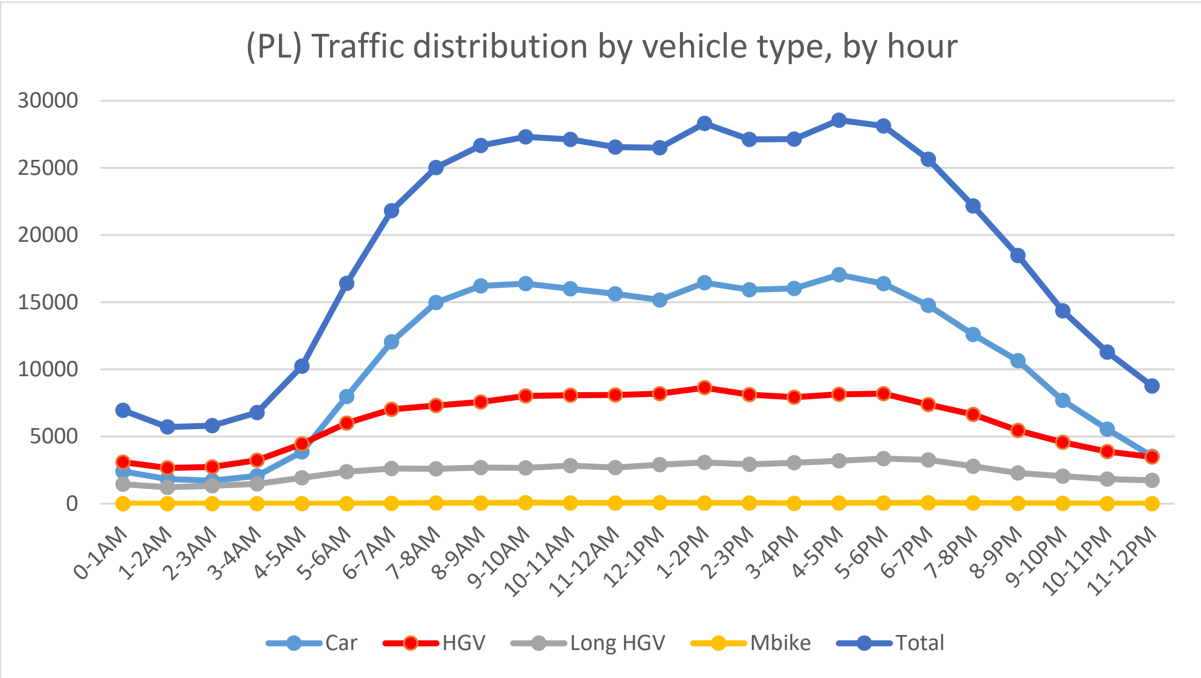

Figure.22: (PL) Traffic distribution by vehicle type, by hour

As can be observed from the Figure 22 above, and from Table 16, we can see that the traffic on the location of the data collections presents several characteristics:

- During the night hours HGV traffic higher than the car traffic (in numbers);
- HGV traffic doesn't vary too much between day and night (1:3), whereas the car traffic is varying to a scale of 1:10;
- The car traffic is reduced during the night but has a quite constant 'peak' volume for the entire day, from around 6AM until around 8PM; the HGVs 'peak' covers about the same time period but the variation compared to night time is smaller;
- The motorbike proportion is less than 1% of the traffic;
- The share of unusual vehicles (either under 2.1m long, the length of a motorcycle, or small trailers detected separately, either unclassifiable, which can mean that they are for instance carried by animals) is also less than 1%.

- The share of long HGVs is of about a quarter of the total HGVs and about 10% of the total vehicles;
- The shares of HGVs in the total vehicle totals varies from around 48% during some night hours to around 28% during some daylight hours.

Table.16: (PL) Traffic distribution by vehicle type, by hour

Hour	Car	HGV	Long HGV	Motorbike	Unclassified	Total
0-1AM	2,392	3,085	1,452	6	6	6,941
1-2AM	1,827	2,656	1,221	3	0	5,707
2-3AM	1,714	2,738	1,343	1	4	5,800
3-4AM	2,069	3,246	1,472	1	5	6,793
4-5AM	3,862	4,446	1,919	6	8	10,241
5-6AM	7,977	6,010	2,374	6	38	16,405
6-7AM	12,057	7,033	2,622	29	67	21,808
7-8AM	14,965	7,308	2,601	42	102	25,018
8-9AM	16,211	7,578	2,679	55	144	26,667
9-10AM	16,378	8,021	2,676	75	150	27,300
10-11AM	15,991	8,074	2,823	54	175	27,117
11-12AM	15,630	8,091	2,681	40	97	26,539
12-1PM	15,176	8,198	2,898	69	162	26,503
1-2PM	16,458	8,631	3,061	42	121	28,313
2-3PM	15,937	8,121	2,937	41	91	27,127
3-4PM	16,022	7,929	3,043	33	120	27,147
4-5PM	17,039	8,136	3,200	55	129	28,559
5-6PM	16,390	8,178	3,357	55	151	28,131
6-7PM	14,773	7,372	3,258	73	170	25,646
7-8PM	12,594	6,650	2,795	39	85	22,163
8-9PM	10,649	5,446	2,292	27	72	18,486
9-10PM	7,685	4,560	2,040	17	49	14,351
10-11PM	5,553	3,874	1,841	7	16	11,291
11-12PM	3,530	3,465	1,729	7	26	8,757
Total:	**262,879**	**148,846**	**58,314**	**783**	**1,988**	**472,810**

Comparing the car and HGVs' traffic share distribution in the two countries, Romania and Poland, we can see some differences:

- For both Romania and Poland, the HGV traffic share is significantly higher during night hours, between 40% and 50%; During the day, the HGV traffic share drops to about 30% for Poland and 20% for Romania;
- The car traffic share is higher for Romania, both day or night by up to 15%;
- Both vehicle types and for both countries, maintain a fairly constant traffic share during the day;
- Although in number, in Poland, the car volumes seem to have big variances from night to day, when analysed in traffic share, the variation is not that high and has a similar path to the Romanian car share variation; The same applies to HGVs, where it seems like, in share, the variation for Poland is even smaller than for Romania.

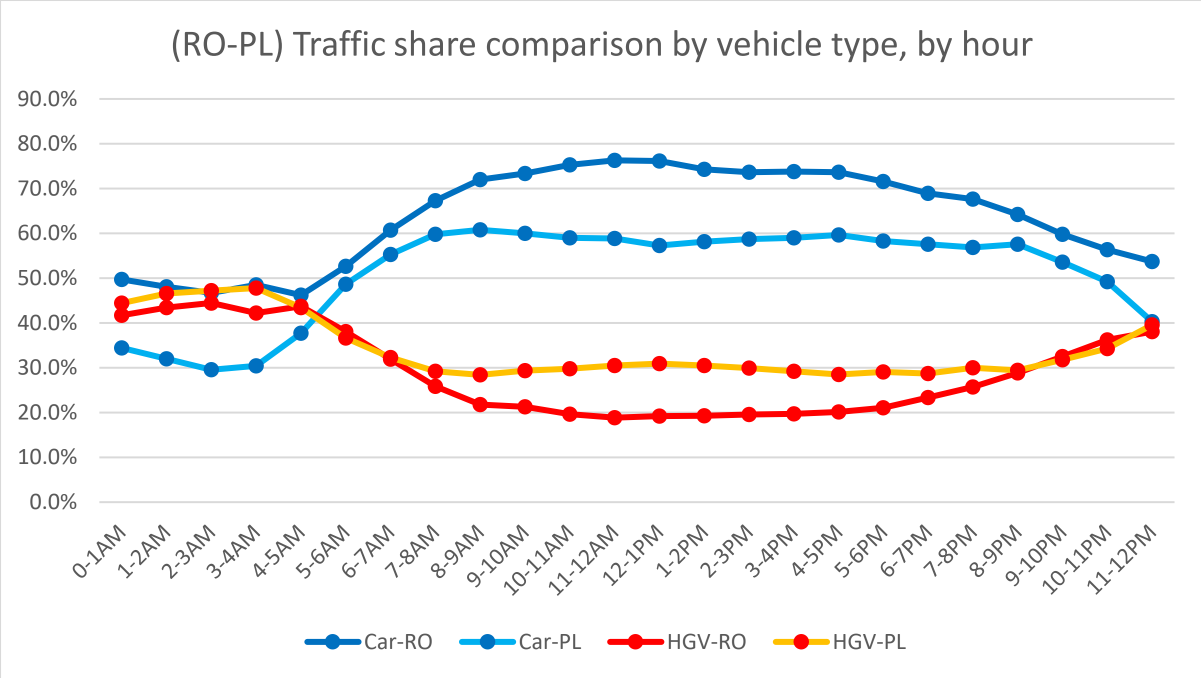

Figure.23: (RO-PL) Traffic share comparison by vehicle type, by hour

Presenting the traffic distribution by time of day in Poland, Figure 24 is showing the same situation, that both the car and the HGV traffic levels are significantly higher during the day than during the night, but pretty constant (for day or for night).

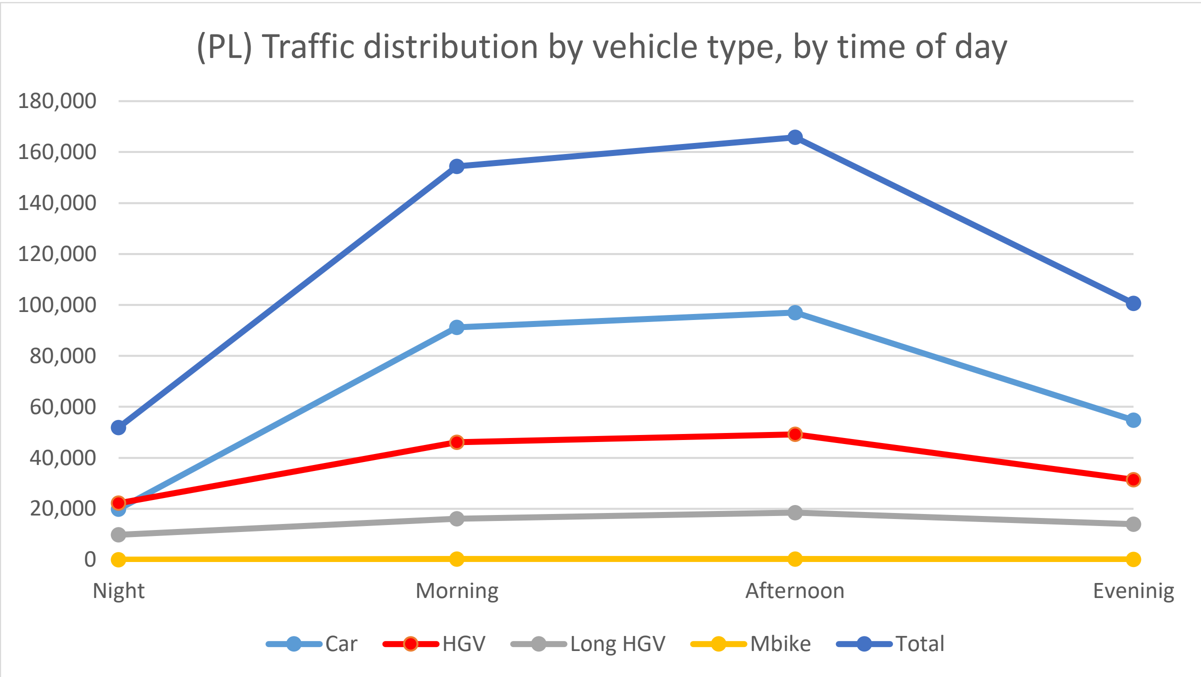

Figure.24: (PL) Traffic distribution by vehicle type, by time of day

Presented by time of day, the situation is similar to the hourly one, showing that traffic share is higher for cars in Romania, compared to Poland, and that the HGV share is lower and has a higher variability in traffic share, when compared to Poland, at any time of day, although in numbers (volume) the situation is opposite. Figure 25 is presenting the difference between the two countries.

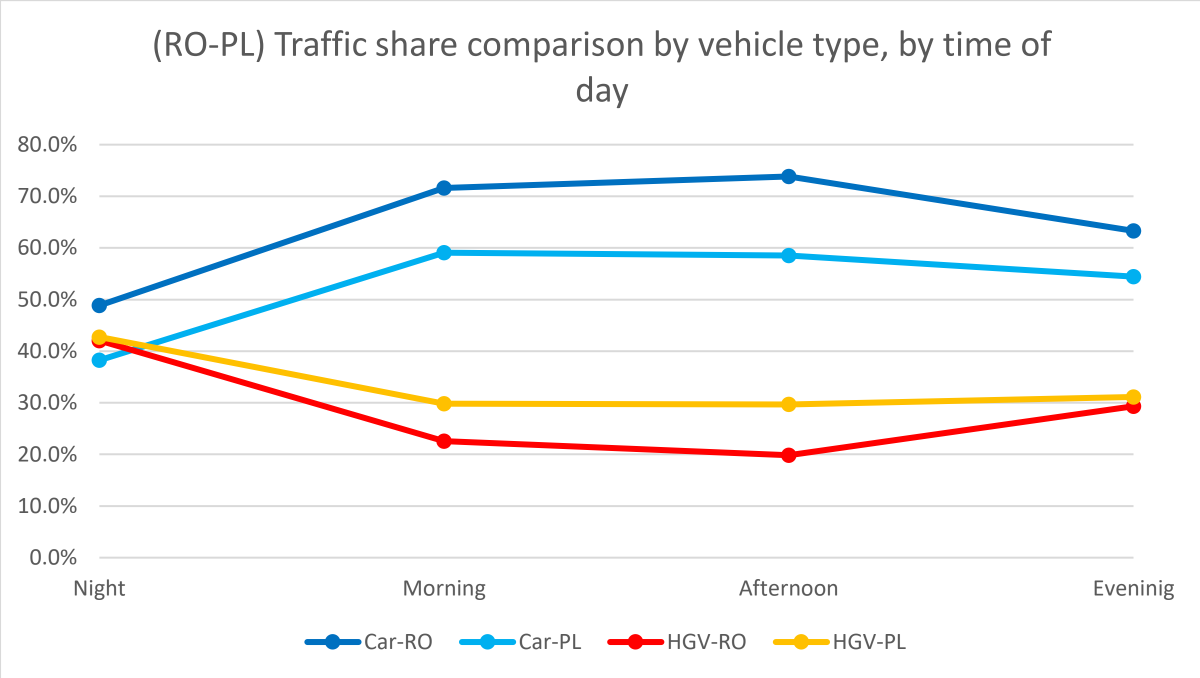

Figure.25: (RO-PL) Traffic share comparison by vehicle type, by time of day

When splitting the data by the speed limit at the locations in Poland where the data was collected, the distributions for 50km/h roads and for 90km/h roads are very similar, as can be seen from Figure 26 and Figure 27.

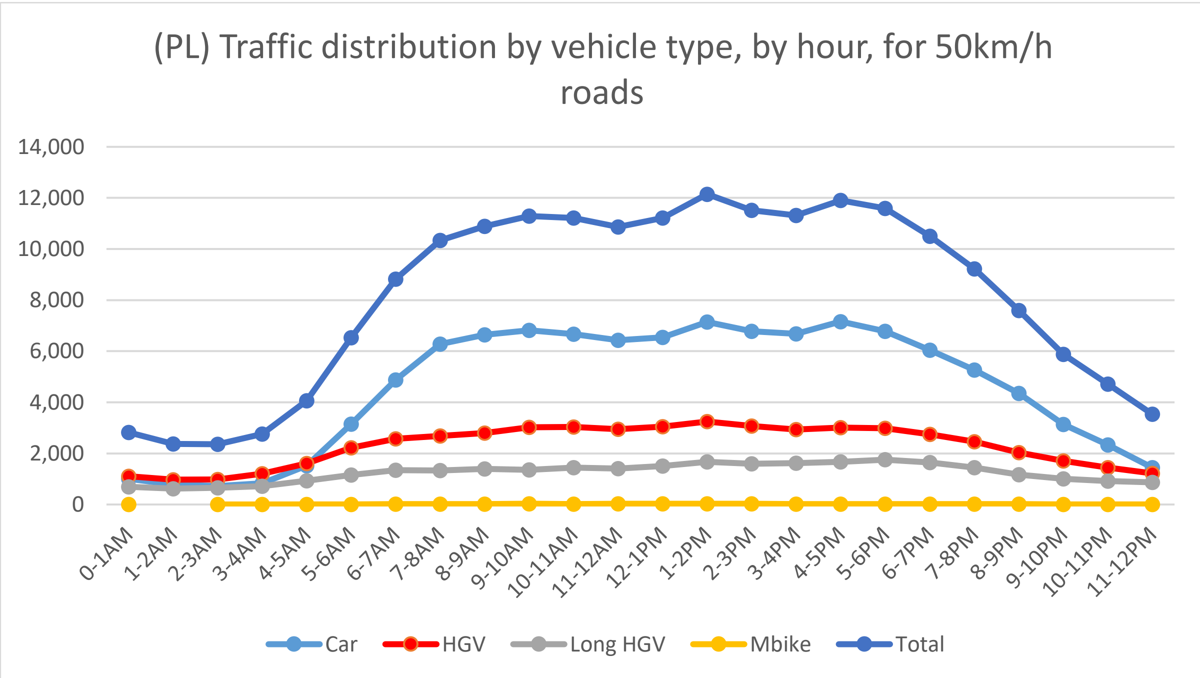

Figure.26: (PL) Traffic distribution by vehicle type, by hour, for 50km/h roads

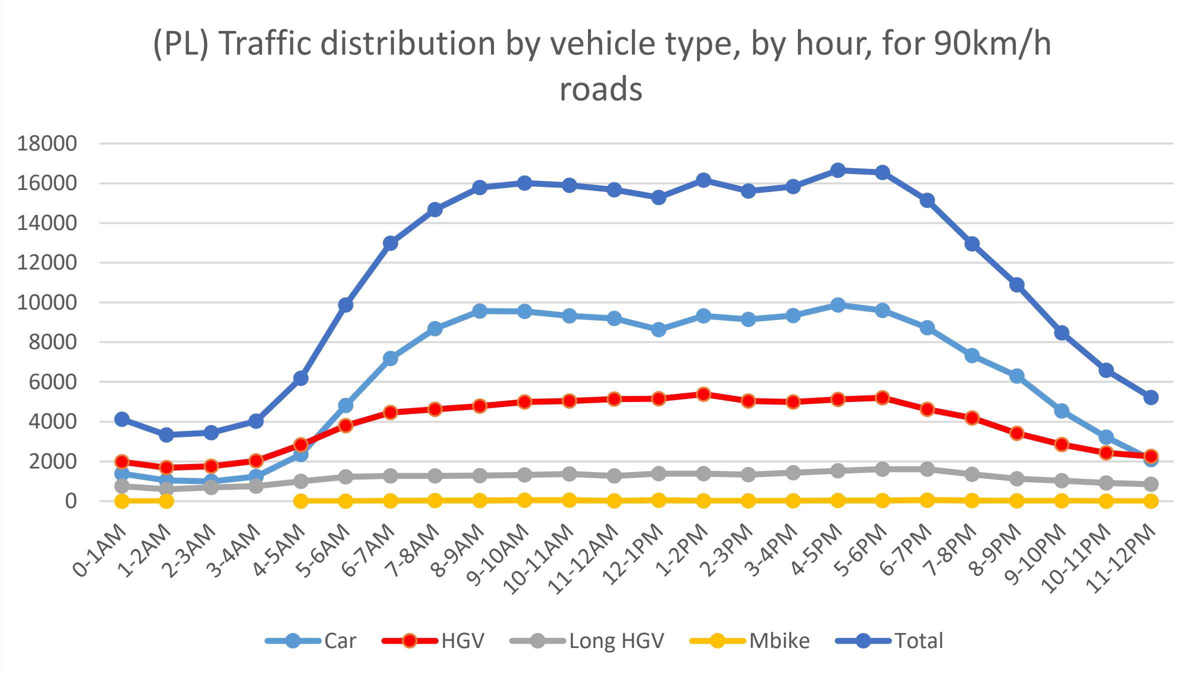

Figure.27: (PL) Traffic distribution by vehicle type, by hour, for 90km/h roads

Traffic speeds

Similar to the Romanian data analysis, the next section is analysing the speeds that different vehicle categories are traveling at, for each category of roads (50km/h roads, with the exception of 60km/h during night hours, and 90km/h roads), looking at the percentage of vehicles traveling within legal speeds or 10km/h above; percentage of vehicles traveling within distinct speed bands; and cumulative percentages. Comparisons with the situation in Romania are made and commented on.

Table.17: (PL) Traffic distribution by speed bands, by vehicle type, for 50km/h (applicable = 50km/h)

Speed band	%Car	%HGV	%Long HGV	%Motorbike	%Unclassified	%Total	Cumulative Total
<20km/h	0.2%	0.2%	0.1%	1.0%	1.1%	0.2%	0.2%
20-30km/h	0.5%	0.4%	0.4%	1.3%	1.3%	0.5%	0.7%
30-40km/h	1.2%	0.9%	1.2%	2.0%	2.0%	1.1%	1.8%
40-50km/h	4.5%	3.8%	3.6%	3.7%	5.4%	4.2%	6.0%
50-60km/h	23.8%	20.4%	21.4%	25.7%	26.7%	22.5%	28.6%
60-70km/h	41.6%	42.9%	44.7%	39.3%	39.4%	42.4%	70.9%
70-80km/h	21.7%	25.4%	23.7%	21.0%	19.0%	23.0%	93.9%
80-90km/h	5.1%	5.1%	4.3%	4.7%	3.3%	5.0%	98.9%
90-100km/h	1.0%	0.7%	0.6%	1.3%	1.3%	0.9%	99.8%
100-110km/h	0.2%	0.1%	0.1%	0.0%	0.3%	0.2%	99.9%
110-120km/h	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	100.0%
>120km/h	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	100.0%
Total:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

As can be observed from Table 17 and Figure 28, only 6% of the total vehicles are travelling within the applicable speed limit, and only 28.6% are travelling within 10 km above the speed limit. The biggest proportion of the vehicles (42.4% are travelling at speeds between 60km/h and 70km/h, with another considerable proportion (23%) travelling at speeds between 70km/h and 80km/h. There are no big differences between the vehicle categories, as can be observed in Figure 28 and Figure 29, in this respect.

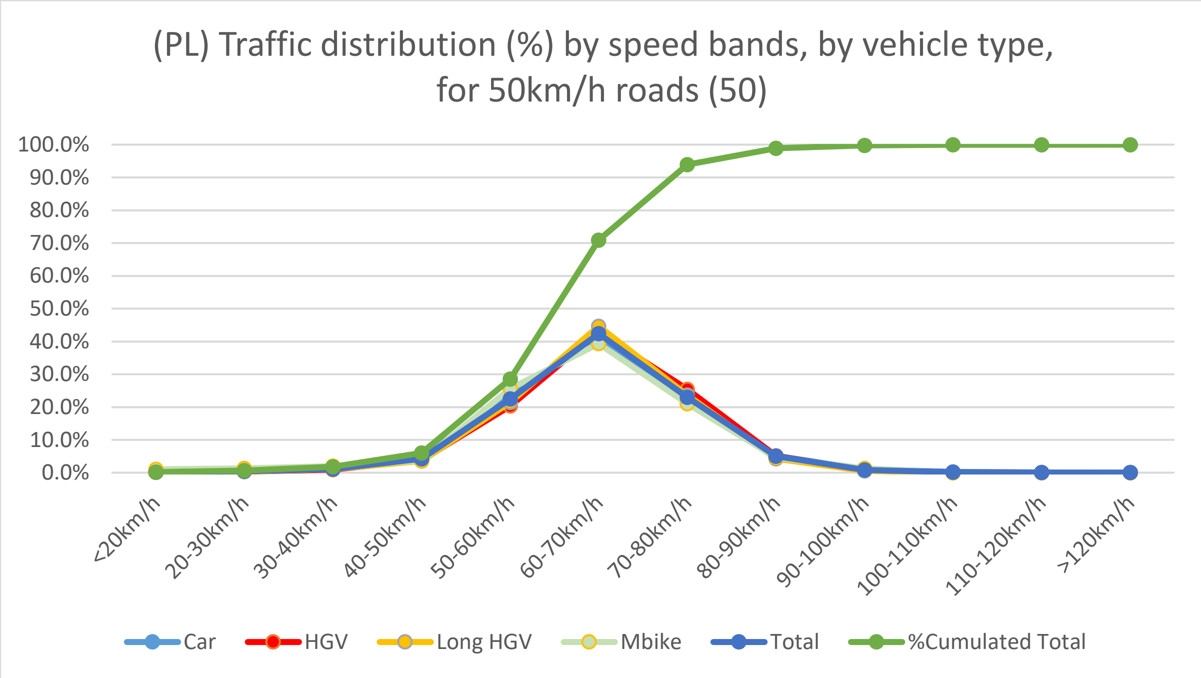

Figure.28: (PL) Traffic distribution by speed bands, by vehicle type, for 50km/h roads (applicable = 50km/h)

The next figure, Figure 29, is showing basically the same information, for total vehicles, cars and HGVs, using a visualisation solution which makes it easier to differentiate between the three categories. As can be observed, for 50km/h limit roads, when 50 km/h limit is applicable, the distribution is pretty similar for all three chosen categories.

