In-depth study of accidents involving light goods vehicles

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Abstract - This work aimed for getting the main features of accidents involving Light Goods Vehicles (LGV), using accident cases collected in the In-Depth Accidents Studies built up at IFSTTAR-LMA (France), in order to analyse thoroughly the proceedings of these accidents and identify the major factors for the different types of LGV. This work was based on the analysis of 88 accident cases involving LGV with a Maximum Authorised Mass inferior to 3.5 tonnes. In particular kinematics reconstruction of these accidents were performed to calculate the average impact speeds and to better understand the compatibility problems between LGV and antagonist vehicles. Specific features have been reviewed to pick up problems concerning safety, maintenance, loading, LGV design: general conditions of the accident, vehicle features, and passive safety. The main results of this study are presented in this paper.

INTRODUCTION

The words “Light Goods Vehicles” (LGV) are commonly used to refer to a vehicle belonging to a company, conceived and fitted out to carry goods, with only two or three places in the front, and especially for a professional use. The term of commercial vehicle can be also considered. For this type of vehicle, the French Highway Code retains the French word “camionnette” (van) with the following definition: motor vehicle with at least four wheels, designed to goods transportation, with a total authorised loaded weight inferior to 3.5 tonnes [1].

According to the ONISR (French national observatory of the road safety) [2, 3, 4], at the beginning of 2011, 5.8 millions of LGV were in service in France. LGV are more and more present on French roads, since they represented 15.4% of all vehicles in 2010, against 11% in 1985. The number of LGV involved in accidents with injuries, inventoried by the ONISR, lightly increased since 2000 (5780 vehicle in 2000 against 5974 in 2010). In parallel, it is observed on one hand an increase of the number of casualties, and on the other a worsening of the accidents.

The tendency extends in all Europe, even if in the last three years the number of LGV licence numbers decreased [5]. According to this study based on the accidents data of 21 European countries on the last available year, 2006, it is inventoried:

- 10% of all vehicles are LGV,
- 8% of all accidents involve LGV,
- 9% of all fatal accidents involve LGV.

A study completed in UK on accidents involving LGV between 2006 and 2008 pointed out that the occupants of cars are very frequently injured in the accidents involving LGV [6]. Otherwise it was observed that about 75% of deceased occupants of LGV went first through a frontal impact; this situation represents also 69% of gravely injured occupants of LGV. Heavy goods vehicles are the most decisive (40%) in deceases of LGV occupants. Nevertheless it should be noted that 41% of deceases of LGV occupants occurs because of an impact other than vehicle-vehicle: rollovers and obstacles.

Despite these studies it has to be pointed out that knowledge of LGV accidents is to date not enough explored, even though the number of accidents involving this type of vehicles reveals itself to be increasing.

The objective of this work was to identify the major technical features of accidents involving LGV. It focused on:

- The impact speeds of these vehicles,
- The influence of loading in the accident: fixing, tidying up, involvement in injury generation, etc.,

- The influence of the type of LGV: shape, presence of partition between passenger compartment and loading, safety equipment, etc.,
- The question of compatibility between LGV and the other vehicles in order to determine the damage sustained by antagonist vehicles such as [9]: weight ratio, localisation of deformations, injuries, etc.

MATERIAL AND METHODS

In-Depth Accident Studies (IDAS)

This work was mainly based on data collected by In-Depth Accident Studies (IDAS) built up at IFSTTAR Laboratory of accident mechanism analysis [7]. It should be noted that the first objective of this database is to be illustrative of the diversity of the accidents but not necessary statistically representative of all the accidents in France.

The principle of IFSTTAR IDAS is to collect in real time as many information as possible on the three components of the system driver-vehicle-environment. The investigation area is around the town "Salon de Provence" in France. A multidisciplinary team of investigators (a technician and a psychologist) is automatically alerted and takes action at the same time as the emergency service on the scene of the accident. It makes its own collection (material tracks, witness statements) focused on the proceedings of the accident and its circumstances. Collected data concern the involved persons, the vehicles, the road and the environment.