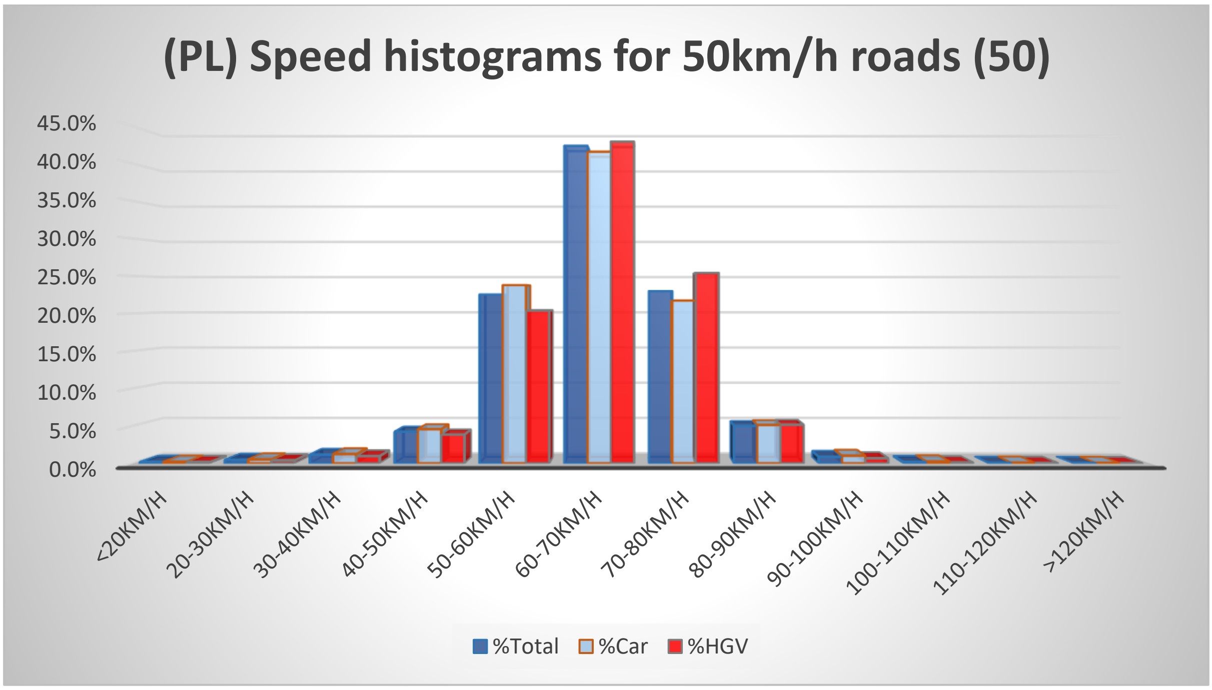

Figure.29: (PL) Speed histograms by speed bands, by vehicle type, for 50km/h roads (applicable = 50km/h)

Similar to the Romanian case, these low percentages travelling within legal speed limits are pointing towards at least two important warning messages: (1) the speed limits seem not to be in accordance with real traffic, therefore not credible, and (2) the speed management system, if any, is not efficient.

During the night time, from 11PM to 5AM the speed limit on the 50km/h speed limit roads are increased to 60 km/h. Table 18 and Figures 30 and 31 are analysing the traffic distribution separately for the mentioned interval (11PM-5AM).

Table.18: (PL) Traffic distribution by speed bands, by vehicle type, for 50km/h (applicable = 60km/h)

Speed band	%Car	%HGV	%Long HGV	%Motorbike	%Unclassified	%Total	Cumulative Total
<20km/h	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%
20-30km/h	0.2%	0.1%	0.0%	0.0%	4.5%	0.1%	0.2%
30-40km/h	0.2%	0.3%	0.3%	0.0%	4.5%	0.3%	0.5%
40-50km/h	2.0%	2.2%	1.6%	0.0%	0.0%	2.0%	2.5%
50-60km/h	16.5%	14.5%	13.5%	20.0%	13.6%	14.9%	17.4%
60-70km/h	35.9%	34.1%	39.3%	30.0%	36.4%	36.1%	53.5%
70-80km/h	30.1%	32.5%	32.4%	50.0%	31.8%	31.7%	85.1%
80-90km/h	11.6%	13.2%	10.6%	0.0%	4.5%	12.0%	97.1%
90-100km/h	2.3%	2.5%	1.9%	0.0%	0.0%	2.3%	99.4%
100-110km/h	0.6%	0.4%	0.3%	0.0%	0.0%	0.4%	99.8%
110-120km/h	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%	99.9%
>120km/h	0.1%	0.1%	0.0%	0.0%	4.5%	0.1%	100.0%
Total:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Although the percentage of vehicles travelling within legal limit or maximum 10km/h above the limit has significantly improved, there are still 46.5% of vehicles travelling with more than 10km/h faster than the legal limit (about 15% travelling with more than 20km/h above the limit).

Figure 30 and Figure 31 present the distribution of the speeds, by vehicle category and the cumulative percentages by speed.

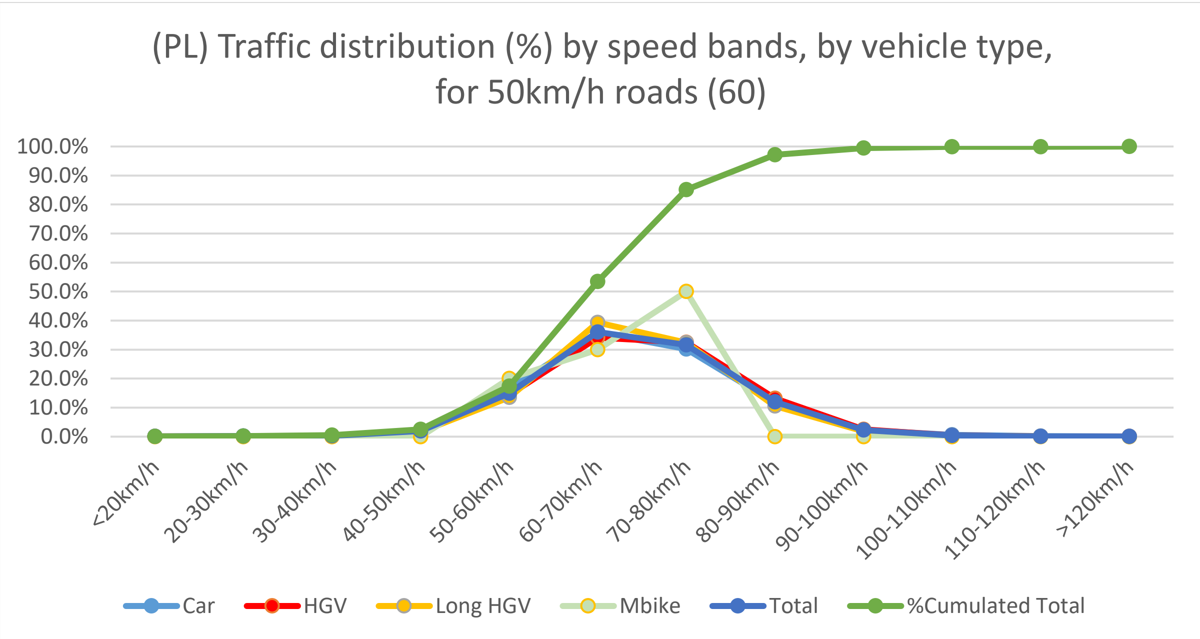

Figure.30: (PL) Traffic distribution by speed bands, by vehicle type, for 50km/h roads (applicable = 60km/h)

From Figure 30 we can see that motorcycles, although very few, are travelling faster during night time, compared to all other vehicles.

Figure 31 is showing the histograms for total vehicles, cars, and HGVs, on speed categories, during night time hours (11PM-5AM (when legal speed limit increases from 50km/h to 60km/h).

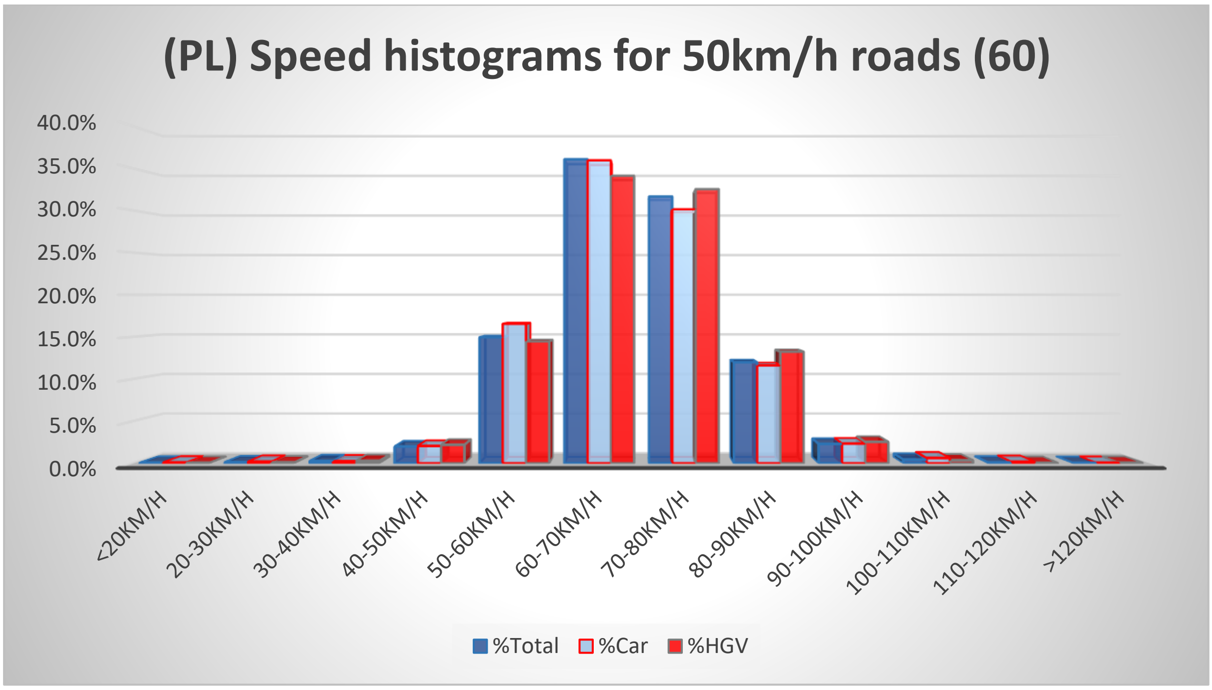

Figure.31: (PL) Speed histograms by speed bands, by vehicle type, for 50km/h roads (applicable = 60km/h)

As can be observed, the situation is a bit different from daytime, with a tendency for more vehicles to travel at speeds between 70km/h and 80km/h. Between vehicle categories there is not too much difference, the same tendency manifesting for all of them.

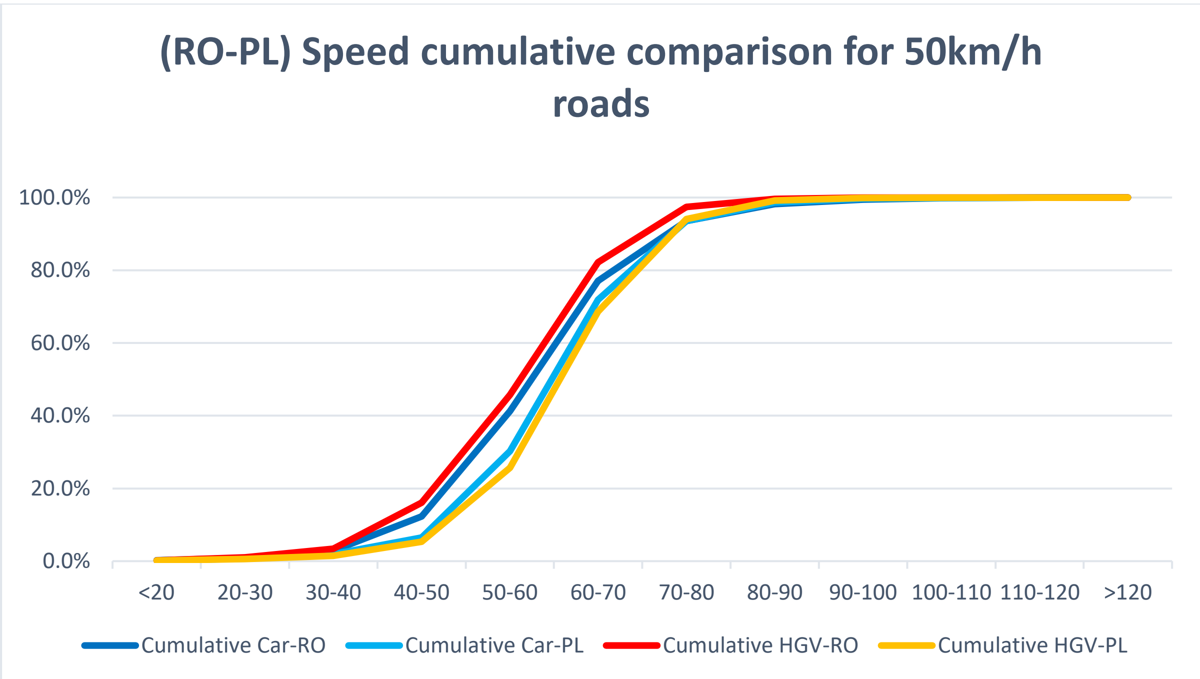

Figure.32: (RO-PL) Speed cumulative comparison by vehicle type, by speed bands, for 50km/h roads

Figure 32 presents a comparison between Romania and Poland of cumulative percentages of vehicles travelling at different speed intervals. For Poland, only the daytime data is used (when the limit of 50km/h is applicable).

Both cars and HGVs travel slightly slower in Romania compared to Poland, with some notable differences for both the legal limit or up to 10km/h above the legal limit. For Romania 12.3% of cars and 16.1% of HGVs are travelling within legal limit, and 41.3% of cars and 45.7% of HGVs are travelling within up to a maximum 10km/h above the legal limit. For Poland, only 6.5% of cars and 5.3% of HGVs are travelling within legal limit, and only 30.3% of cars and 25.7% of HGVs are travelling within up to maximum 10km/h above the legal limit.

For the 90km/h roads, the situation is not as bad, but is far from ideal, as can be observed from Table 19 and Figures 33 and 34.

Table.19: (PL) Traffic distribution by speed bands, by vehicle type, for 90km/h roads

Speed band	%Car	%HGV	%Long HGV	%Motorbike	%Unclassified	%Total	Cumulative Total
<20km/h	0.1%	0.0%	0.1%	0.2%	0.8%	0.1%	0.1%
20-30km/h	0.2%	0.1%	0.2%	0.8%	2.1%	0.1%	0.2%
30-40km/h	0.1%	0.1%	0.1%	0.6%	1.9%	0.1%	0.3%
40-50km/h	0.1%	0.1%	0.1%	0.4%	0.1%	0.1%	0.4%
50-60km/h	0.6%	0.6%	0.4%	0.4%	0.7%	0.6%	1.0%
60-70km/h	4.2%	4.6%	2.6%	3.2%	4.9%	4.2%	5.2%
70-80km/h	17.3%	20.8%	13.1%	17.5%	18.0%	18.0%	23.2%
80-90km/h	34.5%	41.4%	38.0%	32.1%	32.9%	37.2%	60.4%
90-100km/h	24.9%	24.0%	33.5%	23.0%	20.5%	25.5%	85.9%
100-110km/h	9.4%	4.5%	6.9%	12.3%	8.0%	7.5%	93.3%
110-120km/h	4.5%	1.8%	2.4%	2.5%	5.3%	3.4%	96.7%
>120km/h	4.2%	2.0%	2.5%	6.8%	4.9%	3.3%	100.0%
Total:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

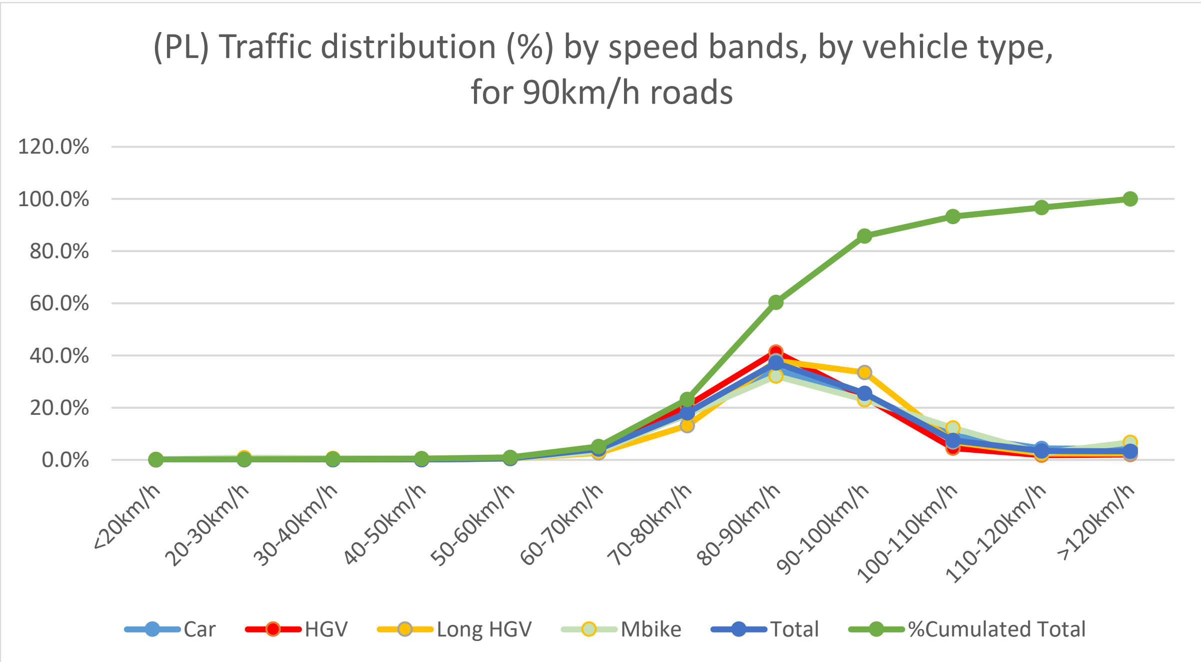

Figure.33: (PL) Traffic distribution by speed bands, by vehicle type, for 90km/h roads

Only 60.4% of the total vehicles are travelling within the legal limit, and 85.9% are travelling within up to a maximum 10km/h above the legal limit. According to best practice, in the absence of enforcement means, the limit should be set where the 85th percentile of the travelling is, which in this case, suggests that the legal limit should be between around 100km/h.

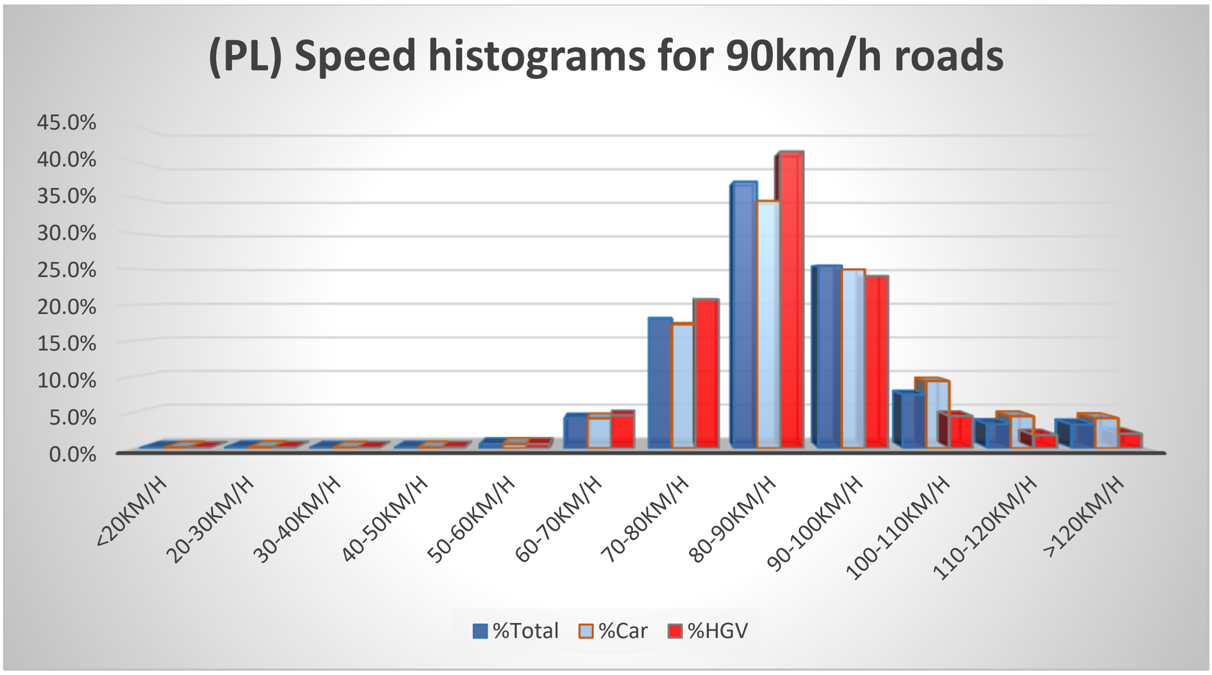

Figure.34: (PL) Speed histograms by speed bands, by vehicle type, for 90km/h roads

The most relevant thing to observe in Figure 34 is that, for the speed bands up to 90km/h (within the legal limit), HGV bars (red) are higher compared to both cars and the total of vehicles, and the phenomenon is opposite for speeds over 90km/h. This means that, compared to the other vehicle types analysed, the HGVs are more likely to travel at speeds within the legal limit.

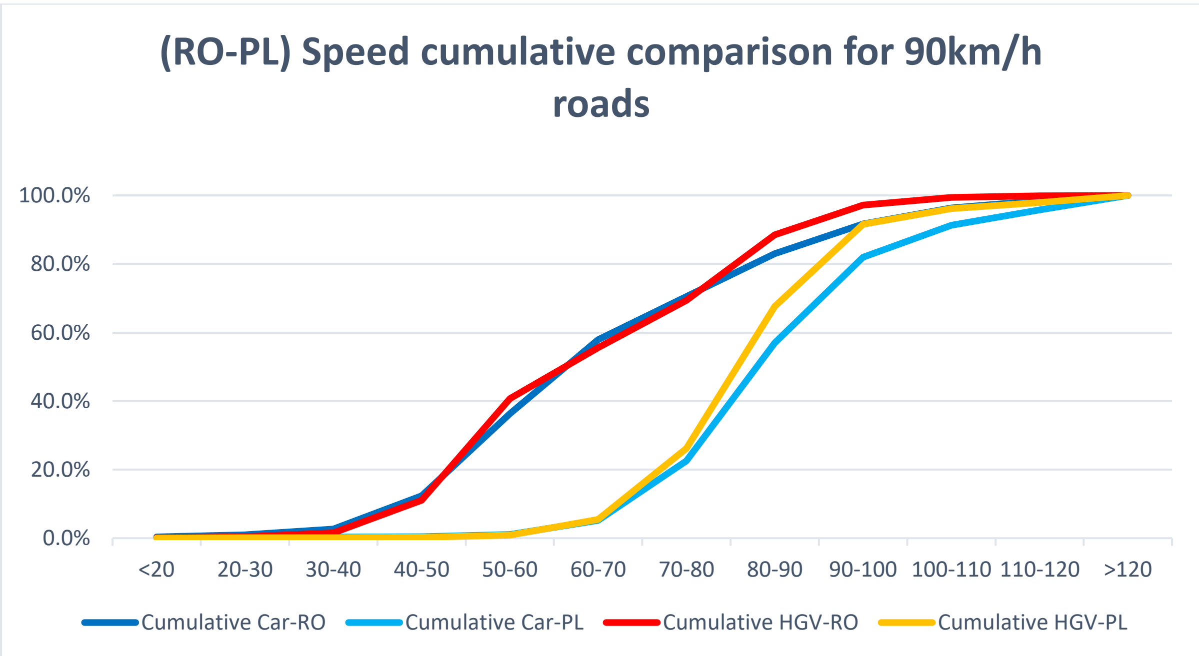

Figure.35: (RO-PL) Speed cumulative comparison by vehicle type, by speed bands, for 90km/h roads

Though, there are still high percentages of HGVs travelling up to 10km/h above the limit (24%) or up to 20km/h above (4.5%). In total, 67.6% of the HGVs, and 57% of the cars are travelling within the legal speed limit. For up to 10km/h above the legal limit, there are 91.6% of the HGVs and 82% of the cars. By comparison, in the Romanian analysis the levels of compliance are significantly higher, both for thr legal limit and 10km/h above the limit, for both cars and HGVs. For Romania, 83% of cars and 88.5% of HGVs are travelling within the legal speed limit on 90km/h roads; and 91.7% of cars and 97.2% of HGVs are travelling within up to 10km/h above the limit. This indicates that for Romania, 90km/h is an appropriate speed limit, but in Poland, according to best practice, an 100km/h limit would be more appropriate (giving the condition analysed in this study).

Analysis of the percentage of distinct vehicle categories travelling within the legal limit or within a maximum 10km/h above the limit was only deployed for 90km/h roads. 50km/h speed limit roads present the particularity of changing the legal limit within the time of day interval which makes the analysis harder on these time periods. An estimate of the percentages can be deduced from the hourly analysis presented earlier. Therefore, Table 20 and Figure 36 will refer to 90km/h roads only.

Table.20: (PL) Percentage of vehicles traveling with up to 90km/h and up to 100km/h, by time of day and vehicle type, on 90km/h limit roads

Time of day	%Car-90km/h	%Car-100km/h	%HGV-90km/h	%HGV-100km/h	%Total-90km/h	%Total-100km/h
Night	55.9%	82.3%	65.8%	91.1%	60.0%	87.1%
Morning	58.5%	82.6%	68.9%	91.9%	61.7%	86.1%
Afternoon	56.3%	82.0%	66.7%	91.9%	59.4%	85.7%
Evening	56.2%	80.7%	68.3%	91.2%	60.1%	85.1%
Total	**87,494**	**125,776**	**63,402**	**85,940**	**167,407**	**238,092**

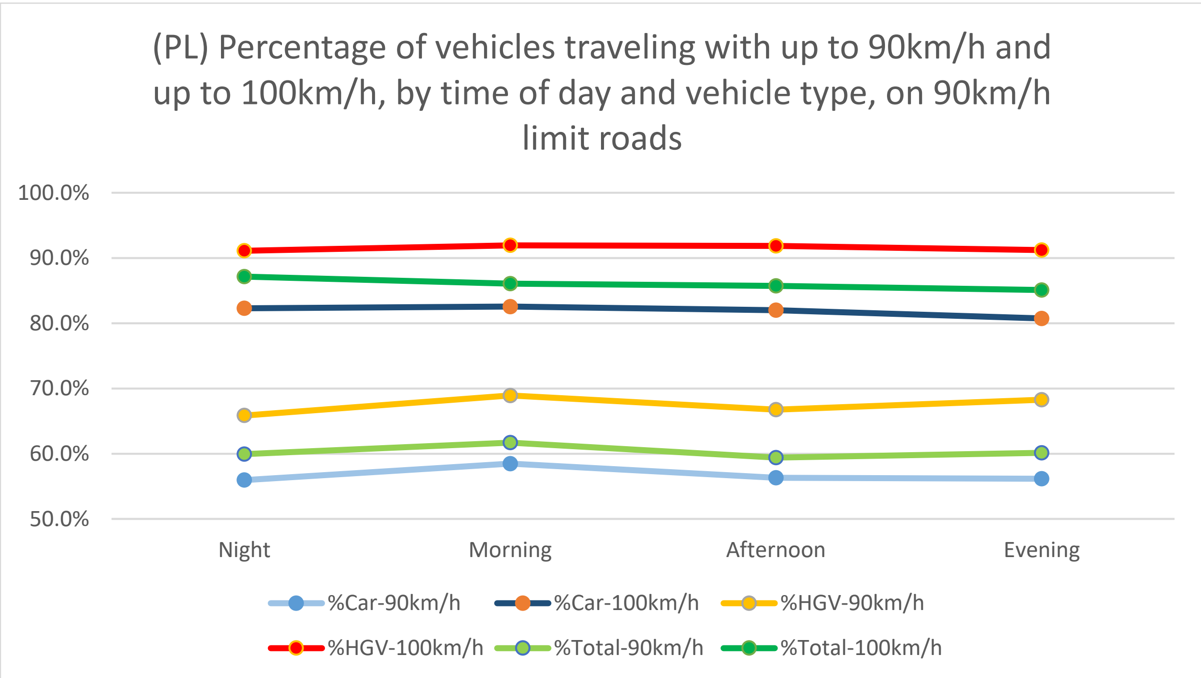

Figure.36: (PL) Percentage of vehicles traveling with up to 90km/h and up to 100km/h, by time of day and vehicle type, on 90km/h limit roads

From Table 20 and from Figure 36, it can be seen that the levels of compliance with the legal limit are:

- ✓ Between 55.9% during the night and 58.2% during the morning for cars;
- ✓ Between 65.8% during the night and 68.9% during the morning for HGVs; and
- ✓ Between 59.4% during the afternoon and 61.7% during the morning for all vehicle categories.

Morning looks to be the time of day with the highest compliance level and night time is the one with the lowest compliance level. Similarly, but with an even lower degree of variance, for the 100km/h limit, we can see the levels of 'compliance' as follows:

- ✓ Between 80.7% during the evening and 82.6% during the morning for cars;
- ✓ Between 91.1% during the night and 91.9% during the morning and afternoon for HGVs; and
- ✓ Between 85.1% during the evening and 87.1% during the afternoon for all vehicle categories.

These levels suggest, as mentioned previously, that 100km/h is a more appropriate speed limit to use, in comparison to the existing 90km/h speed limit.

Gap behind and queue length

To understand the traffic conditions more and how the traffic is behaving in different speeds, two indices were calculated, as follows:

(3) The average gap behind until a gap bigger than 5s is met – A formula was developed to calculate, for each record, the average gap behind each vehicle for queues. The formula is looking at each vehicle and averages the gap between the vehicles behind, until a gap of 5s (an interval for which the vehicles are not considered as being part of the same queue anymore) is met. This index, although somehow useful, has the shortcoming of not being able to differentiate between the queue leader and the vehicles following (therefore, for example, in a queue of 15 cars with an average gap of 2.5s between the cars, the leading vehicle will have an average of 2.5s, of the 14 vehicles behind, but the second vehicle, first in the queue, will have a similar average gap, of the 13 vehicles behind, and so on). Because of this shortcoming, the index is not showing significant differences between categories of vehicles and is more likely to show differences between vehicles travelling at different speeds.

(4) Average number of vehicles behind (average queue length) – A new formula, similar to the one described previously was used, but this time the index is recording the number of vehicles queueing behind for each record, again until a gap bigger than 5s is met. In this case, even if the shortcoming described for the previous index is still influencing the analysis, the leading vehicle would get at least one point more than any other following vehicle, and therefore we should be able to see significant differences between categories of vehicles if they exist in traffic.

The following several charts and tables will be focusing on the two indices described, allowing for a better understanding of the traffic.

Table.21: (PL) Average gap behind (s) until a gap bigger than 5s is met

Time of day	Total (50)	Total (90)	Car (50)	Car (90)	HGV (50)	HGV (90)
Night	2.54	2.36	2.58	2.28	2.42	2.39
Morning	2.56	2.26	2.59	2.29	2.50	2.23
Afternoon	2.47	2.15	2.49	2.19	2.40	2.12
Evening	2.46	2.22	2.47	2.23	2.40	2.20

The situation is presenting the opposite compared to the Romanian analysis:

- ✓ The smallest gap averages can be found behind HGVs (as opposed to Romania where behind HGVs there were the biggest gap averages);
- ✓ The biggest gap averages can be found behind cars (again, for Romania the results were opposite);
- ✓ For all vehicle categories the gap averages are bigger on 50km/h roads;
- ✓ On 50km/h roads, the difference in gap averages between HGVs and cars or other vehicles is more significant;
- ✓ In general, the biggest gap averages are found during night time and the smallest gap averages are found in the afternoon;

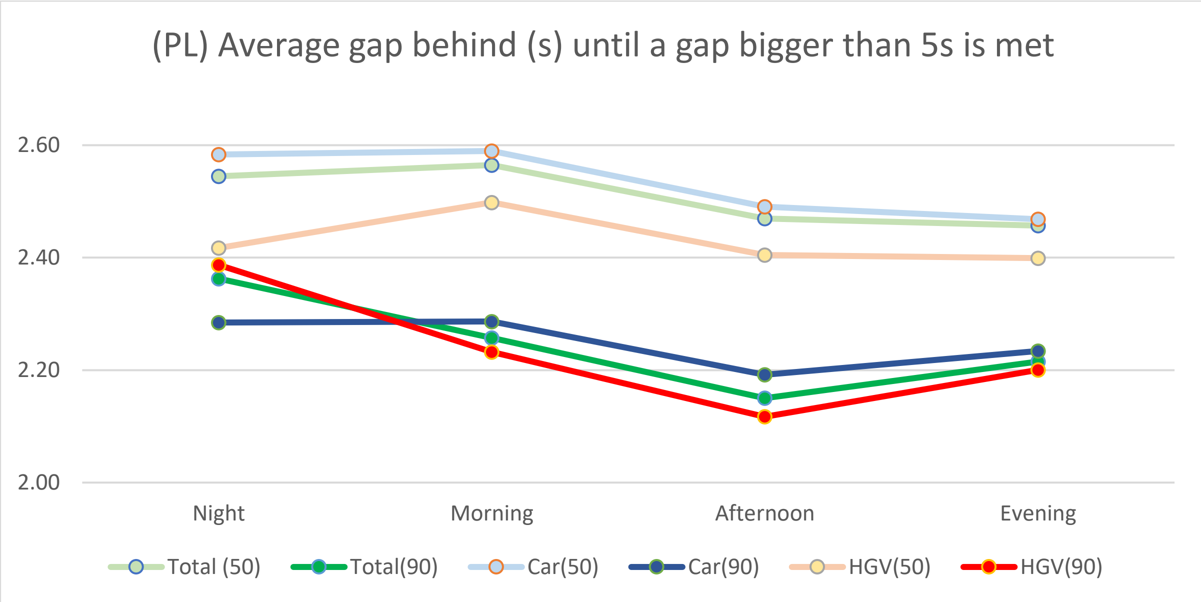

Figure.37: (PL) Average gap behind (s) until a gap bigger than 5s is met

The next two figures are presenting the comparison between the gap averages in Romania and in Poland, for different road limits.

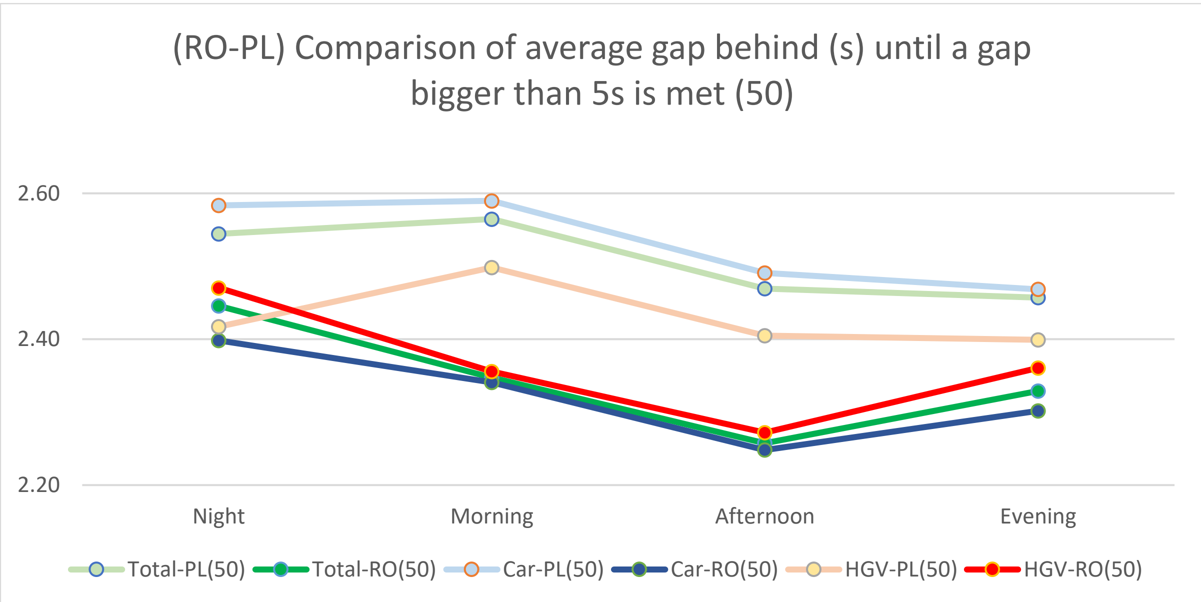

Figure.38: (RO-PL) Comparison of average gap behind (s) until a gap bigger than 5s is met, for 50km/h roads

As can be observed from Figure 38, on 50km/h roads, all vehicles, except HGVs in the morning, have a bigger gap average behind them in Poland, compared to Romania.

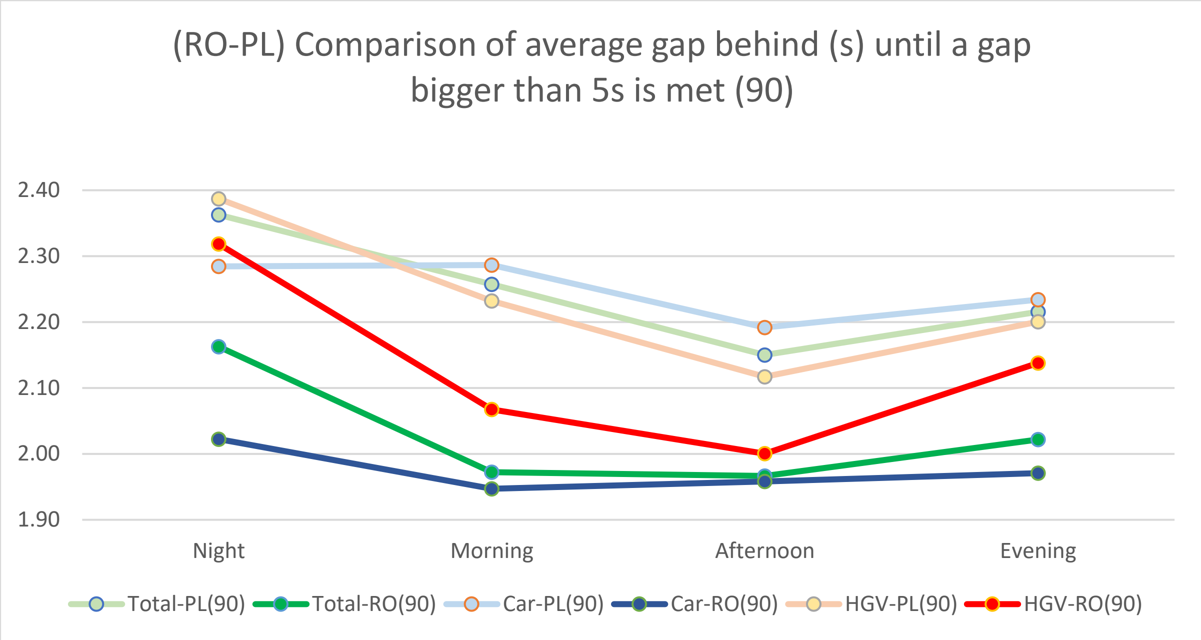

Figure.39: (RO-PL) Comparison of average gap behind (s) until a gap bigger than 5s is met, for 90km/h roads

Similarly, all vehicles travelling on 90km/h roads in Poland (no exception this time), have a bigger gap average than the Romanian ones. Also, in Poland there is less difference in gap average size between vehicle categories, compared to Romania, especially for night and evening hours.

The next charts and tables are looking at the difference between gap averages between HGVs travelling at different speeds, both for 50km/h roads and for 90km/h roads.

Table 22 and Figure 40 are presenting the gap averages for HGVs traveling on 50km/h roads, looking at the differences between gap averages behind HGVs travelling at:

- Any speed;
- Up to 40km/h (slow vehicles);
- Between 40km/h and 50km/h (legal limit);
- Between 50km/h and 60km/h (we keep this for comparison to Romania)

Table.22: (PL) Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Time of day	HGV total (50)	HGV up to 40km/h (50)	HGV 40 to 50km/h (50)	HGV 50 to 60km/h (50)
Night	2.42	2.59	2.56	2.38
Morning	2.50	2.72	2.47	2.41
Afternoon	2.40	2.60	2.47	2.36
Evening	2.40	2.72	2.48	2.34

The main points to mention here are:

- ✓ HGVs travelling up to 40 km/h show significantly higher gap averages than all other HGVs (possibly because of their size – affecting visibility, or they might be accompanied by traffic management vehicles – decrease the willingness to close follow);

- ✓ Except HGVs travelling at speeds up to 40km/h, the rest of the HGVs follow very similar patterns during the day, with regards to gap averages.
- ✓ Similar as for the Romanian analysis, the faster the HGVs are travelling the smaller the gap averages become, for all times of day;

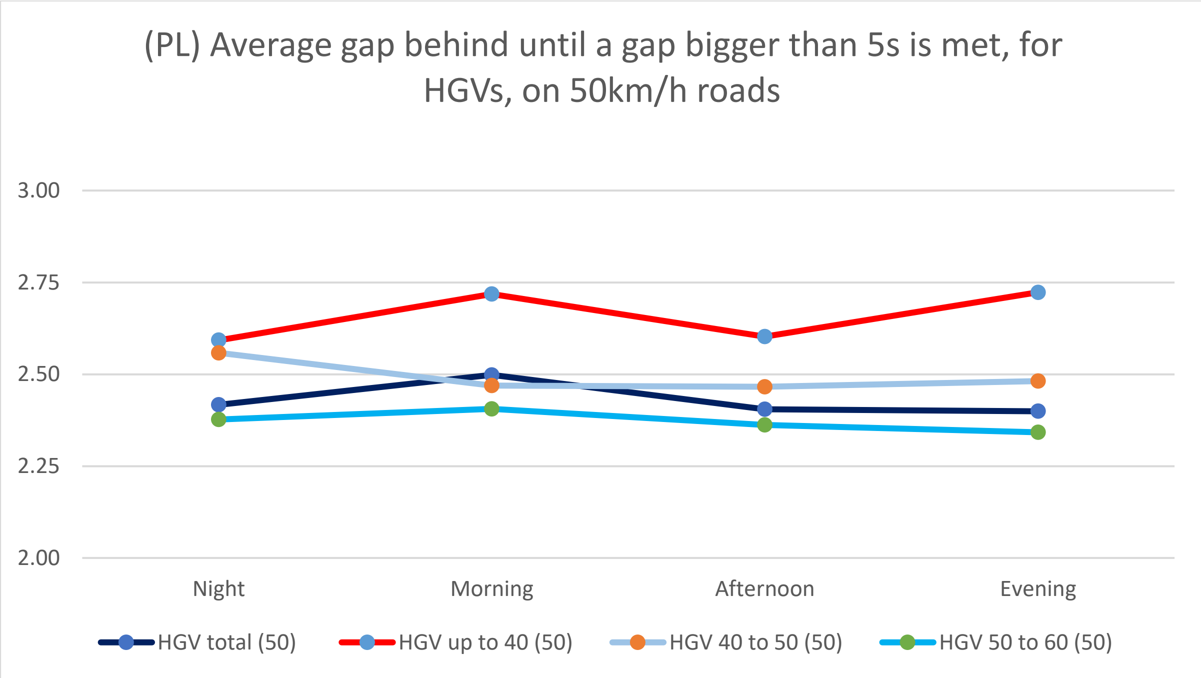

Figure.40: (PL) Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 50km/h roads

The next figure is presenting a comparison between Romania and Poland for HGVs travelling up to 40km/h, and between 40km/h and 50km/h, on 50km/h roads.

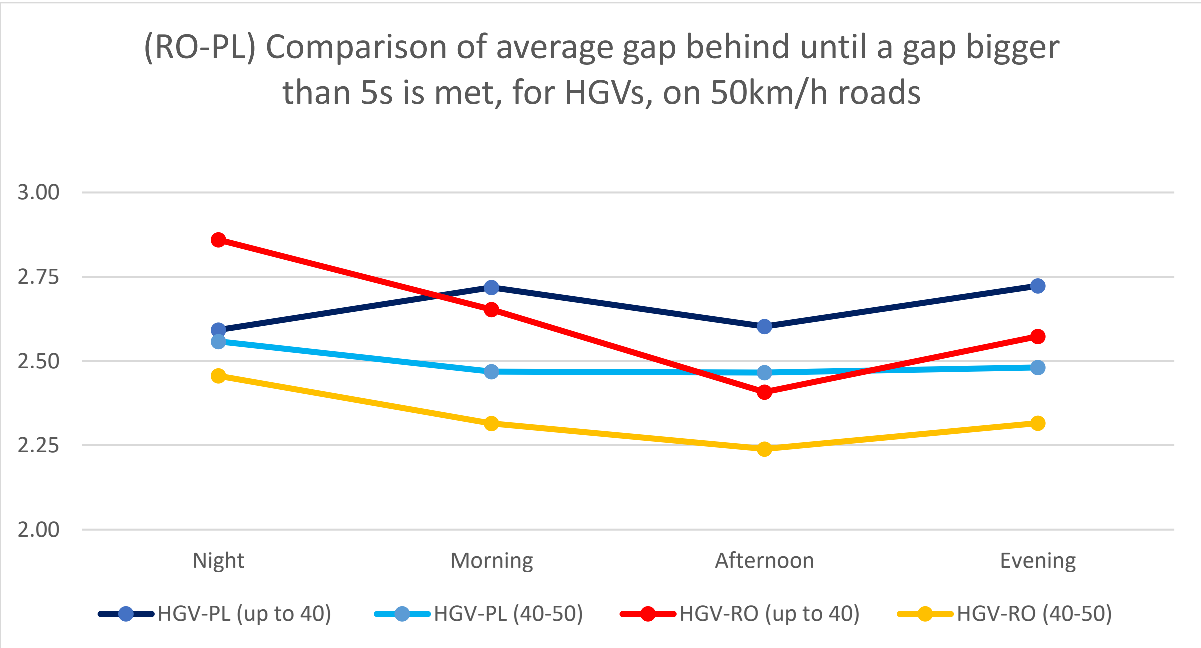

Figure.41: (RO-PL) Comparison of average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 50km/h roads

There are no significant differences between the gap averages behind HGVs travelling with speeds up to 40km/h or between 40km/h and 50km/h, between Romania and Poland.

Similarly, Table 23, Figure 42 and Figure 43 are presenting the gap averages for HGVs travelling on 90km/h roads, looking at the differences between gap averages behind HGVs travelling at:

- Any speed;
- Up to 70km/h (slow vehicles);
- Between 70km/h and 90km/h;
- Between 90km/h and 100km/h.

Relevant mentions:

- ✓ HGVs travelling at speeds up to 70km/h (slow HGVs) have the smaller gap averages and HGVs travelling between 70km/h and 90km/h (legal) have the biggest gap averages behind them; Once the speeds increase above the legal limit, the gap tend to become smaller, especially in the afternoons and evenings;
- ✓ All HGVs follow very similar patterns during the day, with significantly higher gap averages during night time and with the smallest averages during afternoon hours.

Table.23: (PL) Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Time of day	HGV total (90)	HGV up to 70km/h (90)	HGV 70 to 90km/h (90)	HGV 90 to 100km/h (90)
Night	2.39	2.22	2.41	2.33
Morning	2.23	2.11	2.25	2.19
Afternoon	2.12	2.05	2.14	2.03
Evening	2.20	2.13	2.24	2.10

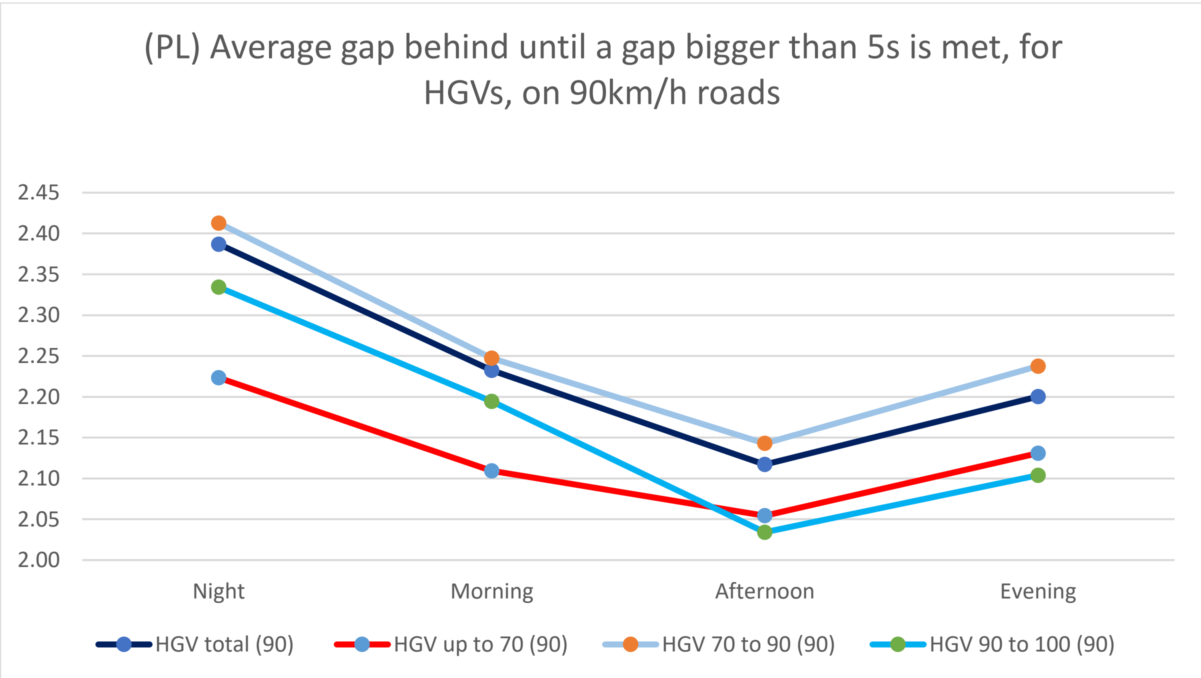

Figure.42: Average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Figure 43 presents a comparison between Romania and Poland for HGVs travelling up to 70km/h, and between 70km/h and 90km/h, on 90km/h roads.