On the scene of accident the priority is to take pictures and films of the final positions of the vehicles, of the tracks on the ground, of the vehicles deformations and every other relevant element that can help to understand the accident. A careful examination of involved vehicles is made to collect the positions of the gear lever, the weight of a possible loading, the presence of a mobile phone…

The whole data collected is structured in check-lists and coded. The medical files (anthropometric measures, statements on lesions, etc.) concerning victims are also colligated in the emergency service of the hospital in Salon de Provence.

A kinematics reconstruction is performed with specific IFSTTAR-LMA software, based on final and impact positions, skid marks, angle of the impact, impact locations on the vehicles, involved persons accounts, victim's injuries… The objective of the reconstruction is to build a spatiotemporal description of the accident proceedings, consistent with the whole data (Figure 1).

The method used requires knowledge in kinematics [8] and is based on the estimation of some parameters such as the energy spent in the vehicle deformation, the decrease in speed of the vehicle depending on the tyre marks on road, etc. Trajectories of vehicles involved are determined according to data collected on the scene of the accident: final positions, marks, estimated positions at impact point, and arrival directions of each vehicle. In general, it is necessary to go back in time and on the trajectory of each vehicle involved with the calculation of simple kinematics sequences (each sequence is associated to a simple kinematics model). The post-crash phase is modelled by a constant speed movement or by a uniformly accelerated movement. The analysis of the collision consists in applying simple mechanical laws: conservation of momentum (two axles) and conservation of energy (kinetic and deformation). The global objective is thus to balance these three simultaneous equations. The study of the pre-crash phase uses exactly the same principles of calculation than the post-crash ones.

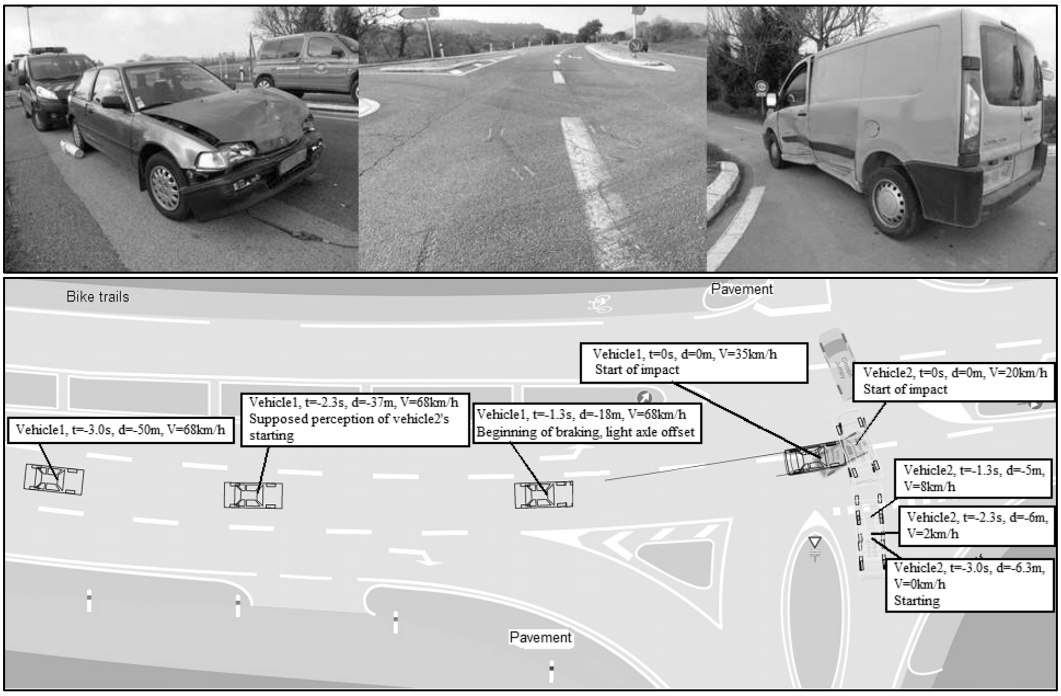


Figure 1. Results of the kinematics reconstruction of an accident, spatiotemporal description of its proceedings

Specific LGV data

The accidents involving at least one LGV were selected in the IDAS database. Types of LGV retained for this work have a Maximum Authorised Mass (MAM) inferior to 3.5 tonnes (ex. delivery van: Peugeot Partner and Renault Master) and are not directly derived from a passenger car, thus not including commercial cars (ex. Peugeot 206 société, Renault Mégane société). In total 88 IDAS accidents involving 90 LGV were selected and analyzed between 1992 and 2012.