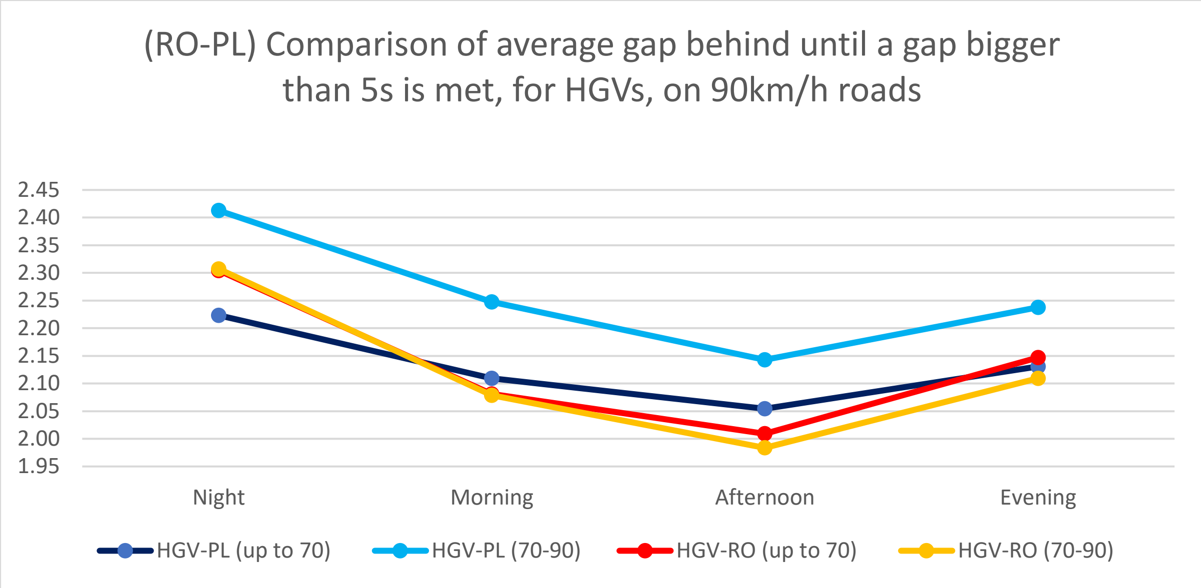

Figure.43: (RO-PL) Comparison of average gap behind (s) until a gap bigger than 5s is met, for HGVs, on 90km/h roads

In general, the gap averages are smaller for Romanian data than for the Polish data, with bigger differences for HGVs travelling with speeds between 70km/h and 90km/h, during the entire day. The patterns during the day follow similar trajectories for both countries and for both analysed speed categories.

The next set of charts and tables are analysing the queues behind vehicles, counting the number of vehicles queuing, for 50km/h roads and for 90km/h roads.

Table 24, Figure 44 and Figure 45 are presenting queue length for HGVs travelling on 50km/h roads, for the same categories as before, traveling at:

- Any speed;
- Up to 40km/h (slow vehicles);
- Between 40km/h and 50km/h (legal limit);
- Between 50km/h and 60km/h.

Relevant mentions:

- ✓ The length of the queue is the smallest during the night and the biggest during the morning hours, for HGVs travelling at any speed;
- ✓ All categories analysed are following similar patterns during the day, with the highest difference showing between HGV total and HGV 40km/h to 50km/h in the morning hours (3.11 vehicles for HGV total and 4.60 vehicles for HGV 40km/h to 50km/h);
- ✓ Slow travelling HGVs (up to 40km/h) present in general lower queues than both HGVs travelling 40km/h to 50km/h, and HGVs travelling 50km/h to 60km/h.

Table.24: (PL) Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Time of day	HGV total (50)	HGV up to 40km/h (50)	HGV 40 to 50km/h (50)	HGV 50 to 60km/h (50)
Night	2.07	2.35	2.99	2.59
Morning	3.11	3.98	4.60	3.85
Afternoon	3.06	3.24	3.83	3.77
Evening	2.52	2.29	3.39	2.90

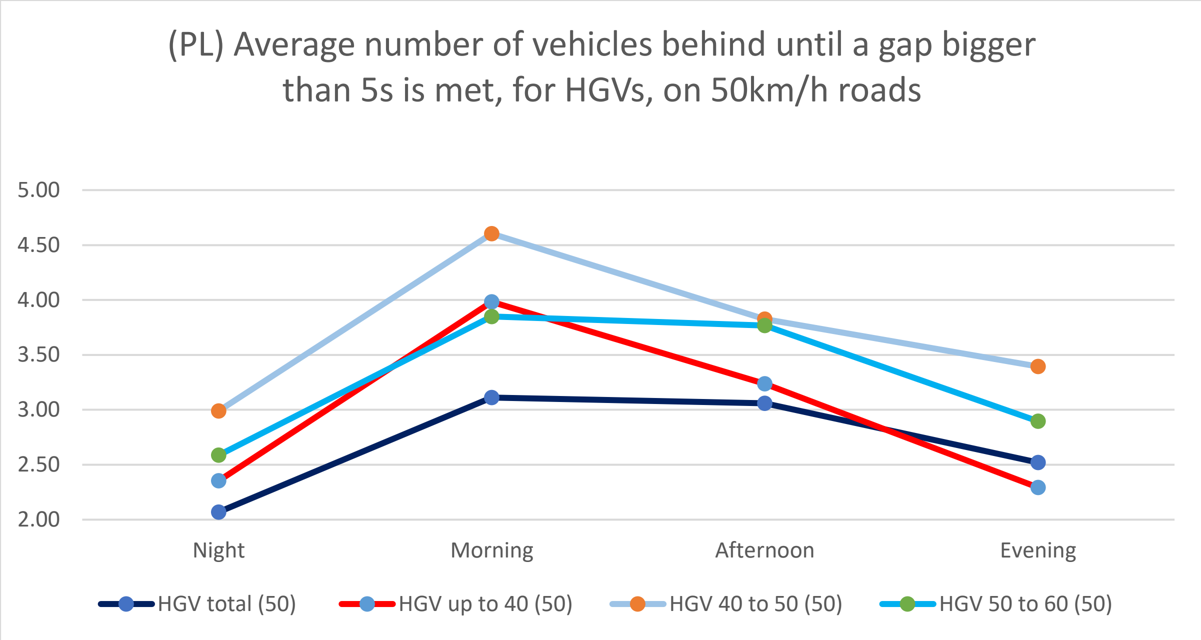

Figure.44: (PL) Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 50km/h roads

Figure 45 presents a comparison between Romania and Poland for HGVs travelling with up to 40km/h, and between 40km/h and 50km/h, on 50km/h roads, in terms of average queue length.

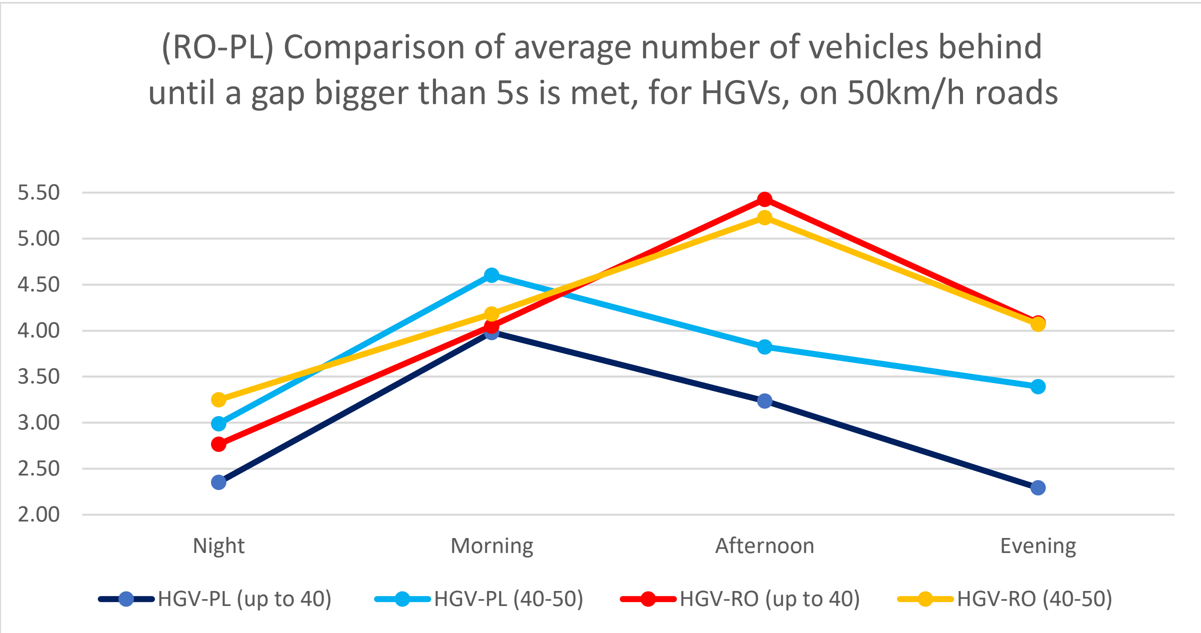

Figure.45: (RO-PL) Comparison of average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 50km/h roads

As can be seen from Figure 45, the length of queues behind HGVs in Romanian is significantly bigger than in Poland, with one exception, during morning hours where the biggest queue is behind HGVs in Poland travelling between 40km/h and 50km/h. During afternoon and evening hours the queues behind HGVs in Romania are up to twice longer than in Poland (2.29 vehicles compared to 4.08 vehicles for HGVs travelling with speeds up to 40km/h, in the evening).

Table 25, Figure 46 and Figure 47 are presenting the queue length for HGVs travelling on 90km/h roads, travelling at:

- Any speed;
- Up to 70km/h (slow vehicles);
- Between 70km/h and 90km/h;
- Between 90km/h and 100km/h.

Table.25: (PL) Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Time of day	HGV total (90)	HGV up to 70km/h (90)	HGV 70 to 90km/h (90)	HGV 90 to 100km/h (90)
Night	2.01	2.95	2.07	1.63
Morning	2.86	4.20	2.98	2.21
Afternoon	2.83	4.26	2.98	2.26
Evening	2.48	3.57	2.51	2.04

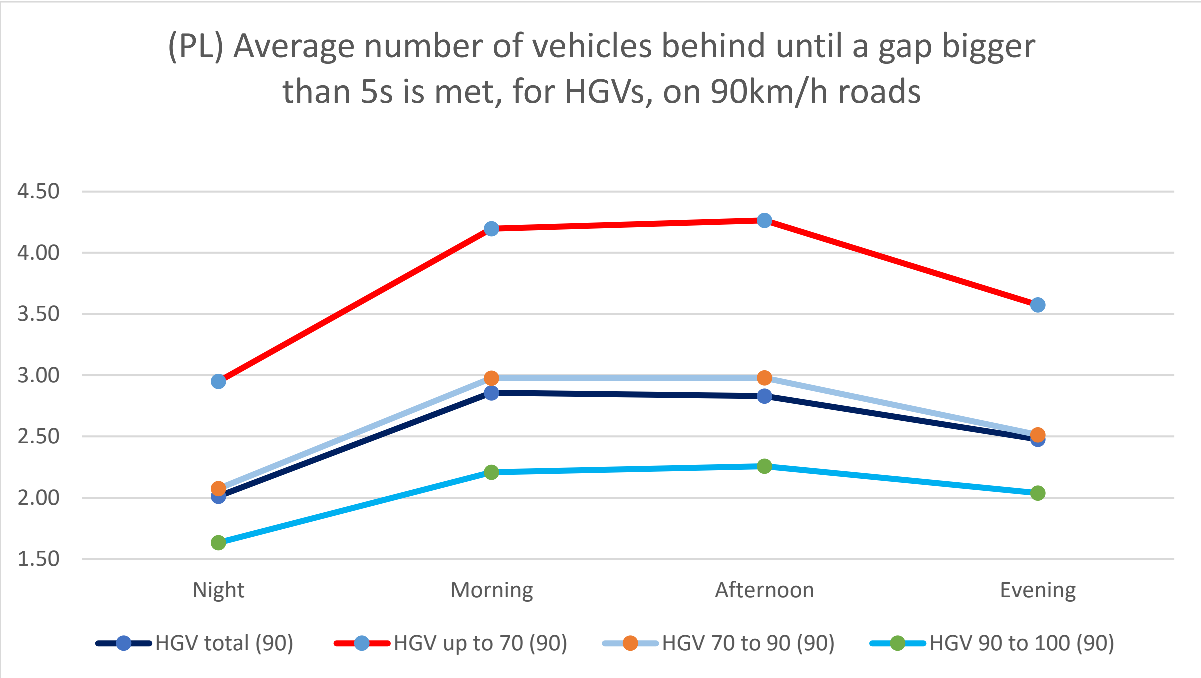

Figure.46: (PL) Average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Relevant mentions:

- ✓ The queue length for HGVs travelling at speeds up to 70km/h are significantly bigger than all other categories, for all times of day;
- ✓ HGVs travelling with speeds between 90km/h and 100km/h have the smallest queues behind.

Figure 47 presents a comparison between Romania and Poland for HGVs travelling with up to 70km/h, and between 70km/h and 90km/h, on 90km/h roads, in terms of average queue length.

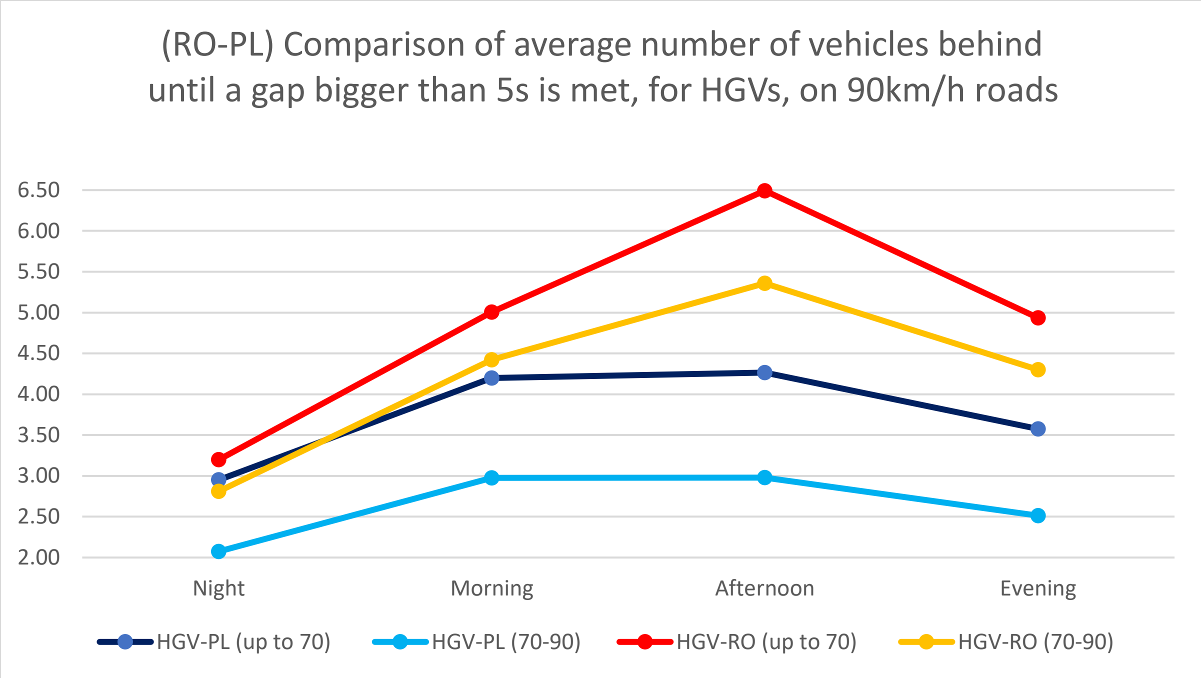

Figure.47: (RO-PL) Comparison of average number of vehicles behind until a gap bigger than 5s is met, for HGVs, on 90km/h roads

Similar to 50km/h roads, and even more pronounced here, for the 90km/h roads, the length of queues behind HGVs in Romanian is significantly bigger than in Poland. The biggest difference can be found during afternoon hours, of about 80% for HGVs travelling between 70km/h and 90km/h (2.98 vehicles in Poland and 5.36 vehicles in Romania), and about 50% for HGVs travelling at speed up to 70km/h (4.26 vehicles in Poland and 6.49 vehicles in Romania).

The next two sets of tables and charts are looking at the comparison between slow HGVs, the majority of the HGV traffic, and the majority of all traffic, to see if and how speed or vehicle category are affecting the length of the queue.

Table 26 and Figure 48 are analysing traffic on 50km/h limit roads:

Table.26: (PL) Average number of vehicles behind, by vehicle category, on 50km/h roads

Time of day	All (40-60km/h)	HGV (up to 40km/h)	HGV (40-60km/h)
Night	2.77	2.35	2.64
Morning	3.91	3.98	3.98
Afternoon	3.47	3.24	3.78
Evening	2.86	2.29	2.97

Relevant mentions:

- ✓ On 50km/h, all three studied categories have very similar queues and trajectories during the day, with slight differences during evening hours, where the queues for slow HGVs (travelling at speed under 40km/h) tend to be slightly smaller;

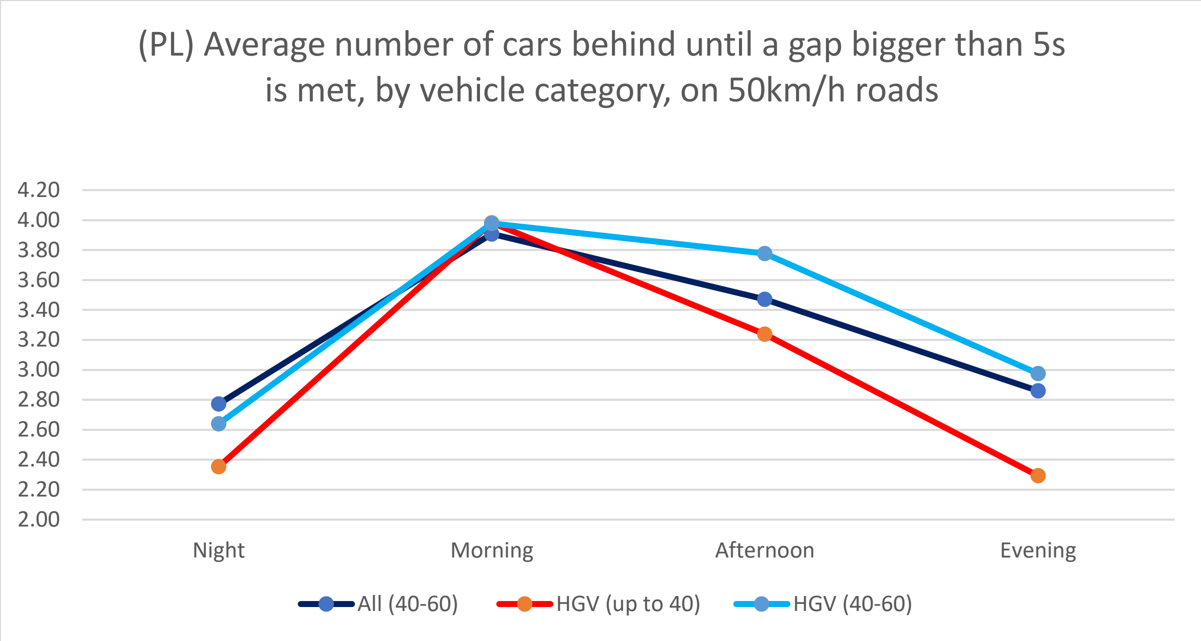

Figure.48: (PL) Average number of vehicles behind, by vehicle category, on 50km/h roads

Table 27 and Figure 49 are analysing traffic on 90km/h limit roads:

Table.27: (PL) Average number of vehicles behind, by vehicle category, on 90km/h roads

Time of day	All (70-90km/h)	HGV (up to 70km/h)	HGV (70-90km/h)
Night	2.20	2.95	2.07
Morning	2.90	4.20	2.98
Afternoon	2.84	4.26	2.98
Evening	2.43	3.57	2.51

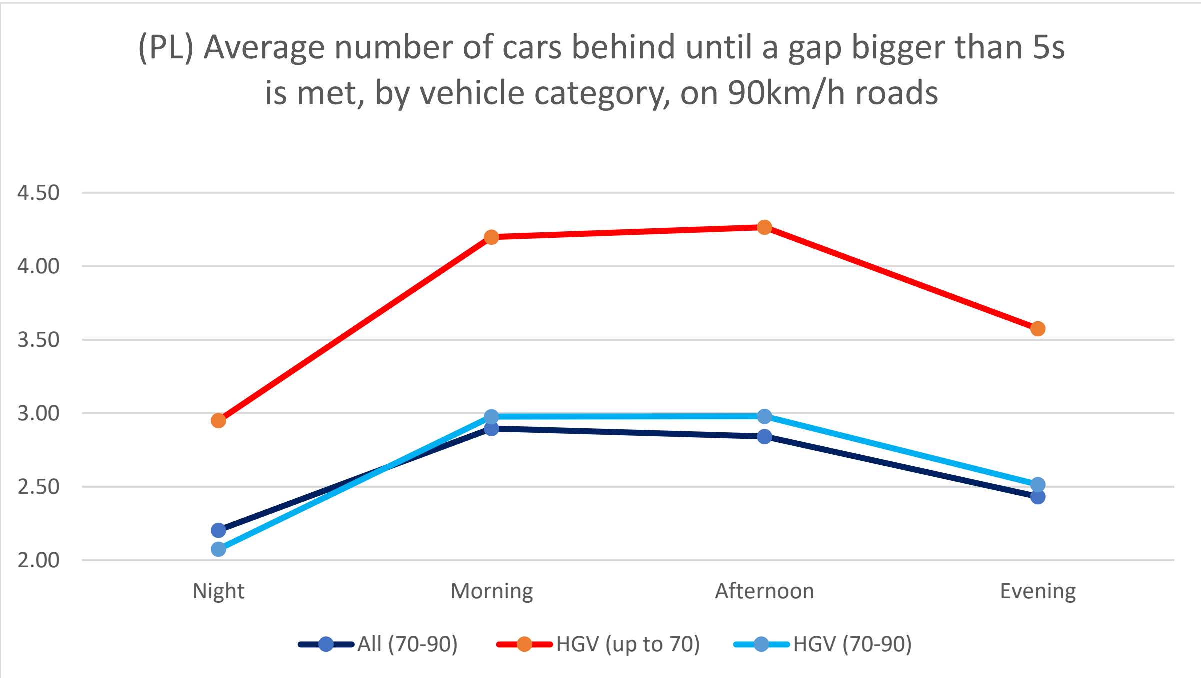

Figure.49: (PL) Average number of vehicles behind, by vehicle category, on 90km/h roads

Relevant mentions:

- ✓ Opposite to 50km/h roads, where the differences where slight or not present, on 90km/h roads the HGVs travelling at slow speeds (under 70km/h) present significantly longer queues for all times of the day, compared to the HGVs travelling between 70km/h and 90km/h, or to all vehicles travelling between 70km/h and 90km/h;
- ✓ HGVs travelling between 70km/h and 90km/h have queues similar in length to all vehicles travelling between 70km/h and 90km/h at all day times.

Similar as for the Romanian analysis, if we consider the shortcomings that are presented in the description of the indices we can assume that the real differences, if we would be assessing only the queues leaders (determinative), are a lot bigger and more pronounced. Anyway, the results are clearly presenting significantly bigger queues behind slow HGVs, even when working with all the shortcomings.