A large part of the data was directly extracted from the IDAS coded database which contains more than 600 variables for every accident. However, this study was focused on accidents involving LGV and a new file of specific data coding was elaborated. New variables were created and added to this file as regards safety problems, maintenance, loading, type of design, useful volume, specific layout, etc.

The whole set of data was classified in different sections briefly described below:

- “Identification” in which there are the general conditions of the accident, types of involved persons, and overall severity of injuries, etc.
- “Vehicles” in which there are vehicles equipment, mileage, design type, general state, useful volume, useful load, presence of ABS (Anti-lock braking system), description of essential elements for primary safety, size of tyres, loading index for each wheel (measure and manufacturer specification), etc.
- “Secondary safety” in which there are the number and types of impacts, the variation of speed due to the impact, the presence of airbags, the fixing and storage of loading, its implication in the accident, etc.
- “Drivers” in which there is a description of the driver physical and mental state, in the long, medium and short terms, his socio-professional category, his driving experience, his relation with his vehicle, his perception of the accident proceedings, his declared speed in approach, etc.
- “Passengers” in which there is a description of each passenger: his place in the vehicle, his age, his size, his weight, his use of the protection systems (seat belt, airbag, …), his injuries, etc.

It should be noticed that all the accidents and all the variables do not have the same level of completeness. Some data are missing in some accidents. In the results presented in this paper, the sample size for each analysis is always given.

RESULTS

In order to explicit specific features of light goods vehicles, a detailed description of the LGV sample is given and often compared to the whole IDAS database if necessary.

Type of LGV

Among the 90 LGV vehicles of the sample, 18 have a MAM <1.5T, 24 a MAM between 1.5T and 2.5T, and 48 a MAM>2.5T and <3.5T.

LGV were also classified according to other factors: useful volume and design type (Table 1). Indeed these two criteria vary a lot from one model to another that can affect for example the inherent aggressiveness of the LGV (height and stiffness of the chassis, position of the centre of gravity, etc.). Thus it is necessary to distinguish between the LGV based on a tourism car, called here “Goods car”, the other design types of auto-porter with a big size called “Van” and “Big van”, and at last the “chassis-cab” LGV with a big compartment or a dump. The table 1 presents the distribution of the LGV sample according to their useful volume and their design type.

	Categories of useful volume in m^3	Number of vehicles	Percentage %
Goods car 	Less than 6	42	47
Van  **Big van** 	Between 6 and 12	25	28
Chassis-cab with compartment 	More than 12	12	13
Chassis-cab with dump 	Type Pick-Up/Dump	11	12
	Total	90	100

Table 1. Distribution of the LGV sample according to the useful volume and the design type

The average age of the LGV at the time of accident is 6 years old: quite recent in relation to the whole national LGV fleet that is 9.3 years old [2]. It denies the hypothesis of the damaged LGV being the elder ones of the national LGV fleet.

Manoeuvre at the origin of the accident

The manoeuvre at the origin of the accident is considered as the driving situation that leaded to the accident, apart from the configuration of the impact itself. Figure 2 shows that the LGV are less subject to loss of control in a straight line, 14% against 19% for all IDAS accidents, and also in bend 13% against 22%. On the contrary LGV are more involved in intersection accidents: 39% against 27% for the whole IDAS.

It seems to highlight that the LGV drivers have difficulties to perceive other road users due to numerous internal obstacles to visibility. It has also been noted that on 4 accidents involving a LGV and a pedestrian, the LGV was going backward in 2 cases. Yet there is no radar detection in the back of the vehicle in the sample. This kind of ADAS (Advanced Driver Assistance System) that is becoming more and more common on passenger cars could be a great element to equip consistently the LGV to avoid this kind of accident in backward configuration.