FIELD STUDY – POLAND – CONCLUSIONS

The main (and relevant) findings are:

- ✓ HGV traffic represents between 28% (during peak afternoon hours) and 48% (during night time) of the total traffic at the analysed locations. These percentages are similar to the ones from the Romanian analysis for the evening and night hours, but significantly higher for the morning and afternoon hours;
- ✓ Over 35% of the total traffic happens in the afternoon. The distribution of the traffic in Poland (at the selected locations) presents a peak period from 8AM to 8PM, with the highest peak around 6PM, and two other important peaks around 10AM and 2PM;
- ✓ The HGV traffic is quite constant during the entire day, varying with a maximum 200% from the lowest to the highest hour (compared to cars which are varying by up to 1,000%);
- ✓ On 50km/h speed limit roads, while the 50km/h limit is applicable, the 'compliance' levels are extremely low, of about 6.4% for cars, about 5.3% for HGVs and about 6% for the total traffic. These levels are twice as low as the levels for the Romanian data analysis;
- ✓ On 50km/h speed limit roads, while the 60km/h limit is applicable, the 'compliance' levels are also low, of about 19% for cars, about 18.2% for HGVs and about 17.4% for the total traffic. These levels are comparable to the levels found for the Romanian data analysis, for the 50km/h limit. These low compliance levels indicate a very big issue around the credibility (and suitability) of the speed limits, and another, maybe bigger issue around the efficiency of the speed management strategies (where existent);
- ✓ On 90km/h speed limit roads the levels of compliance are significantly higher, over 60%, but still far from being ideal. The 85^{th} percentile is around the speed of 100km/h which suggest, according to good practice, that an 100km/h limit would be more appropriate for these roads (the analysed segments). Otherwise, some engineering measures should be put in place to make the 90km/h limit credible;
- ✓ There is no substantial difference between categories of vehicles with regards to speed limit compliance or to speed bands of which they choose to travel. For 50km/h roads, the speed bands and the speed cumulative are very similar to the ones found in the Romanian data analysis. For 90km/h roads there are significant differences between Romania and Poland, in Poland only around 57% of cars and 68% of HGVs travelling within legal speed limit, compared to 83% and 89% respectively for Romanian data;

- ✓ There is no significant variation between distinct time of day with regards to speed bands or speed compliance, regardless of the vehicle category or the type of road (limit);
- ✓ The average gap distance of the vehicles queueing does not differ significantly between vehicle categories, with averages around 2.1-2.6s; Though, these gap averages are slightly higher than the ones from the Romanian data, regardless of vehicle type or time of day;
- ✓ HGVs travelling at lower speeds show a slightly smaller gap average when compared to other HGVs or to other vehicle categories, for any time of day;
- ✓ The length of the queue behind is constantly and significantly higher for slow HGVs when compared to other HGVs travelling at higher speeds or to other vehicle categories. For 90 km/h speed limit roads, these differences can be an average of 2.5 cars (150%), and they tend to remain higher in any condition and compared to any other category. When compared to Romanian data results, there are significant differences, with the queues for the Romanian slow HGVs being up to 80% longer than for the Polish data;
- ✓ Similar as for the previous analysis, the findings prove to be very relevant in relation to the research objectives, because, they are showing that the slow HGVs are representing an increased danger for the roads, through the creation of long queues which will then determine dangerous consequences for the traffic participants. Moreover, compared to the Polish data, where ADR HGVs are not restricted to lower speeds compared to other HGVs, for the Romanian data we can see longer queues behind the slow HGVs on either 50km/h or 90km/h roads. We can also observe a general more fluent traffic in Poland, and less differences between vehicle categories in terms of speeds, gaps or queues behind, although the general speeds tend to be higher and the level of compliance to the legal limits tend to be lower, compared to Romanian data.

REPORT CONCLUSIONS

The topic of this report refers to the speed limits for ADR HGVs in Romania and the effect of these limits on traffic safety. ADR HGVs in Romanian are appointed to travel at the same speeds (or under the same speed limits, of maximum 40km/h on urban roads, respectively maximum 70km/h on rural roads) as oversized vehicles (which are driving at low speeds anyway because of reasons of physics and road fitness). This aspect makes these HGVs (ADR transporters) to be perceived as driving unusually slowly, since HGVs transporting other categories of goods do not fall under the mentioned restrictions. The case is almost singular in Europe, all other countries (except for Bulgaria and Spain) adopting similar speeds for all categories of transported goods, and having the focus on driver training, safe packaging and other aspects which are not traffic related (aspects valid in Romania as well).

Therefore, a first stage of this report was the investigation of the literature related to the effects that slow-moving vehicles produce to the traffic and the traffic safety. After investigating an impressive body of research, the authors found the following effects underlined in the literature:

- ✓ Slow-moving vehicles are found to increase the rate of congestions on the roads;
- ✓ Slow-moving vehicles, by determining congestions, are found to increase driver stress and driver anger levels, which lead to aggressive behaviour and reckless driving;
- ✓ Slow-moving vehicles, through congestions, are increasing the number of large vehicles overtaking each other, which is demonstrated to be within the actions with the highest risk on the roads;
- ✓ Slow-moving vehicles are found to generate individual and public health consequences by increasing the congestion rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road;
- ✓ Slow-moving vehicles are found to generate significant economic consequences, by increasing the congestions rate and the volumes of emissions, which are increasing with the rate of the slow-moving vehicles on the road;

The next stage of the project comprises two field studies, one in Romania and one in Poland, on similar sections of roads and with similar traffic characteristics. These studies measured, for over 5 weeks in total (for each), the following variables of the traffic (individual vehicles): date and time, vehicle length, vehicle direction, speed. With these variables, three other very important variables were computed: gap (and headway), average gap distance (until a gap of certain size was met), and average queue length (again until a gap of a certain size was met). The first part for each of the studies is meant to describe the context, the traffic particularities of the selected locations for each country. The second part is dedicated to the analysis of the specific indicators mentioned previously: gaps, average gaps, and averages queues lengths.

In terms of traffic share, the share of HGV traffic for the two countries is quite similar for evening and night time (45-48%), but significantly different during the day, with about 20% HGV traffic share for Romania and about 30% HGV traffic share for Poland. In both countries the busiest period is the second part of the day, with over 35% of the total traffic happening in the afternoon. For both countries the HGV traffic volume have little variation from night to day (up to twice as many, per hour, for Romania and 3 times as many for Poland), compared to car traffic variation where you can see 6 times as many cars per hour in Romania, and 10 times as many in Poland.

In terms of speed limit compliance, both studies reveal serious compliance and speed management issues around the 50km/h limit roads. For Romania, where the limit of 50km/h is valid the entire day, only about 14% of the entire traffic is driving under the legal limit, with only 12% of the cars and 16% of the HGVs. There is also a ‘popular’ limit, considering that the police won’t penalise drivers if they are above the legal limit by less than 10km/h. Even so, only about 42% of the entire traffic, with 41% of the cars and 46% of the HGVs, are driving at speeds lower than 60km/h. The ‘credible’ limit (where the 85th percentile is situated) seems to be between 70km/h and 80km/h. In Poland there are two legal limits applicable for the same type of roads: 50km/h limit between 5AM and 11PM, and 60km/h limit between 11PM and 5AM. For the period with the 50km/h applicable limit, only about 6% of the entire traffic, with about 6% of the cars and 5% of the HGVs are travelling under the legal limit, and about 29% of the total traffic, with about 30% of the cars and 26% of the HGVs are travelling at speeds up to 10km/h above the speed limit. For the period with the 60km/h applicable limit, about 17% of the total traffic, with 19% of the cars and 17% of the HGVs travelling under legal limits, and around 54% of the total traffic, with 54% of the cars and 51% of the HGVs travelling at speeds up to 10km/h above the speed limit. Again, the 85th percentile seems to be between 70km/h and 80km/h, for both situations (which is increasing the assumption of it being about the ‘credible’ limit). These issues identified in the analysis indicate two important issues:

- ✓ The 50km/h limits are not credible, and they are not in line with the roads characteristics;
- ✓ The speed management strategies (if in place) are not effective.

On the 90km/h limit roads, the situation regarding the compliance level is significantly better for both countries. For Romania, the compliance level is around 84% for the entire traffic (83% for cars and 89% for HGVs) which suggest that the limit is appropriate. For Poland the level of compliance for the entire traffic is around 60% (57% for cars and 67% for HGVs). When looking at the 100km/h limit, about 86% of the entire traffic (82% of cars and 91% of HGVs) are traveling under that limit. This suggest that 100km/h would be a more credible speed limit for the analysed roads. In general, there are no substantial differences between categories of vehicles with regards to speed limit compliance or to speed bands they choose to travel, in each of the two studies. Also, in both studies, there was no significant variation between distinct time of day periods with regards to speed bands or speed compliance, regardless of the vehicle category or the type of road (limit).

Regarding the gaps behind vehicles, although the average gap distance of the vehicles queueing does not differ significantly between vehicle categories or time of day (between 2 and 2.5 seconds for Romania and between 2.1 and 2.6 seconds for Poland), the gap averages for the Poland study tend to be slightly higher than the ones for the Romanian study, regardless of vehicle categories or time of day. In Romania, the HGVs travelling at lower speeds (up to 40km/h) show a slightly higher gap average compared to other HGVs or to other vehicle categories. In Poland the situation is opposite, slower HGVs, presenting smaller gap averages, compared to other HGVs or other vehicle categories, for any time of day.

For both studies, the length of the queue behind slow HGVs is constantly and significantly bigger (up to 150% longer queues) compared to HGVs travelling at higher speeds and compared to all other vehicle categories travelling at any speed. There are also significant differences between Romania and Poland, the Romanian dataset showing queues significantly higher than for the Polish data, mostly when comparing the slow HGVs. For instance, on 90km/h limit roads, in Poland, HGVs travelling with up to 70km/h have average queues varying between 2.95 vehicles in the night to 4.26 vehicles in the afternoon. For the Romanian data, the HGVs travelling with speed up to 70km/h on 90km/h limit roads show queues varying between 3.2 vehicles in the night and 6.49 vehicles in the afternoon. Therefore, the queues behind the Romanian slow HGVs are up to 52% longer than for the same category of vehicles, travelling at similar speeds in Poland.

After analysing the body of evidence available within the literature, and the results of the field studies analysis, the authors would like to make the following recommendations:

1. The Romanian authorities responsible for road safety should eliminate the speed restrictions for ADR and set constant and consequent rules for all traffic participants. The present restrictions are creating big differences in speed between different traffic participants, traffic agglomeration and long queues. These are all creating anger, stress and frustration which are then increasing the likelihood of more drivers behaving aggressive and irresponsible, increasing the risk level on the roads;
2. The Romanian (and Polish) authorities should revise the speed limits and the methodologies of assigning speed limits, such way that the limits to be more credible;
3. After reviewing the speed limits, the Romanian (and Polish) authorities should put in place speed management systems to enforce the new limits;
4. Traffic rules and restrictions should be correlated with international practice, especially for HGVs, where the drivers are driving through multiple countries as their regular routine;
5. Any applicable rules (and especially restrictions) should be very visible on the relevant websites and updated on the EU websites (the ADR restrictions are not presented at the moment on the EU page detailing the limits in all EU countries, and therefore drivers who don’t know the Romanian language can’t find out about it).

APPENDIX I – RESEARCH EVIDENCE REVIEW

METHODOLOGY

The review was undertaken using multiple sources and databases. For legislation and general rules and regulations, as well as for general traffic and road safety reports, the research mostly used, but was not limited to, the following sources:

- European Transport Safety Council (ETSC)
- European Commission
- Romania Traffic Police
- Romanian Road Authority
- Road Safety Observatory
- Safety Cube DSS

For specific research on the investigated topic and the connected topics, the search was undertaken on, although not limited to, the following databases/ search engines:

- Road Safety Observatory — http://www.roadsafetyobservatory.com/
- Safety Cube DSS — https://www.roadsafety-dss.eu/#/
- European Transport Safety Council (ETSC) — http://etsc.eu/
- Google Scholar — https://scholar.google.co.uk/

There were 19 Key Search Terms (KST) used in the methodology. On all investigated sources, the first 50 results, in order of relevance, for each KST, were investigated. An additional 10 Secondary Search Terms (SST) were also used, in combination with each of the KST. For each combination of "KST" AND "SST", the first 30 results, in order of relevance, were investigated. The key terms are:

Key Search Terms (KST)

- Traffic speed dispersion
- Traffic speed restrictions
- Traffic speed differential
- Slow traffic
- Slow vehicles
- Slow driving
- Speed limits increase
- Credible speed limits
- Close following
- Tailgating
- Dangerous overtaking
- ADR restrictions
- ADR vehicles
- ADR rules
- ADR speed
- Dangerous goods vehicle
- Low speed vehicles
- Restricted speed vehicles
- Headway distance

Secondary Search Terms (SST)

- Safety consequences
- Health consequences
- Flow consequences
- Economic consequences
- Psychological
- Anger
- Stress
- Driver behaviour
- Speed limits
- One lane road

The methodology yielded over ***6,650 research evidences*** to investigate for relevance. Out of these, a number of ***208*** were selected as potentially relevant for the topic. The 208 were then reviewed thoroughly and a number of *68* were selected as relevant for the project. Additional *25* policy reports and regulations documents, national and international, were used in constructing arguments and understanding the national and international contexts and are sometimes referred. These documents will be attached in full to the final report, as a compressed archive.

Title:	**Examining Impacts of Increasing Speed Limit on Speed Distribution: Case study**
Published: **Author(s):**	Transportation Research Board 93rd Annual Meeting, 2014 Alemazkoor, N.; Hawkins, H.G.
Free/priced:	Priced: $20.00 via http://amonline.trb.org
Aim:	To evaluate vehicle speed distributions before and after the speed limit change.
Methodology:	In January 2013, the Texas Department of Transportation increased the speed limit on a freeway through College Station, Texas from 70 mph to 75 mph. This stretch of freeway includes a data collection facility that records the speed of every vehicle. The speed data was recorded continuously and there was over 160,000 speed points in each period. Speed data were divided into groups by type of day (weekday or weekend), light condition (daylight or dark), type of vehicle (car or truck), lane position, and volume level for analysis.
Key Findings:	It was found that mean and 85th percentile speeds increased after raising the speed limit, but by less than the 5 mph increase in the speed limit. For the entire set of data, the 85th percentile speed increased from 74.7 in the before period (November 2012) to 77.0 mph in the after period (March 2013).
Relevant findings and comments:	The results indicate that the 75-mph speed limit is a better representation of the 85th percentile speed than the 70-mph speed limit. The results also indicate that, when the speed limit on a high-speed road is increased, there may not be a similar magnitude of increase in the 85th percentile speed.

Title:	**Effects of Increasing Freeway Speed Limits on Crashes: Case Study from Israel**
Published: **Author(s):**	Transportation Research Board 96th Annual Meeting, 2017 Harari, A.; Musicant, O.; Bar-Gera, H.; Schechtman, E.
Free/priced:	Priced: $20.00 via http://amonline.trb.org
Aim:	The speed limits in Israel were updated twice in recent years: in January 2011 and again in January 2013. The updates were by 10 to 20 km/h in twenty-six segments in seven different highways, with total length of 148 km. The study explores the change in safety that resulted from this action.

Methodology:	The authors use three different approaches: (1) a simple before-and-after approach (2) before-and-after study with a comparison group (3) before-and-after study with traffic flow correction, using the empirical Bayes method.
Key Findings:	All the methods showed decreases in the number of crashes after the speed limit change. Relative to one of the comparison groups the decreases were statistically significant, 18% (CI= [9%,28%]) by method (2) and 21% (CI= [12%,30%]) by method (3).
Relevant findings and comments:	The findings suggest an increase in safety after the increase in the speed limits to more credible limits.

Title:	**Safety Effects of Differential Speed Limits on Rural Interstate Highways**
Published: **Author(s):**	Transportation Research Record: Journal of the Transportation Research Board, 2014 Garber, N.; Miller, J.; Yuan, B.; Sun, X.
Free/priced:	Priced: $25.00
Aim:	To compare the safety effects of a uniform speed limit (USL) for all vehicles and a differential speed limit (DSL) for cars and heavy trucks.
Methodology:	Crash, speed, and volume data for rural Interstate highways for the period 1991 through 2000 were obtained from nine states. These states were divided into four policy groups based on the type of speed limit employed during the period: maintenance of a uniform limit only, maintenance of a differential limit only, a change from a uniform to a differential limit, and a change from a differential to a uniform limit. Statistical tests (analysis of variance, Tukey's test, and Dunnett's test) and the empirical Bayes method were used to study speed and crash rate changes in the four policy groups.
Key Findings:	The safety effects of DSL and USL were not different within the scope of the study. The mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the 10-year period regardless of which type of speed limit was employed. When all sites within a state were analysed, temporal differences in these variables were often not significant.
Relevant findings and comments:	Differential speed limits for cars and heavy trucks were not found to have significant safety effects.

Title:	**Towards Safe Speeds and Credible Speed Limits**
Published: **Author(s):**	4th International Symposium on Highway Geometric Design, 2010 Aarts, L.; Van Nes, N.; Donkers, E.; Van de Heijden, D.

Free/priced:	Priced: $20.00 via http://amonline.trb.org
Aim:	To develop into a set of algorithms on safe speeds and credible speed limits (SaCredSpeed) that could be used in a decision support instrument for all types of roads.
Methodology:	The SaCredSpeed algorithm uses input data of road design and image, and traffic characteristics of stretches of roads in order to calculate a safe speed and speed limit for that particular situation. This means that, depending on the legal traffic situation and further road design details, safe speed limits are defined. The safe speed is related to the real speed (V90 as a default) if this data is available.
Key Findings:	The SaCredSpeed algorithm can then check the credibility of the speed limit (current or ideal) and the enforcement situation (optional). Depending on the fit between the results of all these assessments, SaCredSpeed offers suggestions for adaptations. These can consist of a) speed limit adaptations, b) road design adaptations or c) additional adaptations in enforcement. These suggestions can also take into account the road network function, the condition of the adjacent roads, the traffic volume, and the priorities the decision maker wants to set.
Relevant findings and comments:	The credibility of the speed limits and the enforcement possibilities are important factors for suggestions of adaptations.

Title:	**Speed and road accidents. An evaluation of the Power Model**
Published: **Author(s):**	The Institute of Transport Economics (TOI), Oslo, 2014 Elvik, R.; Christensen, P.; Amundsen, A.
Free/priced:	Free
Aim:	The relationship between speed and road safety has been evaluated by means of a meta-analysis of studies that provide estimates of how changes in speed affect the number of road accidents and the number and severity of injuries to road users.
Methodology:	Meta-analysis of studies
Key Findings:	Principles for setting speed limits: 1. Adapting speed limits to actual driving speed, such as the 85th percentile of the speed distribution, to ensure that the limits seem reasonable from motorists' point of view and are not too widely disregarded;

	2. Setting speed limits according to roadway geometry (low speed limits on narrow and winding roads, high speed limits on straight and wide roads); 3. Setting speed limits according to the type and level of roadside development (low speed limits in residential and commercial areas, high speed limits in rural areas); 4. Setting speed limits according to human tolerance for biomechanical energy, in order to ensure that nobody is killed or permanently injured (Vision Zero speed limits); 5. Setting speed limits so as to minimize the total societal costs of transport. Speed limits set this way are generally referred to as optimal speed limits.
Relevant findings and comments:	Optimal speed limits are those that minimize the total costs to society of transport. The following impacts of speed are normally included in these costs when optimal speed limits are estimated: 1. Costs of travel time; 2. Vehicle operating costs; 3. Road accident costs; 4. Costs of traffic noise; 5. Costs of air pollution; and possibly 6. Costs of road maintenance, as these depend on speed.

Title:	**The factors that influence a driver's choice of speed — a questionnaire study**
Published: **Author(s):**	Transport Research Laboratory, 1999 Quimby, A.; Maycock, G.; Palmer, C.; Buttress, S.
Free/priced:	Free
Aim:	The objectives of this study are to identify those characteristics of a driver that are most influential in determining his or her choice of speed, and to explore the links between these characteristics, the speeds chosen, and the accidents in which the drivers are involved.
Methodology:	The study used a combination of on-road observation and survey techniques.
Key Findings:	The apparently strong 'cross-sectional' association between speed and accidents does not necessarily imply a causal link between the two, and it cannot be assumed that reductions in speed by particular drivers (a 'within driver' effect) will necessarily result in accident reductions of a size

	predicted by this association. It seems probable that the association arises from the fact that both speed and accidents are related in similar ways to the same variables - particularly age, experience, and exposure.
Relevant findings and comments:	While there are a variety of interacting factors which determine an individual driver's choice of speed, the largest single influence was the site characteristics, which accounted for over half of the variation in speed.

Title:	**Modelling instantaneous traffic emission and the influence of traffic speed limits**
Published: **Author(s):**	Science of the Total Environment (2006), Vol 371, pp.270-285 Panis, L.I.; Broekx, S.; Liu, R.
Free/priced:	Priced: $39.00
Aim:	This paper considers the effect of active speed management on traffic-induced emissions. In particular, the traffic emissions caused by acceleration and deceleration of vehicles are modelled based on an instantaneous emission model integrated with a microscopic traffic simulation model.
Methodology:	The traffic model captures the second-by-second speed and acceleration of individual vehicles travelling in a road network based on their individual driving style, the vehicle mechanics, and their interaction with other traffic and with traffic control in the network. The integrated model is applied to test a new technology to actively manage the driving speed of the vehicles in an urban network. Their impacts on vehicle emission in the network are assessed to give an indication of the relative effectiveness of the different technological designs and different levels of driver responses.
Key Findings:	The results show that, while the speed management has effectively reduced the average speed of the traffic, their impact on vehicle emissions is complex. For the study network, the frequent acceleration and deceleration movements in the network has significantly reduced the effect of the reduced average speed on emission. The net results are that the active speed management has no significant impact on pollutant emissions.
Relevant findings and comments:	The frequent acceleration and deceleration movements in the network has significantly reduced the effect of the reduced average speed on emission.

Title:	**Environmental effects of driving behaviour and congestion related to passenger cars**
Published:	Atmospheric Environment (2000), Vol. 34, pp.4649-4655

Author(s):	De Vlieger, I.; De Keukeleere, D.; Kretzschmar, J.G.
Free/priced:	Priced: $39.00
Aim:	Driving behaviour and traffic conditions on fuel consumption and emissions were studied for a small test fleet of passenger cars.
Methodology:	Vito's on-board measuring system
Key Findings:	City traffic resulted in the highest fuel consumption and emissions. Fuel consumption was about two times higher than for ring roads, which generally gave the lowest values. This was even more pronounced for emissions. Depending on road type and technology, fuel consumption increased by up to 40% for aggressive driving compared to normal driving. Again, this was more pronounced for emissions, with increases up to a factor of 8. Driving behaviour had a greater influence on petrol-fuelled than on diesel-fuelled cars. Traffic condition also has a major effect on fuel consumption and emissions. For city driving intense traffic increased fuel consumption by 20-45%. The increase in fuel consumption and emissions during rush hours were the highest on ring roads, with increases between 10 and 200%. In absolute terms, a surplus of up to 5 l fuel per 100km was measured. More environment-friendly route option requires the use of ring roads and motorways during rush hours instead of short cuts.
Relevant findings and comments:	Fuel consumption increased by up to 40% for aggressive driving compared to normal driving. Traffic conditions also have a major effect on fuel consumption and emissions.

Title:	**Operational Effects of Slow Vehicle Turnouts on a Rural Highway in Alaska**
Published: **Author(s):**	International Conference on Transportation and Development Proceedings, 2016, pp.1087-1098 Bowie, J.M.; Kinney, J.R.
Free/priced:	Free
Aim:	The paper reports on the actual change in percent impeded (PI) and makes conclusions about the efficacy of slow vehicle turnouts (SVT) for operational improvements.
Methodology:	Twenty-two slow vehicle turnouts (SVTs) were constructed on the 70-mile section of the Sterling Highway between Homer and Soldotna in the summer of 2014. Prior to this, there were no passing lanes or designated SVTs within the project area. Speed, volume, and gap data were collected

	in the project area both before and after construction of the slow vehicle turnouts.
Key Findings:	SVTs were not shown to have a large impact on the operational characteristics of the highway, reducing PI on only 4 out of 6 combinations of data collection site and travel direction. Nevertheless, the trend suggests that the SVTs are being used by some lead vehicles and that the result is an overall reduction in the percentage of vehicles that are impeded by a slow vehicle in front of them. The effect was greater just downstream of a SVT than it was for locations further away from the SVT.
Relevant findings and comments:	The trend suggests that the SVTs are being used by some lead vehicles and that the result is an overall reduction in the percentage of vehicles that are impeded by a slow vehicle in front of them. The effect was greater just downstream of an SVT than it was for locations further away from the SVT.

Title:	**Low Speed Car Following Behaviour from Floating Vehicle Data**
Published: **Author(s):**	Intelligent Vehicles Symposium, Proceedings. IEEE, 2003 Piao, J.; McDonald, M.
Free/priced:	Priced: $33.00
Aim:	An analysis of driver behaviour is reported focusing on car following separation at low speed traffic conditions.
Methodology:	The data used for this analysis were collected using an Instrumented Vehicle in three European cities: Oslo (Norway), Paris (France) and Southampton (UK). The data collection covered a wide range of traffic conditions on urban motorways, urban arterial roads and urban streets. Time gaps and distance gaps in low speed traffic conditions were investigated and were compared with those in high speed traffic conditions.
Key Findings:	The results showed that time gaps were more variable in low speed situations than in high speed situations. However, distance gaps are more variable at high speeds than at low speeds. The inability of human drivers to accurately estimate longitudinal distance to the car ahead might be one of the main reasons for this.
Relevant findings and comments:	Both the time gaps and their standard deviations decreased as the following speed increased, however, such changes were much more obvious when at low speeds than those when at high speeds. 1. Speed <10km/h - Large time gaps and large standard deviations; 2. Speed between 10 km/h and 60km/h - Clear trend of time gaps and standard deviation decreasing as speed increases; 3. Speed >70km/h - Relatively stable time gap and standard deviations.

Title:	**Overtaking Frequency and Advanced Driver Assistance Systems**
Published: **Author(s):**	IEEE Intelligent Vehicles Symposium, Parma, Italy, 2004 Hegeman, G.
Free/priced:	Priced: $33.00
Aim:	The paper shows results of an observation of overtaking frequencies on roads with opposing traffic.
Methodology:	The study determines overtaking frequencies as a function of flow rates on both directions, distinguishing different vehicle types.
Key Findings:	The observed overtaking frequencies are 9 times and 29 times as small as theoretical overtaking density respectively. The theory, formula, assumes no opposing traffic. This leads to the conclusion that overtaking on a two-lane road is dependent on the opposing traffic flow. Although the simulation model simulates fewer overtakings than the theory, it still overestimates the real frequencies.
Relevant findings and comments:	The total risk of overtaking is a multiplication of frequency of overtaking times the risk of each overtaking action. If overtaking frequency increases, the total risk of overtaking will only increase if the risk per overtaking action remains the same or increases as well.

Title:	**The Economic Costs of Road Traffic Congestion**
Published: **Author(s):**	The Rail Freight Group, London, 2004 Goodwin, P.
Free/priced:	Free
Aim:	Discussion paper
Methodology:	Analysis and discussion of current and future practices for determining the costs of road traffic congestion
Key Findings:	The two key important things to do are: • Strategic action to reduce traffic volume to a level where conditions do not vary too much from day to day. It will greatly increase reliability; • Practical measures to provide good alternatives for freight and passenger movements which reduce the intensity of use of scarce road space in congested conditions. Even where this only applies to a minority of movements, significant effects are possible.
Relevant findings and comments:	Widely used and accepted method of calculating congestion costs:

	[(Time at 'free-flow' speed) – (Time at actual speed)] * (Volume of traffic) = Total congestion delays; Total congestion delays * Value of time = Economic cost of congestion

Title:	**Studying the Vehicle Headway Issue and Its Impact on the Slow-Down Effect**
Published: **Author(s):**	University of Rhode Island, 2009 Wang, J-W.; Song, M.
Free/priced:	Free
Aim:	The project presents a human-factors study, consisting of a vehicle headway analysis and a questionnaire survey, aiming to identify the causes of tailgating and to find effective means for tailgating treatments.
Methodology:	In the vehicle headway analysis, vehicle headways on specific segments of major highways in Rhode Island were examined. With tailgating phenomenon confirmed from the analysis, the study next searched means to mitigate tailgating behaviour. A questionnaire survey was conducted to find the leading causes of tailgating.
Key Findings:	The results of the survey indicated that the majority considered "tailgating" a serious offense. Most of them, however, did not know what the proper vehicle headway was when driving on highways. Among the few different tailgating treatments, most preferred the one where equal-distanced horizontal bars were used as reference markings.
Relevant findings and comments:	Top causes for tailgating: • Heavy traffic; • ***Slow car ahead***; • In a hurry; • Poor visibility; • Distraction; • Weather conditions; • Hypermiling.

Title:	**Driving speed and the risk of road crashes: A review**
Published: **Author(s):**	Accident Analysis and Prevention (2006), Vol. 38, pp.215–224 Aarts, L.; Van Schaegen, I.
Free/priced:	Priced: $39.00
Aim:	To discuss the relationship between speed and the risk of being involved in crashes.

Methodology:	The paper discusses the most important empirical studies into speed and crash rate with an emphasis on the more recent studies.
Key Findings:	The majority of the studies looked at absolute speed, either at individual vehicle level or at road section level. Respectively, they found evidence for an exponential function and a power function between speed and crash rate. Both types of studies found evidence that crash rate increases faster with an increase in speed on minor roads than on major roads. At a more detailed level, lane width, junction density, and traffic flow were found to interact with the speed–crash rate relation. Other studies looked at speed dispersion and found evidence that this is also an important factor in determining crash rate. Larger differences in speed between vehicles are related to a higher crash rate. Without exception, a vehicle that moved (much) faster than other traffic around it, had a higher crash rate. With regard to the rate of a (much) slower moving vehicle, the evidence is inconclusive.
Relevant findings and comments:	Studies looked at speed dispersion and found evidence that this is also an important factor in determining crash rate. Larger differences in speed between vehicles are related to a higher crash rate.

Title:	**The Influence of Environmental Factors on Speed Choice**
Published: **Author(s):**	IEEE Forum on Integrated and Sustainable Transportation Systems, Vienna, Austria, 2011 Aarts, L.; Brandenburg, S.; Van Nes, N.
Free/priced:	Free
Aim:	This study investigates the relationship between speed and environmental factors for single lane rural roads, one of the most hazardous road types in the Netherlands.
Methodology:	The study uses data from two provincial road authorities. Data consists of speed data from loop detectors, road design characteristics, characteristics of the road environment, and police enforcement.
Key Findings:	The study has shown the differential effects of some variables (e.g. road width) on different parts of the distribution of percentiles of speeds. This result should alert researchers focusing on mean speed and mean homogeneity only. Additionally, the study may also have raised some interesting points while taking speed distribution related measures into account. It may be interesting to focus future research on more detailed studies of speed behaviour of particular groups and the factors that influence these groups. As is supposed by models, adding personal or cognitive factors as explanatory variables may give better insight into the process of speed choice and speed behaviour.

Relevant findings and comments:	A speed limit with high credibility implies that drivers consider that speed limit as logical or appropriate in light of characteristics of the road and its immediate surroundings. Speed limits can also have low credibility. Typically, when the speed limit lacks credibility, it is perceived as too low (although a speed limit that is perceived as too high is also possible) and people tend to speed. Incredible speed limits may also have an adverse effect on the speed limit system as a whole, and finally even on the acceptation of other traffic rules.

Title:	**Situational (state) anger and driving**
Published: **Author(s):**	Transportation Research Part F (2012), Vol. 15, pp.575–580 Abdu, R.; Shinar, D.; Meiran, N.
Free/priced:	Priced: $39.00
Aim:	Examine the direct causal relation between situational anger and driving choices and abilities
Methodology:	15 licensed drivers drove twice in a driving simulator, each time following one of two emotion inductions based on event recall: angry and neutral.
Key Findings:	Following anger induction, the drivers crossed more yellow traffic lights ($p < .01$) and tended to drive faster (non-significant). However, performance on emergency manoeuvres was unaffected by anger. In conclusion, it appears that state anger affects driving behaviour by increasing risk taking, without necessarily compromising the skilled driving behaviour, at least as far as these behaviours were evaluated in emergency situations in simulated driving.
Relevant findings and comments:	State anger affects driving behaviour by increasing risk taking.

Title:	**Driving speeds in Europe for pollutant emissions estimation**
Published: **Author(s):**	Transportation Research Part D (2000), Vol. 5, pp.321-335 Andre, M.; Hammarstrom, U.
Free/priced:	Priced: $39.00
Aim:	An examination of the various means of driving speed investigations, fundamental for emissions estimations and inventories.
Methodology:	Examination of various means of investigations: surveys, vehicle instrumentation, traffic modelling, etc., through a European synthesis.
Key Findings:	The significant variations of the speed according to the time of the day, to the areas of a city, and the large dispersion for a given situation raise the

	question of using single average values. In fact, emissions estimation can be affected by 30% by the quality of the driving speed data.
Relevant findings and comments:	CO and CO2 emissions generally are high at low speeds, decrease up to 60-80 km/h and then increase again.

Title:	**The tendency of drivers to pass other vehicles**
Published: **Author(s):**	Transportation Research Part F (2005), Vol. 8, pp.429–439 Bar-Gera, H.; Shinar, D.
Free/priced:	Priced: $39.00
Aim:	The purpose of this study was to assess the speed differential threshold—if there is one—at which drivers decide to pass a lead vehicle.
Methodology:	Drivers in a simulator encountered vehicles in front that were programmed to travel at speeds that were similar, slightly below, or even slightly above the drivers' own speed. The study involved a total of 152 such passing opportunities.
Key Findings:	In almost all of the encounters with slower vehicles (traveling at speeds slower than 3 km/h of the driver) they passed them, and in two thirds of the encounters when the lead vehicles were moving at their speed they passed them too. Most surprising was that in 50% of the encounters drivers passed the lead vehicle when it was traveling faster than their average speed. In these situations, drivers actually increased their own speed substantially to accomplish the passing manoeuvre, despite the fact that not passing the lead vehicle would not have caused any delays.
Relevant findings and comments:	The tendency to pass appears to be related to the drivers' own speed variability: the more variable the driver's speed the more likely he or she was to pass the vehicle ahead even when its speed was greater than their average speed.

Title:	**Real-World Carbon Dioxide Impacts of Traffic Congestion**
Published: **Author(s):**	Transportation Research Record: Journal of the Transportation Research Board (2008), pp.163–171 Barth, M.; Boriboonsomsin, K.
Free/priced:	Priced: $25.00
Aim:	Traffic congestion and its impact on CO2 emissions were examined by using detailed energy and emission models, and they were linked to real-world driving patterns and traffic conditions.

Methodology:	Freeway Performance Measurement System (PeMS) - collects real-time speed, flow, and density data from loop detectors embedded in California's freeways and makes the information available for transportation management, research, and commercial use. The system provides real-time 30-s (and 5-min), per-loop averages of lane occupancy, flow, speed, and delay for various links in the roadway network (*All the data are available over the Internet*).
Key Findings:	CO_2 emissions can be lowered by improving traffic operations, specifically through the reduction of traffic congestion.
Relevant findings and comments:	CO_2 emissions could be reduced by up to almost 20% through three different strategies: • congestion mitigation strategies that ***reduce severe congestion***, allowing traffic to flow at better speeds; • speed management techniques that reduce excessively high free-flow speeds to more moderate conditions; • and shock wave suppression techniques that ***eliminate the acceleration and deceleration events associated with the stop-and-go traffic that exists during congested conditions***.

Title:	**Driver irritation and aggressive behaviour**
Published: **Author(s):**	Accident Analysis and Prevention (2008), Vol. 40, pp.1069–1077 Bjorklund, G.
Free/priced:	Priced: $39.00
Aim:	One aim of the present study was to apply the UK DAS to a Swedish sample of drivers. A second aim was to investigate to what extent different irritation-provoking situations lead to openly aggressive reactions as reported by the respondents. A third aim was to test models of drivers' irritation and aggressive behaviour according to the assumptions described above.
Methodology:	A sample of 98 drivers responded to a Swedish version of the UK Driving Anger Scale.
Key Findings:	The models suggested a positive relationship between the amount of driver irritation and frequency of aggressive actions for all three sources of irritation.
Relevant findings and comments:	Three sources of driver irritation: "***progress impeded***", "reckless driving", and "direct hostility".

Title:	**Determinants of following headway in congested traffic**
Published:	Transportation Research Part F (2009), Vol. 12, pp.131–142

Author(s):	Brackstone, M.; Waterson, B.; McDonald, M.
Free/priced:	Priced: $39.00
Aim:	The paper reports on results of a study undertaken in the UK aimed at investigating factors affecting the car following process.
Methodology:	The study used an instrumented vehicle to collect time dependent following data for a group of test drivers. Data were collected on two differing types of high speed road, using six primary subjects who drove a test vehicle, supplemented by data on 123 drivers that were observed following the test vehicle. Examination was made of how the time headway chosen by a driver is influenced by a range of situational variables commonly believed to affect behaviour, with four main findings.
Key Findings:	Firstly, headway was found to change according to the type of vehicle being followed (i.e. subjects followed closer to trucks than to cars), secondly, little variation was found with changes in overall traffic flow, thirdly, little correlation was found with road type, and lastly a distinct day-to-day variation in individual behaviour was observed.
Relevant findings and comments:	Headway was found to change according to the type of vehicle being followed (i.e. subjects followed closer to trucks than to cars).

Title:	**Car following decisions under three visibility conditions and two speeds tested with a driving simulator**
Published: **Author(s):**	Accident Analysis and Prevention (2007), Vol. 39, pp.106–116 Broughton, K.L.M.; Switzer, F.; Scott, D.
Free/priced:	Priced: $39.00
Aim:	The research aimed to reveal factors that govern car following under conditions of reduced visibility.
Methodology:	It employed a KQ-Vection high-fidelity driving simulator to measure the behaviour of automobile drivers following a lead vehicle at 13.4 m/s (30 MPH) or 22.4 m/s (50 MPH) under three visibility conditions—clear or one of two densities of simulated fog.
Key Findings:	At the higher speed, fog conditions separated participants into a group that stayed within visible range of the lead car, even though the headway time violated the NHTSA recommendations for the speed involved, and another group that lagged beyond the visible range.
Relevant findings and comments:	Car following behaviour and the decision-making habits of drivers seem fundamental to understanding how to avoid these rear-end crashes.

Title:	**Chapter 2. Modelling Vehicle Interactions and the Movement of Groups of Vehicles**
Published: **Author(s):**	Book: An Introduction to Traffic Flow Theory, 2014 Elefteriadou, L.
Free/priced:	Priced: £35.99
Aim:	The chapter examines these interactions between vehicles.
Methodology:	Book chapter
Key Findings:	Vehicle interactions can be defined in terms of three basic relationships: car-following, lane changing, and gap acceptance. • Car-following occurs when the speed of the lead vehicle affects the speed of the following vehicle; more aggressive car-following generally leads to higher (although not necessarily safer) overall speeds; • Lane changing generally involves the requirement or decision to change lanes, the selection of a target lane (when it is relevant), and the selection of a suitable gap; • Gap acceptance involves the selection of a suitable gap (usually defined as the time headway between the rear end of the lead vehicle and the front end of the following vehicle) to change lanes, or to cross a conflicting traffic stream, as in the case of a STOP-controlled approach.
Relevant findings and comments:	The size of the gap a driver would accept varies based on the amount of time a driver has already been waiting; the longer this interval is, the more likely that the driver would accept a shorter gap.

Title:	**How do time pressured drivers estimate speed and time?**
Published: **Author(s):**	Accident Analysis and Prevention (2013), Vol. 55, pp.211– 218 Coeugnet, S.; Miller, H.; Anceaux, F.; Naveteur, J.
Free/priced:	Priced: $39.00
Aim:	The purpose of the laboratory study was to investigate the influence of time pressure on the perception of speed and duration in driving situations.
Methodology:	Participants provided estimations of speed and performed both productions and reproductions of time durations, based on traffic films. The experimental films were made from a driver's point of view within a moving car, and audio-recorded instructions invited participants to imagine that they were driving while under time pressure or while relaxed.
Key Findings:	The results obtained using this within-participant design support the hypothesis that time pressure promotes fast driving and may induce an

	underestimation of speed and trip-related durations, the latter of which suggests that time pressure modulates time perception. Some of these effects were mediated by the emotional impact of time pressure. Links between time perception and speed were also observed.
Relevant findings and comments:	Time pressure promotes fast driving and may induce an underestimation of speed and trip-related durations.

Title:	**Effect of directional split and slow-moving vehicles on two-lane capacity**
Published: **Author(s):**	Road and Transport Research (2001), Vol. 10(4), pp.33-41 Chandra, S.; Sinha, S.
Free/priced:	Priced: $20.00 via http://amonline.trb.org
Aim:	Analyse the capacity of two-lane roads when the split moves from 50/50
Methodology:	Study
Key Findings:	The capacity of two-lane roads at even split is estimated at 2920 passenger car units per hour. The capacity of two-lane roads reduces when the split moves away from 50/50.
Relevant findings and comments:	The capacity of two-lane roads decreases as the proportion of slow-moving vehicles in the traffic stream increases.

Title:	**Development of a Driver Anger Scale**
Published: **Author(s):**	Psychological Reports (1994), Vol. 74, pp.83-91 Deffenbacher, J.L.; Oetting, E.R.; Lynch, R.S.
Free/priced:	Priced: $39.00
Aim:	The development of a driving anger scale
Methodology:	A cluster analysis of responses from more than 1,500 college students to 53 potentially angering driving-related situations.
Key Findings:	A 33-item driving anger scale (alpha reliability = .90) with six reliable subscales involving hostile gestures, illegal driving, police presence, ***slow driving***, discourtesy, and traffic obstructions. Subscales all correlated positively, suggesting a general dimension of driving anger as well as anger related to specific driving-related situations. A 14-item short form (alpha reliability = .SO) was developed from scores more highly correlated (r = .95) with scores on the long form.
Relevant findings and comments:	Men were more angered by police presence and ***slow driving*** whereas women were more angered by illegal behaviour and ***traffic obstructions***,

	but differences compensated so there were no gender differences on total score.

Title:	**The Driving Anger Expression Inventory: a measure of how people express their anger on the road**
Published: **Author(s):**	Behaviour Research and Therapy (2002), Vol. 40, pp.717–737 Deffenbacher, J.L.; Lynch, R.S.; Oetting, E.R.; Swain, R.C.
Free/priced:	Priced: $39.00
Aim:	The research undertook the development of a measure of expressing anger while driving, the Driving Anger Expression Inventory (DAX), and provides initial reliability, gender difference, and validity data on the DAX.
Methodology:	*Driving Anger Expression Inventory (DAX).* Sixty-two items reflecting ways people express their anger when driving, were developed from interviews with 23 university students, 14 faculty members, and 19 community members. They were asked to describe the ways in which they or others express their anger while driving. Common ways of expressing anger were abstracted, and the language was standardized (e.g., reference was always made to the 'other driver' rather than unique references interviewees made). Forms of expressing anger were then described in a simple sentence beginning in the first person singular (e.g., I try to cut in front of the other driver, or I glare at the other driver). Items were then randomly ordered in a questionnaire, with the instructions and rating scale described below. Items were rated on a 4-point scale (1=almost never, 4=almost always) according to how often the individual expresses his/her anger in the manner described.
Key Findings:	Four ways people express their anger when driving, were identified: • Verbal Aggressive Expression (α=0.88) assesses verbally aggressive expression of anger (e.g., yelling or cursing at another driver); • Personal Physical Aggressive Expression (α=0.81), the ways the person uses him/herself to express anger (e.g., trying to get out and tell off or have a physical fight with another driver); • Use of the Vehicle to Express Anger (α=0.86), the ways the person uses his/her vehicle to express anger (e.g., flashing lights at or cutting another driver off in anger); and • Adaptive/Constructive Expression (α=0.90), the ways the person copes positively with anger (e.g., focuses on safe driving or tries to relax). Aggressive forms can be summed into Total Aggressive Expression Index (α=0.90). Aggressive forms of expression correlated positively with each other (rs=0.39–0.48) but were uncorrelated or correlated negatively with adaptive/constructive expression (rs=-0.02 to -0.22). Aggressive forms of anger expression correlated positively with driving related anger,

	aggression, and risky behaviour; adaptive/constructive expression tended to correlate negatively with these variables.
Relevant findings and comments:	Use of the Vehicle to Express Anger (α=0.86) = the ways the person uses his/her vehicle to express anger (e.g., ***flashing lights at or cutting another driver off in anger***)

Title:	**Simulation of Mixed Traffic Flow on Two-Lane Roads**
Published: **Author(s):**	Journal of Transportation Engineering (2008), Vo. 134, pp.361-369 Dey, P.P: Chandra, S.; Gangopadhyay, S.
Free/priced:	Priced: $30.00
Aim:	To determine the capacity of a two-lane road and to study the effect of traffic mix on capacity and speed.
Methodology:	Data were collected at several locations of two-lane roads in different parts of India and were analysed to study the speed, placement, arrival, acceleration, and overtaking characteristics of different types of vehicles. A computer program is developed to simulate the traffic flow on a two-lane highway incorporating all these characteristics. The simulation program is coded in Visual Basic language and has also been animated.
Key Findings:	Capacity of a two-lane road under an all cars situation is estimated as 2,860 PCU/ h. It increases to 5,600 vehicles per hour (vph) in case of all two wheelers and reduces to 580 vph in case of an all tractors situation. The capacity also reduces as the directional split moves away from an even split of 50/50 and this reduction is linear. It is further observed that the capacity of a two-lane road decreases as the proportion of three-wheeler, tractor, or heavy vehicle increases in the traffic stream. But, in the case of two-wheelers the capacity was found to increase with their own proportion. This is attributed to the small size of two-wheelers and their manoeuvrability.
Relevant findings and comments:	It is observed that the capacity of a two-lane road decreases as the proportion of tractor or heavy vehicle increases in the traffic stream.

Title:	**Effect of Car/Truck Differential Speed Limits on Two-Lane Highways Safety Operation using Microscopic Simulation**
Published: **Author(s):**	Procedia - Social and Behavioural Sciences (2012), Vol. 53, pp.834 – 841 Ghods, A.H.; Saccomanno, F.; Guido, G.
Free/priced:	Free
Aim:	Research the safety implications of car-truck speed limits for two-lane highways.

Methodology:	Two different types of speed control strategies are considered: Uniform and Differential. Safety implications are considered using three overtaking-related indicators: • Number of vehicles overtaking; • Percentage of time spent in "desire to overtake mode"; and • Average Time-to-Collision with the on-coming vehicle prior to returning to the original lane. Vehicle interactions affecting safety are estimated through the application of a calibrated microscopic traffic simulation model to a 6Km straight segment of two-lane highway.
Key Findings:	On two-lane highways speed controls can have a significant effect on vehicles interactions. Although differential speed strategies (DSL and MSL) were observed to have a minimal increase in the total number of overtake manoeuvres in comparison to a uniform strategy (USL), the effect on the nature of the overtakes i.e. car-car versus ***car-truck*** was significant. Differential speed strategies increased the number and rate of car-truck overtakes over the range of volumes considered in this analysis.
Relevant findings and comments:	Differential speed strategies increased the number and rate of car-truck overtakes.

Title:	**The impacts of congestion on time-definitive urban freight distribution networks CO2 emission levels: Results from a case study in Portland, Oregon**
Published: **Author(s):**	Transportation Research Part C (2011), Vol. 19, pp.766–778 Figliozzi, M.A.
Free/priced:	Priced: $39.00
Aim:	The research focuses on the analysis of CO_2 emissions for different levels of congestion and time-definitive customer demands.
Methodology:	Travel time data from an extensive archive of freeway sensors, time-dependent vehicle routing algorithms, and problems-instances with different types of binding constraints are used to analyse the impacts of congestion on commercial vehicle emissions.
Key Findings:	Increased congestion during peak morning and afternoon periods in urban areas is increasing logistics costs. In addition, environmental, social, and political pressures to limit the impacts associated with CO_2 emissions are mounting rapidly.
Relevant findings and comments:	The impacts of congestion or speed limits on commercial vehicle emissions are significant but difficult to predict since it is shown that it is possible to

	construct instances where total route distance or duration increases but emissions decrease. ***Comment:*** that is for the commercial vehicles. What about the other affected cars (private passenger cars)?

Title:	**Safety Impacts of Differential Speed Limits for Trucks and Passenger Cars on Rural Interstate Highways: A Modified Empirical Bayes Approach**
Published: **Author(s):**	Journal of Transportation Engineering (2006), Vo. 132, pp.19-29 Garber, N. J.; Miller, J.S.; Sun, X.; Yuan, B.
Free/priced:	Priced: $30.00
Aim:	To compare the safety effects of a uniform speed limit (USL) for all vehicles as opposed to a differential speed limit (DSL) for cars and heavy trucks.
Methodology:	Detailed crash data for six states were obtained for rural interstate highways for the period 1991–2000. The states were categorized into four policy groups based on the speed limit type employed during that decade: maintenance of a uniform limit, maintenance of a differential limit, a change from a uniform to a differential limit, and a change from a differential to a uniform limit. A modified empirical Bayes framework was used to evaluate crash frequency changes without presuming a constant relationship between crashes and traffic volume.
Key Findings:	Aggregate results showed no consistent safety effects of DSL as opposed to USL. The reason for this finding is that within each state, the modified empirical Bayes methodology suggested that crash risk increased regardless of speed limit policy.
Relevant findings and comments:	The study found the crash frequency increasing regardless of whether a state changed from DSL to USL, changed from USL to DSL, maintained USL, or maintained DSL, leading one to conclude that speed limit policy has no consistent impact on safety.

Title:	**Perceptual Processes Used by Drivers During Overtaking in a Driving Simulator**
Published: **Author(s):**	Human Factors (2005), Vol. 47(2), pp.394-417 Gray, R.; Regan, D.M.
Free/priced:	Priced: $36.00
Aim:	The study investigated the control strategies and decision making of drivers who were executing overtaking manoeuvres in a fixed-base driving simulator.

Methodology:	Observation
Key Findings:	Drivers were frequently inaccurate in deciding whether it was safe to overtake in front of an oncoming vehicle. One source of error in this situation was the control strategy adopted by the driver; in several instances drivers initiated an overtaking manoeuvre when the oncoming car's distance was above a critical value, even though there was not sufficient time to complete a safe manoeuvre. Adaptation to closing speed (produced by driving on a straight open road) also had large effects on overtaking behaviour. For all participants, closing speed adaptation resulted in decisions that were delayed, of higher risk, and more variable.
Relevant findings and comments:	Drivers were frequently inaccurate in deciding whether it was safe to overtake in front of an oncoming vehicle. ***Comment***: It's human error, not a fault or something to blame

Title:	**The stress of driving: a diary study**
Published: **Author(s):**	Work and Stress (1990), Vol. 4, pp.7-16 Gulian, E.; Glendon, A.I.; Matthews, G.; Davies, D.R.; Debney, L.M.
Free/priced:	Priced: £30.00
Aim:	A study of daily behaviours and feelings while driving.
Methodology:	A sample of drivers were asked to ascertain driving stress levels and changes in these as a function of time of day and day of the week in a specially designed diary/checklist.
Key Findings:	Drivers experience more stress in the evening than in the morning, and in mid-week than either at the beginning or end of the week. Daily driving stress varies with age and experience as well as with health condition and sleep quality. It is also related to driving conditions and depends upon people's overall perception of driving as a stressful activity.
Relevant findings and comments:	Driving stress is related to driving conditions. Comment: Stress alters driving (and not only) abilities and capabilities, through determination of feeling and actions such as anxiety, fear, lack of reaction, delayed responses etc.