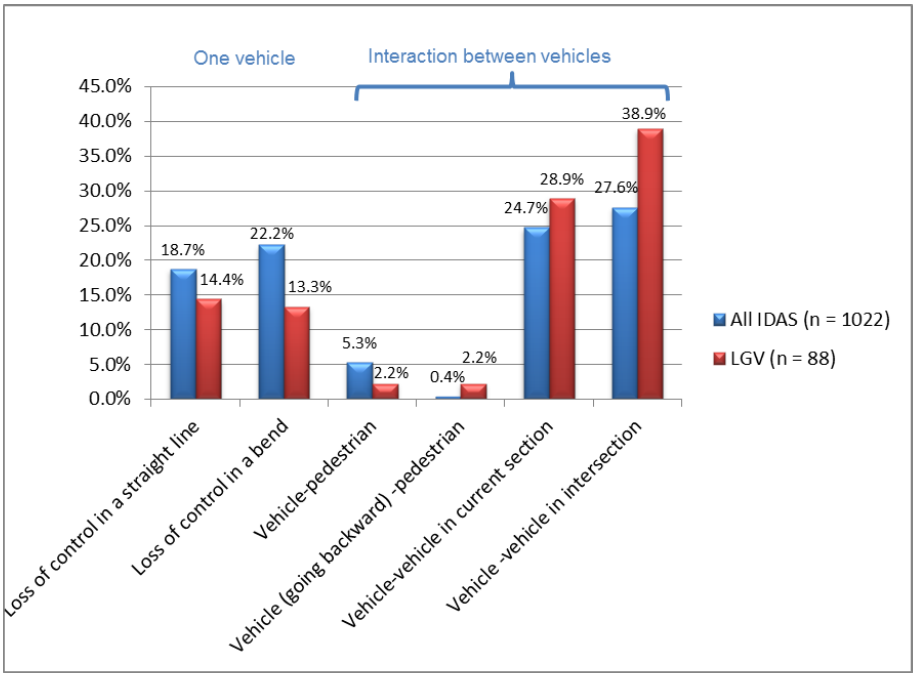


Figure 2. Distribution of the manoeuvres at the origin of the accidents

Type of impact

Figure 3 presents the distribution of the types of impact for the 90 LGV. The most frequent configuration is the frontal impact (53%), then the lateral impact (20%), and at last the rear impact (13%).

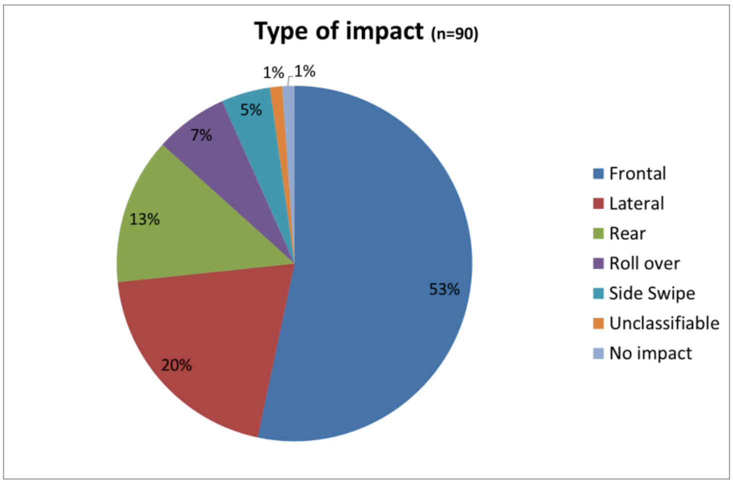


Figure 3. Configuration of the first impact for the LGV

Obstacle

This part considers the obstacle hit by the LGV during the impact phase, and not the type of antagonist vehicle or pedestrian with whom there was an interaction leading to the accident. It should be noted that LGV have less impacts against tourism cars (43% against 48% for all IDAS), but more impacts against 2 wheels-motorised (22% against 9%), as can be seen at Figure 4. Again it could be a problem of internal obstacles to visibility leading to worse perception of vulnerable road users, which have a lower visible size than cars.