Title:	**When norms turn perverse: Contextual irrationality vs. rational traffic violations**
Published: **Author(s):**	Transportation Research Part F (2012), Vol.15, pp.144–151 Havarneanu, G.M.; Havarneanu, C.E.
Free/priced:	Priced: $39.00

Aim:	This study examined traffic rule obedience in situations in which the rule was not in accordance with real safety needs.
Methodology:	Six rules with major impact on road safety were analysed: waiting at red traffic lights, legal overtaking, obeying the 50 km/h speed limit, wearing seatbelts, legal stopping/parking, and driving the car in good technical condition. Participants evaluated how adequate these rules are for safety. Then they were faced with six scenarios, that made each of these rules appear irrational, and were asked to report their potential engagement in deviant behaviour. The survey data were collected in a sample of 605 drivers.
Key Findings:	Multiple regression analyses showed that in most situations rule violation depended on the usual deviant behaviour, perceived irrationality of the rule, little respect for the law and low risk perception. These factors best explained the 50 km/h speed limit violation. The results suggest that the lack of situational risk factors, which makes the rule look meaningless, is an important determinant of rule violation. Implications for massive disobedience and road safety are discussed.
Relevant findings and comments:	A perfectly adequate traffic rule can turn ‘‘perverse’’ in situations when it ***does little to enhance road safety but seems*** – at least in the drivers' minds – ***directed primarily at punishing those who violate it***. Rule violation depended on the usual deviant behaviour, ***perceived irrationality of the rule***, little respect for the law and ***low risk perception***.

Title:	**The relationship between traffic congestion, driver stress and direct versus indirect coping behaviours**
Published: **Author(s):**	Ergonomics (1997), Vol. 40(3), pp.348-361 Hennessy, D.A; Wiesenthal, D.L.
Free/priced:	Priced: £35.00
Aim:	To measure driver stress in different traffic conditions
Methodology:	Drivers experiencing rush hour congestion were interviewed using cellular telephones to study stress and coping responses. Measures were taken of each driver' s predisposition to stress (trait stress) as well as their reactions to the experience of either low or high traffic congestion (state stress). Two interviews were conducted during the trip when drivers experienced both low and high congestion conditions.
Key Findings:	Although state stress was greatest for all drivers experiencing the high congestion condition, a trait X situation interaction was obtained, indicating that stress levels were highest for high trait stress drivers experiencing the congested roadway. In terms of trait coping behaviours, participants indicated a preference for direct over indirect behaviours. A greater variety of direct and indirect behaviours were reported in high

	congestion. Reports of aggressive behaviours showed the greatest increase from low to high congestion.
Relevant findings and comments:	Reports of ***aggressive behaviours*** showed the greatest ***increase from low to high congestion***.

Title:	**Traffic Congestion, Driver Stress, and Driver Aggression**
Published: **Author(s):**	Aggressive Behaviour (1999), Vol. 25, pp.409-423 Hennessy, D.A; Wiesenthal, D.L.
Free/priced:	Priced: £35.00
Aim:	To determine predictors of state driver stress
Methodology:	Drivers were interviewed over cellular telephones in high- and low-congestion conditions during a single commute. During each interview, state measures of driver stress and driver behaviours were obtained. Behaviour responses were subdivided into six categories: aggressive, information seeking, planning, minor self-destructive, distraction, and relaxation techniques.
Key Findings:	Both state driver stress and aggression were greater in high than in low-congestion conditions. No other behaviour category differed between low and high congestion. Multiple regressions were calculated to determine the predictors of state driver stress. In low congestion, time urgency predicted state driver stress, while aggression predicted driver stress in high congestion. In both conditions, a trait susceptibility toward viewing driving as generally stressful was predictive of state driver stress levels, which further strengthens the use of the Driving Behaviour Inventory—General as a predictor of "trait" driver stress. Females and males did not differentiate on state stress or any behaviour category.
Relevant findings and comments:	In low congestion, time urgency predicted state driver stress, while ***aggression predicted driver stress in high congestion***.

Title:	**The Influence of Traffic Congestion, Daily Hassles, and Trait Stress Susceptibility on State Driver Stress: An Interactive Perspective**
Published: **Author(s):**	Journal of Applied Biobehavioural Research (2000), Vol. 5(2), pp.162-179 Hennessy, D.A; Wiesenthal, D.L.; Kohn, P.M.
Free/priced:	Priced: $39.00
Aim:	To determine the influence of traffic congestion, daily hassles and trait stress susceptibility on state driver stress

Methodology:	State driver stress was measured in both low and high traffic congestion using cellular telephones. The contributions of time urgency, trait driver stress. and hassles were also examined.
Key Findings:	Drivers showed substantially more state driver stress under high than low congestion. Time urgency made a significant positive contribution to state driver stress at both congestion levels. Trait driver stress also contributed positively under low congestion. There was a significant hassles X trait stress interaction under high congestion. Hassles exposure moderately increased state driver stress for high trait stress drivers, but reduced state driver stress for medium and low trait stress drivers. These findings indicate that state driver stress is influenced by a combination of situational and personal factors, including factors external to the driving context.
Relevant findings and comments:	Time urgency made a significant positive contribution to state driver stress at both congestion levels. State driver stress is influenced by a combination of situational and personal factors, including factors external to the driving context.

Title:	**Impact and Strategies for Slow Moving Vehicles: Case Study of Azadpur Mandi, Delhi**
Published: **Author(s):**	International Research Journal of Engineering and Technology - IRJET (2018), Vol. 5(1), pp.542-547 Singh, Y.P.
Free/priced:	Free
Aim:	The paper attempts to review the current practices and minimize the congestion due to SMV's through traffic-regulation techniques, street vendors policies and parking management.
Methodology:	Case study – Azadpur Mandi. India
Key Findings:	India is developing with rapid urbanization over the last few decades. With the passage of time urbanization leads to the high utilization of goods and services developing centres for trade and commerce and influencing economic growth. Marketing of goods and services is possible with an effective transport network maintaining a customer buyer relationship. Slow moving vehicles (SMV) are one of the crucial factors responsible for the traffic problems and congestion affecting a transport network. The research paper experiments to examine the impact of SMV's in informal sectors. The current practices in different urban centres include traffic-regulation and increasing number of parking area. The paper attempts to review the current practices and minimize the congestion due to SMVs through traffic-regulation techniques, street vendors policies and parking management.

Relevant findings and comments:	Slow moving vehicles (SMV) are one of the crucial factors responsible for traffic problems and congestion affecting the transport network.

Title:	**Passing Bays for Slow Moving Vehicles on Rural Two-lane Roads**
Published: **Author(s):**	Transport Reviews: A Transnational Transdisciplinary Journal (2006), Vol. 25(4), pp.491-509 Jaarsma, C.F.; Botma, H.; Beunen, R.
Free/priced:	Priced: £30.00
Aim:	The paper investigates the impacts of a passing bay on the total delay for other motorized vehicles, the number of passing manoeuvres and hindered vehicles, and the mean delay per hindered vehicle. The latter is also considered to be an indicator for traffic safety.
Methodology:	Conceptual model
Key Findings:	The passing bay is an effective solution to reducing delays on arterial highways when two-way hourly volumes exceed 600–1000 vehicles. The effects depend on the trip length and speed of the slow-moving vehicle, and on the passing sight distance limitations of the road. A distance of 2–4 km between the passing bays seems an acceptable compromise between the reduction of delay for other motorized vehicles and the extra discomfort and delay for drivers of slow-moving vehicles. This result also shows that passing bays are not effective in regions where slow-moving vehicles mainly make trips shorter than this distance.
Relevant findings and comments:	Slow-moving vehicles, including agricultural vehicles, on arterial highways can cause serious delays to other traffic as well as posing an extra safety risk.

Title:	**When emotions disturb the localization of road elements: Effects of anger and sadness**
Published: **Author(s):**	Transportation Research Part F (2014), Vol. 23, pp.125–132 Jallais, C.; Gabaude, C.; Paire-ficout, L.
Free/priced:	Free
Aim:	To study the interference of negative emotions with the information processing and the management of attentional resources while driving.
Methodology:	The research compared two negative emotions according to the arousal dimension (exciting versus calming) rather than according to the hedonic value. Three mood states (anger, sadness and neutral) have been induced to reveal their effects on the localization of road elements. The research used a modified version of the jumble scenes paradigm to provide

	evidence for the existence of driving-related schemata which appeared to be guiding visual search.
Key Findings:	The results reported here revealed that the three groups take more or less advantage of the use of their visual schemata to localize road elements. Sadness increased the localization error rate. Participants induced in anger, were slower to locate road elements than participants induced in sadness and in neutral mood. These results are congruent with the fact that drivers exposed to anger could be slower to detect atypical hazards. Future studies should go deeper in the understanding of how emotional states regulate attentional capacities.
Relevant findings and comments:	Participants induced in anger, were slower to locate road elements than participants induced in sadness and in neutral mood. Drivers exposed to anger could be slower to detect atypical hazards.

Title:	**Effects of specific emotions on subjective judgment, driving performance, and perceived workload**
Published: **Author(s):**	Transportation Research Part F (2014), Vol. 24, pp.197–209 Jeon, M.; Walker, B.N.; Yim, J-B.
Free/priced:	Priced: $39.00
Aim:	The aim of this paper was to explore effects of specific emotions on subjective judgment, driving performance, and perceived workload.
Methodology:	To identify more specific affective effects, seventy undergraduate participants drove in a vehicle simulator under three different road conditions, with one of the following induced affective states: anger, fear, happiness, or neutral. Researchers measured their subjective judgment of driving confidence, risk perception, and safety level after affect induction; four types of driving errors: Lane Keeping, Traffic Rules, Aggressive Driving, and Collision while driving; and the electronic NASA-TLX after driving.
Key Findings:	Induced anger clearly showed negative effects on subjective safety levels and led to degraded driving performance compared to neutral and fear. Happiness also showed degraded driving performance compared to neutral and fear. Fear did not have any significant effect on subjective judgment, driving performance, or perceived workload. Results suggest that we may need to take emotions and affect into account to construct a naturalistic and generic driving behaviour model. To this end, a specific-affect approach is needed, beyond the sheer valence and arousal dimensions. Given that workload results are similar across affective states, examining affective effects may also require a different approach than just the perceived workload framework.

Relevant findings and comments:	Anger clearly showed negative effects on subjective safety level and led to degraded driving performance compared to neutral and fear.

Title:	**An experimental study of factors associated with driver frustration and overtaking intentions**
Published: **Author(s):**	Accident Analysis and Prevention (2015), Vol. 79, pp.221–230 Kinnear, N.; Helman, S.; Wallbank, C.; Grayson, G.
Free/priced:	Priced: $39.00
Aim:	This study examined directly the impact of various factors associated with driving on ‘A-class’ roads in the United Kingdom (specifically length of platoon, proportion of heavy goods vehicles (HGVs), speed and opportunities for overtaking) on self-reported frustration and overtaking intentions. The impact of situational variables (being under time pressure, and time behind a slower moving platoon) were also examined, as was the association between frustration and self-reported overtaking intentions.
Methodology:	183 members of the public from the areas around Perth and Inverness, Scotland took part in the study. Participants viewed simulated ‘driver’s viewpoint’ clips representing all the combinations of the experimental variables (except time pressure, which was a between-groups variable, and time behind platoon, which was examined separately in four specific clips). After each clip, participants responded on a paper questionnaire as to the level of frustration they would feel for a given clip, and the likelihood that at some point during the clip they would have attempted an overtake manoeuvre.
Key Findings:	The findings show that the links between traffic variables such as speed and platoon length, and behaviourally-relevant variables such as frustration and overtaking intentions, are not simple. Although there are broad and predictable effects of speed and platoon length (lower speeds and longer platoons leading to greater frustration) these are mediated by other variables, and it is not always the case that more frustration leads to more intention to overtake. Analysis of driver attitudes identified three clusters (low, medium and high-risk drivers) and suggests that higher risk drivers’ levels of frustration are more affected by situational changes than those of lower risk drivers.
Relevant findings and comments:	Although there are broad and predictable effects of speed and platoon length (lower speeds and longer platoons leading to greater frustration) these are mediated by other variables, and it is not always the case that more frustration leads to more intention to overtake.

Title:	**Passing Opportunities at Slow-Vehicle Bays**
Published: **Author(s):**	Journal of Transportation Engineering (2007), Vol. 133, pp.129-137 Koorey, G.
Free/priced:	Free
Aim:	The paper focuses on studies of the performance of slow-vehicle bays (SVBs), also known as "turnouts."
Methodology:	Field surveys at eight sites identified the effect of different features on SVB usage and on reduction in following.
Key Findings:	Higher levels of SVB use than reported overseas were observed; however, this use appears to be very dependent on the location and design of each site. The SVBs' effects on vehicle following was generally not substantial, although the short-term benefits probably reduce driver frustration.
Relevant findings and comments:	The SVBs' effects on vehicle following was generally not substantial, although the short-term benefits probably reduce driver frustration.

Title:	**Evaluation of the public health impacts of traffic congestion: a health risk assessment**
Published: **Author(s):**	Environmental Health (2001), Vol. 9(65), pp.1-12 Levy, J.I.; Buonocore, J.J.; Von Stackelberg, K.
Free/priced:	Free
Aim:	To quantify or to determine how these impacts compare in magnitude to the economic costs.
Methodology:	The study evaluated 83 individual urban areas using traffic demand models to estimate the degree of congestion in each area from 2000 to 2030. The research linked traffic volume and speed data with the MOBILE6 model to characterize emissions of PM2.5 and particle precursors attributable to congestion and used a source-receptor matrix to evaluate the impact of these emissions on ambient PM2.5 concentrations. Marginal concentration changes were related to a concentration response function for mortality, with a value of statistical life approach used to monetize the impacts.
Key Findings:	Across cities and years, the public health impacts range from more than an order of magnitude less to in excess of the economic impacts.
Relevant findings and comments:	The analyses indicate that the public health impacts of congestion may be significant enough in magnitude, at least in some urban areas, to be considered in future evaluations of the benefits of policies to mitigate congestion.

Title:	**Jamming transitions induced by a slow vehicle in traffic flow on a multi-lane highway**
Published: **Author(s):**	Journal of Statistical Mechanics (2009), PO4002, pp.1-17 Masukura, S.; Nagatani, T.; Tanaka, K.
Free/priced:	Free
Aim:	To study the current–density diagram for when a slow vehicle is introduced in multi-lane traffic flow. The study extended the conventional optimal velocity model to the multi-lane traffic by taking into account the lane changing.
Methodology:	Experiment – phase diagrams
Key Findings:	The dynamical state of the traffic changes with increasing density. The dynamical phase transitions occur at certain densities. The dependence of the current on the velocity of a slow vehicle is derived numerically and analytically.
Relevant findings and comments:	Slow vehicles induce traffic jams on multi-lane highways.

Title:	**The paradox of driving speed: two adverse effects on highway accident rate**
Published: **Author(s):**	Accident Analysis and Prevention (2003), Vol. 35, pp.361–367 Navon, D.
Free/priced:	Priced: $39.00
Aim:	To analyse the relationship between average speed or speed limits, and accident-prone interactions (APIs)
Methodology:	Simulation
Key Findings:	It is suggested here that the seeming puzzle actually may have a straightforward explanation: accident–prone interactions (APIs) between cars occur when they pass each other—mostly moving in the same directions or in opposite ones. Such interactions are shown here to happen more frequently, the lower average speed is. To the extent that high speed limits contribute to increase in average speed, they serve to reduce the number of such interactions, thereby to moderate at least part of the negative effect of speed on the driver's ability to avoid an impending accident.
Relevant findings and comments:	High speed limits serve to reduce the number of accident-prone interactions (APIs)

Title:	**Safety Impacts and Other Implications of Raised Speed Limits on High-Speed Roads**
Published: **Author(s):**	National Cooperative Highway Research Program (2006) Kockelman, K.
Free/priced:	Free
Aim:	The report describes the analyses performed and results obtained by a study of safety and other impacts of speed limit changes on high-speed roads.
Methodology:	Safety-related analyses were based on a comprehensive framework of the disaggregate relationships between speed limits, driver speed choices, crash occurrence and crash severity. Using a variety of datasets, the project conducted numerous statistical analyses to elucidate and quantify these relationships.
Key Findings:	It was found that a speed limit increase on a high-speed road is generally associated with a less-than-equivalent increase in average vehicle speed: a 10 mph speed limit increase, for example, corresponds to average speeds around 3 mph higher. The project identified a relatively small but statistically significant correspondence between speed limits and total crash rates: a speed limit increase from 55 to 65 mph on an "average" high-speed road section would be associated with a crash rate increase of around 3%. Finally, the project found a statistically significant association between speed limits and the distribution of injury severities following a crash. The higher speeds resulting from a speed limit increase lead to travel time savings that have an economic value. The vehicles most likely to experience such savings are those making long distance trips primarily in rural areas, where vehicle speeds are not significantly constrained by congestion.
Relevant findings and comments:	The higher speeds resulting from a speed limit increase lead to travel time savings that have an economic value. The vehicles most likely to experience such savings are those making long distance trips primarily in rural areas, where vehicle speeds are not significantly constrained by congestion.

Title:	**Transportation, Stress, and Community Psychology**
Published: **Author(s):**	American Journal of Community Psychology (1979), Vol. 7(4), pp.361-380 Novaco, R.W.; Stokols, D.; Campbell, J.; Stokols, J.
Free/priced:	Priced: £35.94

Aim:	Conditions of transportation were investigated as sources of psychological stress as they affect the physiology, task performance, and mood of commuters.
Methodology:	Participants in the study were 100 employees of industrial firms. Traffic congestion was construed as a behavioural constraint in terms of the concept of impedance which is defined by the parameters of distance and time. It was expected that the effects of impedance would be mediated by personality factors, such as locus of control.
Key Findings:	Multivariate tests of the internal validity of the impedance factor was significant. However, significant main effects for impedance were obtained only for mood and residential adaptation. The predicted interactions of impedance with locus of control were obtained across task performance indices. In multiple regression analyses, the distance and speed of the commute to work were found to account for significant proportions of variation in blood pressure, while several indices of personal control had significant regression effects on the task measures.
Relevant findings and comments:	In multiple regression analyses, the distance and speed of the commute to work were found to account for significant proportions of variation in blood pressure.

Title:	**Modelling Slow Lead Vehicle Lane Changing**
Published: **Author(s):**	Virginia Polytechnic Institute and State University (2003) Olsen, E.C.B.
Free/priced:	Free
Aim:	Driving field experiment data were used to investigate lane changes in which a slow lead vehicle was present to: 1) characterize lane changes, 2) develop predictive models, and 3) provide collision avoidance system (CAS) design guidelines.
Methodology:	A total of 3,227 slow lead vehicle lane changes over 23,949 miles were completed by sixteen commuters. Two instrumented vehicles, a sedan and an SUV, were outfitted with video, sensor, and radar data systems that collected data in an unobtrusive manner.
Key Findings:	Results indicate that 37.2% of lane changes are slow lead vehicle lane changes, with a mean completion time of 6.3 s; most slow lead vehicle lane changes are leftward, rated low in urgency and severity. Turn signals are used 64% of the time but some drivers signal after the lane change starts. Of cases in which signals are not used, 70% of them are made with other vehicles nearby. Eyeglance analysis revealed that the forward view, rear-view mirror, and left mirror are the most likely glance locations.

Relevant findings and comments:	Results indicate that 37.2% of lane changes are slow lead vehicle lane changes, with a mean completion time of 6.3 s.

Title:	**Annoyance from road traffic noise: A review**
Published: **Author(s):**	Journal of Environmental Psychology (2001), Vol. 21, pp.101-120 Ouis. D.;
Free/priced:	Priced: $39.00
Aim:	The negative effects resulting from exposure to road traffic noise on people's wellbeing is reviewed in the light of the latest published findings.
Methodology:	Review
Key Findings:	In general terms, it is found from the present review that the continuous exposure of people to road traffic noise leads to suffering from various kinds of discomfort, thus reducing appreciably the number of their well-being elements. The results of several decades of research on this topic have permitted lately the establishment of a more or less quantitative relationship between the objective quantities characterizing road traffic noise and the human subjective reaction to it as expressed by annoyance.
Relevant findings and comments:	Exposure of people to road traffic noise leads to suffering from various kinds of discomfort.

Title:	**Anger and aggression among drivers in three European countries**
Published: **Author(s):**	Accident Analysis and Prevention (2002), Vol.34, pp.229–235 Parker, D.; Lajunen, T.; Summala, H.
Free/priced:	Priced: $39.00
Aim:	The study had three main aims: (a) to discover how angry, if at all, a range of situations on the road make drivers, (b) to find out how many drivers are likely to react aggressively to those situations, and (c) to investigate individual and/or cultural differences in terms of anger and/or aggressive responses among motorists.
Methodology:	A postal questionnaire survey of more than 2500 drivers was carried out in three European countries: Britain, Finland and the Netherlands.
Key Findings:	Results indicate that the same types of behaviour provoke anger and aggression in all three countries, and that traffic density may play a role.
Relevant findings and comments:	Items related (among others) to driver anger: • Someone is driving too slowly in the outside lane, and holding up the traffic;

	• Someone is driving more slowly than is reasonable for the traffic flow.

Title:	**Speeding and the time-saving bias: How drivers' estimations of time saved in higher speed affects their choice of speed**
Published: **Author(s):**	Accident Analysis and Prevention (2010), Vol. 42, pp.1978–1982 Peer, E.
Free/priced:	Priced: $39.00
Aim:	The study examined the effect the time-saving bias may have on drivers' choice of speed using hypothetical situations.
Methodology:	Drivers were presented with a situation involving acceleration from a relatively low speed in order to arrive at a destination on time and were asked to estimate the time that could be saved by increasing to higher speeds. Drivers also estimated the speed required for arriving on time, the speed they would personally choose and the speed they believed other drivers would opt for in such a situation.
Key Findings:	Results showed that drivers indeed underestimated the time that could be saved by increasing from a low speed. In addition, drivers who showed a high time-saving bias (above median) indicated notably higher speeds in all three categories above and their indicated speeds exceeded the speed limit more frequently. The findings suggest that the time-saving bias may help explain why drivers, in some situations, prefer an overly high speed and violate the legal speed limit.
Relevant findings and comments:	Drivers overestimate the time saved when increasing from an already relatively high speed and underestimate the time saved when increasing from a relatively low speed. Time-saving bias may help explain why drivers, in some situations, prefer an overly high speed and violate the legal speed limit.

Title:	**Exploring the Relationship Between Average Speed, Speed Variation, and Accident Rates Using Spatial Statistical Models and GIS**
Published: **Author(s):**	Journal of Transportation Safety & Security (2013), Vol. 5, pp.27–45 Quddus, M.
Free/priced:	Priced: £35.00
Aim:	The primary objective of the article is to contribute to the debate on the relationship between average speeds, speed variations, and accident rates.

Methodology:	The objective is achieved by the use of two advanced statistical models: (1) a non-spatial random-effects negative binomial model and (2) a spatial Poisson-lognormal model using a full hierarchical Bayesian model to explore the relationship. Disaggregated segment-based traffic, road geometry, and accident data from 266 road segments including 13 different motorways (including the M25 motorway) and 17 different trunk A-class roads around London from 2003 to 2007 are used in the analysis. GIS tools are used to achieve the appropriate data and to derive the weight matrix among neighbouring segments that is necessary for the spatial model.
Key Findings:	The results suggest that average speeds are not associated with accident rates when controlling for other factors affecting accidents such as traffic volume, road geometry (e.g., grade and curvature), and number of lanes. However, speed variation is found to be statistically and positively associated with accident rates. A 1% increase in speed variation is associated with a 0.3% increase in accident rates, ceteris paribus (all other things being equal).
Relevant findings and comments:	***Speed variation*** is found to be ***statistically and positively associated with accident rates***. A 1% increase in speed variation is associated with a 0.3% increase in accident rates, ceteris paribus (all other things being equal).

Title:	**Close-following drivers on two-lane highways**
Published: **Author(s):**	Accident Analysis and Prevention (1997), Vol. 29(6), pp.723–729 Rajalin, S.; Hassel, S-O.; Summala, H.
Free/priced:	Priced: $39.00
Aim:	This study was intended first to replicate, on two-lane highways, the Evans and Wasielewski (Accident Analysis & Prevention 14, 57-64, 1982; 15, 121-136, 1983) results on the connection between close-following driving and traffic offenses and, second, to reveal reasons for close-following.
Methodology:	A sample of close-following drivers (N= 157) and control drivers (N= 178) was picked from the flow on two-lane main highways.
Key Findings:	The driver records of the past 3 years showed retrospectively that the close-followers had accumulated 2.3 times more traffic offenses than had the control drivers and 2.0 times more when mileage was taken into account. The result is in agreement with the Evans and Wasielewski results for multi-lane highways, with the additional check for mileage in these data. However, the effect only occurred in males and was more marked in young males. Close-following females even indicated a tendency of having fewer offenses than their controls when their higher mileage was taken into account. Another sample of close-followers interviewed on the road revealed that hurry or desire to overtake the car ahead was the justification for the close-following in the majority of cases. It was

	suggested that on two-lane highways close-following substantially stems from overtaking needs and manoeuvring connected to higher target speeds. This study partly confirms the connection between close-following and an increased number of offenses in comparisons between drivers.
Relevant findings and comments:	Hurry or desire to overtake the car ahead was the justification for the close-following in the majority of cases.

Title:	**Risk taking - Close Following Behaviour**
Published: **Author(s):**	Safety Cube DSS - European Road Safety Decision Support System (2016) Aigner-Breuss, E.; Russwurm, K.
Free/priced:	Free
Aim:	Summarise the research on the risk of the close following behaviour
Methodology:	Review of research
Key Findings:	The close following situation is a complex process and varies according to local conditions and hence, is challenging to investigate. Studies are rare that quantify the effect of close following on road safety in terms of crash risk. Most identified studies focused on the influence of several driving characteristics and situational factors on headway choice. Among the identified studies, one naturalistic driving study shows an increased crash risk for following too closely. Concerning driving characteristics, age and personality seem to have an effect on close following behaviour. Drivers who once showed a risky driving behaviour tend to have more traffic offences in the past and differed significantly from non-risky drivers in their further police records. In addition, it was found that teens had a higher rate of following too closely than other drivers. Among the situational factors there is an indication that weather, especially fog, provokes some groups of drivers into risky behaviour of following too closely to be safe. As well, roadworks seem to decrease headway distances after the roadworks.
Relevant findings and comments:	Following situations occur, when a driver arrives behind a vehicle at a lower speed and needs to react to this situation. In low traffic flow there might be sufficient opportunity for overtaking and maintaining the speed. If traffic flow is high, there might be reasons to follow but there might be an impact on the motivation and willingness to take risks.

Title:	Risk Taking - Overtaking
Published: Author(s):	Safety Cube DSS - European Road Safety Decision Support System (2016) Soteropoulos, A.
Free/priced:	Free
Aim:	Summarise the research on the risk of the close following behaviour
Methodology:	Review of research
Key Findings:	Regarding the effects of (risky) overtaking on road safety, it appears that compared to other vehicle manoeuvres, overtaking significantly increases accident severity. However, regarding accident frequency, although it was associated with a higher crash risk in one study, it seems that only a small share of crashes occurs while overtaking another vehicle. Studies which instead investigate the relationship between different situational factors in an overtaking task, or driver characteristics and parameters which indicate effects regarding risky overtaking, showed that in particular age is significantly (negatively) associated with risky overtaking, meaning that younger drivers tend to be more likely to engage in risky overtaking manoeuvres than older drivers. In addition, it seems that other situational factors such as traffic volume and speed as well as other driver characteristics like gender also seem to influence the frequency of risky overtaking.
Relevant findings and comments:	Situational factors for close following: traffic volume, traffic scenery or speed related factors appear to influence the frequency of risky overtaking.

Title:	Speed, Speed Dispersion, and the Highway Fatality Rate
Published: Author(s):	Southern Economic Journal (1990), Vol. 57(2), pp. 349-356 Rodriguez, J.R.
Free/priced:	Priced: $14.00
Aim:	Compare the “speed kills” and the “variance kills, not speed” paradigms.
Methodology:	The paper developed and tested a model of the highway fatality rate, based on the assumption that the probability that an individual driver suffers a fatal accident increases with speed.
Key Findings:	Empirical tests using data from 1981-85 generally confirm the negative connection between the average speed and the fatality rate, even after correcting for collinearity. The research also found a positive and significant relationship between the variance of the speed distribution and the fatality rate.

Relevant findings and comments:	The research also found a positive and significant relationship between the variance of the speed distribution and the fatality rate.

Title:	**Emotional states of drivers and the impact on speed, acceleration and traffic violations—A simulator study**
Published: **Author(s):**	Accident Analysis and Prevention (2014), Vol. 70, pp.282–292 Roidl, E.; Frehse, B.; Hoger, R.
Free/priced:	Priced: $39.00
Aim:	The present study has pursued two different goals: first, the emotion-eliciting potential of various situational factors as well as personal characteristics were tested. A second aim was to evaluate the impact of emotions of anger and anxiety on driving behaviour in the simulator.
Methodology:	In a simulator study, seventy-nine participants took part in four traffic situations which each elicited a different emotion. Each situation had ***critical elements*** (e.g. ***slow car***, obstacle on the street) based on combinations of the appraisal factors. Driving parameters such as velocity, acceleration, and speeding, together with the experienced emotions, were recorded.
Key Findings:	The study definitely shows that anger, anxiety and fright had significant influence on several aspects of driving performance in various simulated traffic situations. Results indicate that anger leads to stronger acceleration and higher speeds even for 2 km beyond the emotion-eliciting event. Anxiety and contempt yielded similar but weaker effects yet showed the same negative and dangerous driving pattern as anger. Fright correlated with stronger braking momentum and lower speeds directly after the critical event.
Relevant findings and comments:	The fact that the participant had to wait (regardless of length of time) was sufficient to elicit measurable anger levels. The experience of anger in arrival and safety related goals could be explained as due to near accidents caused by another driver eliciting an anger reaction.

Title:	**Safe speeds and credible speed limits (SACREDSPEED): A new vision for decision making on speed management**
Published: **Author(s):**	SWOV Institute for Road Safety Research (2008) Aarts, L.; Van Nes, N.; Wegman, F.; Van Schagen, I.; Louwerse, R.
Free/priced:	Free
Aim:	Decision support instrument

Methodology:	Relevant knowledge has been worked out into an algorithm to be used in practice by decision makers to assist them in speed management for their roads. The developed algorithms serve as an input for the programming of a software tool, to make knowledge easily accessible and a support in a more integral decision-making process.
Key Findings:	The SaCredSpeed algorithm uses data about the road design and road image, traffic characteristics and behavioural data (if available) to assess the safety and credibility of a road traffic situation. The algorithm makes use of scientific knowledge as much as possible. It offers the opportunity to make this knowledge and complex interacting factors available to decision makers and make it easy to understand and apply due to a transparent decision support instrument.
Relevant findings and comments:	When operation speed is generally higher than the posted and/or safe speed limit, there is a speeding issue. One reason for speeding could be because the speed limit is not perceived as credible. A speed limit is credible when the limit in force conforms to what the road user considers to be reasonable for that particular road section. Drivers tend to better comply with speed limits when they are more credible.

Title:	**Big Data applications in real-time traffic operation and safety monitoring and improvement on urban expressways**
Published: **Author(s):**	Transportation Research Part C (2015), Vol. 58, pp.380–394 Shi, Q.; Abdel-Aty, M.
Free/priced:	Priced: $39.00
Aim:	The viability of a proactive real-time traffic monitoring strategy evaluating operation and safety simultaneously, was explored. The objective was to improve the system performance of urban expressways by reducing congestion and crash risk.
Methodology:	Microwave Vehicle Detection System (MVDS) deployed on an expressway network in Orlando was utilized to achieve the objectives. The system consisting of 275 detectors covers 75 miles of the expressway network, with average spacing less than 1 mile. Comprehensive traffic flow parameters per lane are continuously archived on one-minute interval basis. The scale of the network, dense deployment of detection system, richness of information and continuous collection turn MVDS as the ideal source of Big Data.
Key Findings:	It was found that congestion on urban expressways was highly localized and time-specific. As expected, the morning and evening peak hours were the most congested time periods. The results of congestion evaluation encouraged real-time safety analysis to unveil the effects of traffic dynamics on crash occurrence. Data mining (random forest) and Bayesian

	inference techniques were implemented in real-time crash prediction models. The identified effects, both indirect (peak hour, higher volume and lower speed upstream of crash locations) and direct (higher congestion index downstream to crash locations) congestion indicators confirmed the significant impact of congestion on rear-end crash likelihood. As a response, reliability analysis was introduced to determine the appropriate time to trigger safety warnings according to the congestion intensity. Findings of this paper demonstrate the importance to jointly monitor and improve traffic operation and safety.
Relevant findings and comments:	The identified effects, both indirect (peak hour, higher volume and lower speed upstream of crash locations) and direct (higher congestion index downstream to crash locations) congestion indicators ***confirmed the significant impact of congestion on rear-end crash likelihood***.

Title:	**Aggressive driving: an observational study of driver, vehicle, and situational variables**
Published: **Author(s):**	Accident Analysis and Prevention (2004), Vol. 36, pp.429–437 Shinar, D.; Compton, R.
Free/priced:	Priced: $39.00
Aim:	To study aggressive driving context
Methodology:	Over 2000 aggressive driving behaviours were observed over a total of 72h at six different sites. The behaviours selected for observation were those that are commonly included in 'aggressive driving' lists, and they consisted of honking, cutting across one or more lanes in front of other vehicles, and passing on the shoulders. In addition, an exposure sample of 7200 drivers were also observed at the same times and places. Relative risks (RRs) and odds ratios (ODs) were calculated to show the relative likelihood that different drivers under different conditions will commit aggressive behaviours.
Key Findings:	The rate of aggressive actions observed in this study decreased from the most frequent behaviour of cutting across a single lane, through honking, and to the least frequent behaviours of cutting across multiple lanes and passing on the shoulders. Relative to their proportion in the driving population, men were more likely than women to commit aggressive actions, and the differences increased as the severity of the action increased. Drivers who were 45 years old or older were less likely to drive aggressively than younger ones. The presence of passengers was associated with a slight but consistent reduction in aggressive driving of all types; especially honking at other drivers. There was a strong linear association between congestion and the frequency of aggressive behaviours, but it was due to the number of drivers on the road. However, when the value of time was high (as in rush hours), the likelihood of

	aggressive driving—after adjusting for the number of drivers on the road—was higher than when the value of time was low (during the non-rush weekday or weekend hours).
Relevant findings and comments:	There was a ***strong linear association between congestion and the frequency of aggressive behaviours***, but it was due to the number of drivers on the road. However, when the value of time was high (as in rush hours), the likelihood of aggressive driving—after adjusting for the number of drivers on the road—was higher than when the value of time was low (during the non-rush weekday or weekend hours).

Title:	**Speed Limits. A review of evidence**
Published: **Author(s):**	Royal Automobile Club Foundation for Motoring (2012) Box, E.; Bayliss, D.
Free/priced:	Free
Aim:	To review evidence on speed limits
Methodology:	Literature review
Key Findings:	***The benefits of speed*** Speed is often viewed in a negative way, but there are undoubtedly some tangible and positive benefits to increasing the average speed of traffic. For individuals this includes reduced journey times and enhanced mobility and access options. If car journey speeds were increased by 10% then the area that could be accessed by the average journey would increase from 55 square miles to 67 square miles. There are also benefits for the economy with regard to reducing the time associated with transporting goods and with journeys in the course of work. However, journey-time savings are often small, particularly in urban areas where increased running speeds may provide only small savings as a result of delays at intersections and traffic lights. In his study of the long-term links between transport and the UK's economic productivity, growth and stability, Sir Rod Eddington concluded that eliminating existing congestion on the road network would be worth some £7–8 billion of GDP per year. However, reducing congestion and increasing average speeds is not mainly a matter of increasing speed limits. For example, if a rise in the motorway speed limit to 80 mph increased the average speed of free-flowing traffic from 69 mph to 71 mph this would save around 16 million vehicle hours a year – about a fifth of what is lost from congestion. Therefore, average speeds can be best increased by reducing congestion. ***The negative consequences of speed*** Speed has significant consequences for the environment and road safety, which need to be addressed and recognised when making decisions about speed limits. The negative impacts of speed are particularly felt in urban

	areas. Fast-moving motor vehicle are hazardous for pedestrians and cyclists; noise and fumes are a nuisance for both road users and frontages; and speeding traffic in residential streets can change their character from 'places' to 'thoroughfares'. On poorly laid-out rural roads excessive speeds increase the frequency and seriousness of crashes.
Relevant findings and comments:	There are undoubtedly some tangible and positive benefits to increasing the average speed of traffic. For individuals this includes reduced journey times and enhanced mobility and access options. If car journey speeds were increased by 10% then the area that could be accessed by the average journey would increase from 55 square miles to 67 square miles. There are also benefits for the economy with regard to reducing the time associated with transporting goods and with journeys in the course of work. In the UK's economic productivity, growth and stability, eliminating existing congestion on the road network would be worth some £7–8 billion of GDP per year.

Title:	**Following slower drivers: Lead driver status moderates driver's anger and behavioural responses and exonerates culpability**
Published: **Author(s):**	Transportation Research Part F (2014), Vol. 22, pp.140–149 Stephens, A.N.; Groeger, J.A.
Free/priced:	Priced: $39.00
Aim:	Two experiments investigated the effects of lead-driver status on the anger-experienced and aggression-expressed in traffic scenarios in which the lead drivers' actions were determined by an event obviously beyond, or within, their control.
Methodology:	Experiment I contrasted reactions to lead-cars bearing Learner driver markings (Low Status) or similar unmarked cars (Control), while Experiment II contrasted reactions to Ambulances (High Status) or otherwise identical generic work vans (Control). Reported anger, heart-rate and behaviour were measured while drivers drove.
Key Findings:	When the lead vehicle slowed or changed course because of the actions of another road user, drivers were reliably more angered when slowed by a learner driver than an unmarked sedan. Drivers reported less anger when slowed by an Ambulance, than by a work van, when there was no apparent cause for the lead-vehicle slowing. Driver behaviour also differed according to lead-vehicle status. Drivers allowed greater headway between themselves and a slower ambulance, but drove closer to the work-van, and followed Learner drivers at a dangerously close distance, leaving greater headway behind a similar, unmarked car. Reliable differences in subjective anger ratings and behaviour suggest that anger experienced and expressed depends not just on the actions of the

	perpetrator but on the perceived status of that perpetrator. Higher status vehicles appear to be forgiven their indiscretions more readily even when there are no extenuating circumstances, whilst lower status drivers are likely to be blamed more readily for circumstances beyond their control.
Relevant findings and comments:	Reliable differences in subjective anger ratings and behaviour suggest that ***anger experienced and expressed depends not just on the actions of the perpetrator but on the perceived status of that perpetrator***. Higher status vehicles appear to be forgiven their indiscretions more readily even when there are no extenuating circumstances, whilst lower status drivers are likely to be blamed more readily for circumstances beyond their control.

Title:	**The safety impacts of differential speed limit on rural interstate highway**
Published: **Author(s):**	TRB Annual Meeting (2003) Garber, N.J.; Miller, J.S.; Yuan, B.; Sun, X.
Free/priced:	Free
Aim:	To compare the safety effects of a uniform speed limit (USL) for all vehicles as opposed to a differential speed limit (DSL) for cars and heavy trucks.
Methodology:	Crash, speed, and volume data were obtained from ten states for rural interstate highways for the period 1991 to 2000. These states were divided into four policy groups based on the type of speed limit employed during the period: maintenance of a uniform limit only, maintenance of a differential limit only, a change from a uniform to a differential limit, and a change from a differential to a uniform limit. Statistical tests (analysis of variance, Tukey's test, and Dunnett's test) and the Empirical Bayes Method were used to study speed and crash rate changes in the four policy groups.
Key Findings:	No consistent safety effects of DSL as opposed to USL were observed within the scope of the study. The mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the ten-year period, regardless of whether a DSL or USL limit was employed. When all sites within a state were analysed, temporal differences in these variables were often not significant; however, in several cases, significance was observed if one then excluded sites with unusually high or low traffic volumes from the data set. Further examination suggests that while these data do not show a distinction between DSL and USL safety impacts, the relationship between crashes and traffic volume cannot be generalized but instead varies by site within a single state.
Relevant findings and comments:	No consistent safety effects of DSL as opposed to USL were observed. The mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the ten-year period, regardless of whether a DSL or USL limit was employed.

Title:	**Anger while driving**
Published: **Author(s):**	Transportation Research Part F (1999), Vol. 2, pp.55-68 Underwood, G.; Chapman, P.; Wright, S.; Crundall, D.
Free/priced:	Priced: $39.00
Aim:	The study examined the causal factors associated with anger while driving and the possible consequences of that anger on driving behaviour.
Methodology:	Drivers kept diaries over a period of two weeks, detailing the events occurring during each journey in that time, with notes on events such as near accidents and on feelings of anger. The study examined the diaries of 100 drivers, who reported a total of 293 near accidents and 383 occasions when they experienced anger. The drivers also completed questionnaires that assessed a number of individual differences such as propensity towards mild social deviance and towards committing traffic violations.
Key Findings:	On a journey by journey basis drivers were more likely to report anger when congestion was present, but there was no evidence that the drivers who generally experienced higher levels of congestion also experienced more anger. The study found a strong association between the number of near accidents and occasions of anger a person experiences while driving, but this concealed two separate relationships. Near accidents frequently provoked feelings of anger, particularly where the driver felt that they were not at fault in the incident. However, there was also a separate link between the experience of anger in other situations and reports of near accidents where the driver was to blame. Such anger also appeared to be linked to mild social deviance and the commission of driving violations.
Relevant findings and comments:	On a journey by journey basis drivers were more likely to report anger when congestion was present. The study found a strong association between the number of near accidents and occasions of anger a person experiences while driving, but this concealed two separate relationships.

Title:	**Improving speed behaviour: the potential of in-car speed assistance and speed limit credibility**
Published: **Author(s):**	IET Intelligent Transport Systems (2008), Vol. 2(4), pp.323 – 330 Van Nes, N.; Houtenbos, M.; Van Schagen, I.
Free/priced:	Priced: $33.00
Aim:	The aim was to investigate the potential of both approaches and particularly the potential of the combination of these measures.

Methodology:	A driving simulator study was conducted to investigate the individual and combined effects of the use of an ISA system and the speed limit credibility on drivers' average speed and the amount of time spent speeding.
Key Findings:	The results indicated that both the informative ISA system used here and the speed limit credibility significantly improved speed behaviour. Drivers not using ISA appeared to be more susceptible to the speed limit credibility than those using ISA. It is concluded that both the measures can be effective to improve speed behaviour. The results obtained suggest that the properties of this particular informing and warning type of ISA could have resulted in the speed limit credibility neither affecting the amount of time speeding nor the average speed.
Relevant findings and comments:	Drivers not using ISA appeared to be more susceptible to the speed limit credibility than those using ISA.

Title:	**Effect of speed limits on speed and safety: a review**
Published: **Author(s):**	Transport Reviews (1999), Vol. 19(4), pp.315-329 Wilmot, C.G.; Khanal, M.
Free/priced:	Priced: £30.00
Aim:	This paper draws on the results of studies conducted around the world on the effect of speed limits on speed and safety.
Methodology:	Literature review
Key Findings:	It is observed that, generally, motorists do not adhere to speed limits but instead choose speeds they perceive as acceptably safe. Perceptions of safety are influenced by the environment in which travel takes place such as whether the road is a controlled access facility, the nature of adjoining land use, the geometry of the road and existing weather conditions. The relationship between speed and safety is influenced by factors such as the type of road, driver age and vehicle safety devices. Research shows that speed cannot be linked statistically to the incidence of accidents, although it is statistically significant in accident severity. If speed limits are increased only on controlled-access facilities, while retaining lower speed limits on other facilities, system-wide safety may not be adversely affected. The main benefits of increasing speed limits seem to be in improving their credibility with the public and regaining control of speed behaviour on highways.
Relevant findings and comments:	Motorists do not adhere to speed limits but instead choose speeds they perceive as acceptably safe. Research shows that speed cannot be linked statistically to the incidence of accidents.

	The main benefits of increasing speed limits seem to be in improving their credibility with the public and regaining control of speed behaviour on highways.

Title:	**The Effect of Speed Limit Credibility on Drivers' Speed Choice**
Published: **Author(s):**	Transportation Research Part F (2017), Vol. 45, pp.43–53 Lee, Y. M.; Chong, S. Y.; Goonting, K.; Sheppard, E.
Free/priced:	Priced: $27.95
Aim:	Two experiments were conducted to investigate how credibility of speed limits affects judgments of appropriate speed.
Methodology:	The first experiment aimed to establish speeds deemed appropriate by investigating Malaysians drivers' judgments of the appropriate speed to drive based on photographs of roads with the speed limit sign erased. The second experiment tested the impact of credibility of speed limit information on the speed drivers judged appropriate. Drivers judged the appropriate speed to drive for the same photographs as in Experiment 1 with speed limit information provided. Four conditions were included: two conditions where the speed limit posted was 10% higher or 10% lower than the appropriate speed established in Experiment 1 (credible speed limits), and two conditions where the posted speed limit was 50% higher or 50% lower than the appropriate speed (non-credible speed limits).
Key Findings:	Drivers' judgments were more affected by characteristics of the road than road side. Posted speed limits affected drivers' judgments of appropriate speed. Drivers choose speeds consistent with credible (10% lower) posted speed limits.
Relevant findings and comments:	Drivers choose speeds consistent with credible posted speed limits.

Title:	**Evaluation of the national HGV speed limit increase in England and Wales: year 1 interim summary**
Published: **Author(s):**	Department for Transport (2017), UK N/A
Free/priced:	Free

Aim:	In April 2015, new national speed limits came into force for heavy goods vehicles (HGVs) over 7.5 tonnes on single carriageway and dual carriageway roads in England and Wales. The new limits are: • 50 mph (up from 40 mph) on single carriageway roads; • 60 mph (up from 50 mph) on dual carriageway roads. The primary aim is to determine and understand the impacts of the speed limit changes. A secondary aim is to generate evidence to support future policy decisions.
Methodology:	Traffic speeds and flows. Data from April to December 2014 were used for understanding the baseline situation (before the speed limit changes). Data from April to December 2015 were used for the analysis of the initial impact of the speed limit changes. Safety. Collision data (STATS19) for the period from January 2005 to September 2015 were used. There was therefore approximately 10 years of pre-change data and only 6 months of post-change data available. The 2016 analyses are therefore initial findings and should not be interpreted as robust evidence of change.
Key Findings:	The initial analysis of traffic speeds and flows found that: • speeds for HGVs over 7.5 tonnes on single carriageway roads had increased between 2014 and 2015 by more than 1 mph, on average, across a range of flow conditions; • the equivalent figure for dual carriageways was an increase of less than 0.5 mph. The initial analysis of safety data between 2005 and 2015 identified that: • historically, up to 17% of all reported collisions in England and Wales have taken place on single (50 mph and 60 mph speed limit) and dual carriageway (60 mph and 70 mph speed limit) roads - 7.6% of the total collisions on these roads were reported to involve HGVs; • prior to the introduction of the new speed limits there had already been a trend of collisions reducing on these roads, though the rate of reduction had slowed in recent years; • in the period following the introduction of the new speed limits there is preliminary evidence of a reduction in HGV collisions estimated to be between 10% and 36%, however, it is not possible to attribute this directly to the speed limit changes.
Relevant findings and comments:	In the period following the introduction of the new speed limits there is preliminary evidence of a reduction in HGV collisions estimated to be between 10% and 36%, however, it is not possible to attribute this directly to the speed limit changes.

Title:	**Investigating Improper Lane Changes: Driver Performance Contributing to Lane Change Near-Crashes**
Published: **Author(s):**	Proceedings of the Human Factors and Ergonomics Society (2012), 56th Annual Meeting, pp.2231-2235 Fitch, G.M.; Hankey, J.M.
Free/priced:	Priced: $36.00
Aim:	To investigate the contributing factors that led to the lane change near-crashes.
Methodology:	The study investigated the contributing factors that led to the lane change near-crashes recorded in the 100-Car Naturalistic Driving Study using a case-crossover experimental design. Drivers' visual behaviour and vehicle control were compared across a sample of lane change near-crashes and matched baselines. Baseline lane changes were sampled if they occurred prior to the near-crash, had a similar manoeuvre as the near-crash (including direction and speed), occurred within ± 2 hours from the time of day, occurred in similar light conditions, occurred on a similar day of the week (weekday vs. weekend), occurred on a road that had a similar number of lanes, had a similar placement of surrounding vehicles, and were made by the same driver.
Key Findings:	A total of 18 lane change near-crashes and 33 baseline lane changes were identified. Left lane changes near-crashes appear to have resulted in part because drivers tended to slow down at the start of the manoeuvre and were less likely to use their rear-view mirror. Right lane changes near-crashes appeared to have occurred because of more aggressive manoeuvring, infrequent turn signal use, and because drivers were less likely to look over their shoulder. Deficiencies in judging the distance and approach rate to adjacent vehicles, as well as circumstances in the environment, may also have played a contributing role.
Relevant findings and comments:	HGV traffic (lane) restrictions can affect road safety in a positive way by potentially enabling an improved traffic flow and less overtaking by large vehicles, which can sometimes cause sudden braking in traffic and more lane movement, which can increase accident risk.

agilysis.co.uk

27 Horse Fair | Banbury | Oxfordshire | OX16 0AE
+ 44 1295 731810 | info@agilysis.co.uk | www.agilysis.co.uk

An associated company of Road Safety Analysis
A company registered in England, Company Number: 10548841
VAT Reg No: 260474119

agilysis