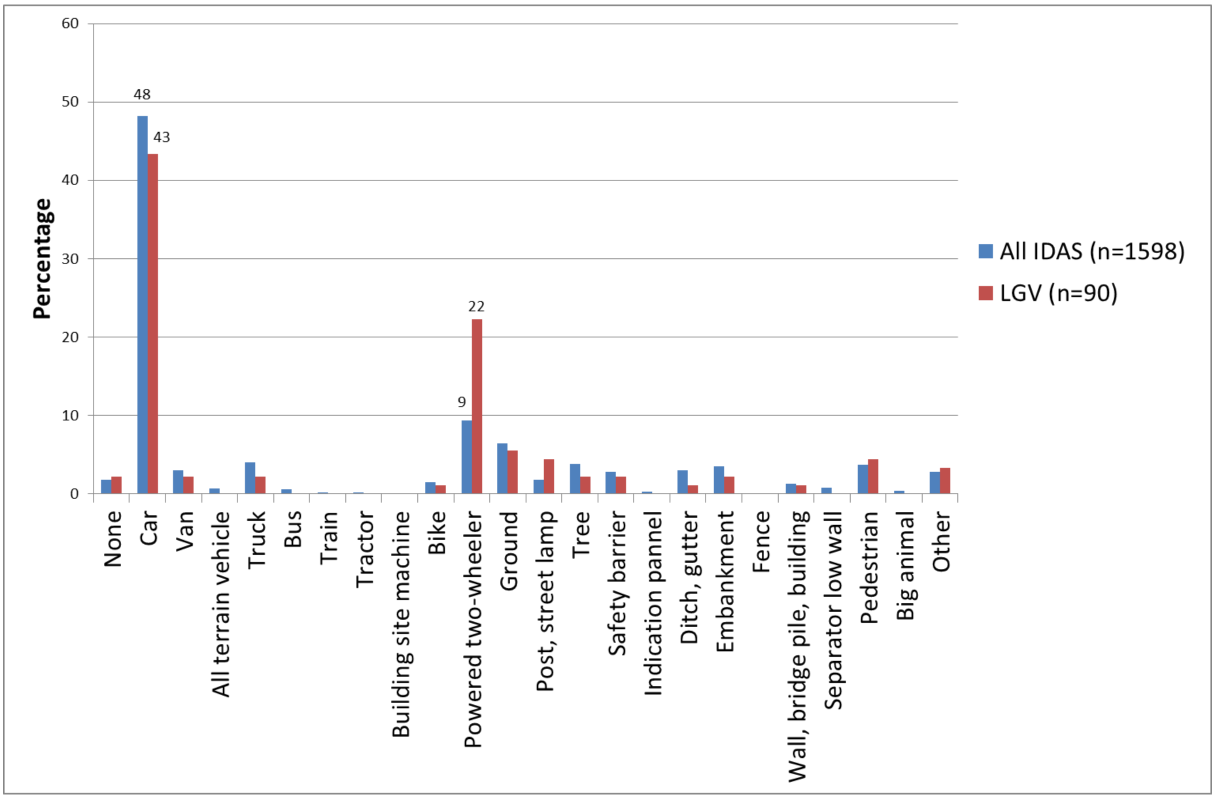


Figure 4. Distribution of accidents according to the impacted obstacle

Impact Speeds

The sample presented here includes 45 accidents of LGV. The cases where the LGV go backward are stationed, or have a speed under 10 km/h (moving of, slow manoeuvre, U-turn, entry/exit of parking, etc.) were suppressed. The considered speed is the one just before the impact. These impact speeds were calculated thanks to the kinematics reconstructions carried out in the IDAS.

Figure 5 presents the distributions of impact speeds for all IDAS and for LGV accidents. The average impact speed for the LGV accidents outside urban area is 44 km/h (n=36, median 44 km/h, standard deviation 21 km/h) and 35 km/h in urban area (n=9, median 38 km/h, standard deviation 15 km/h). The average impact speed of all IDAS cases outside urban area is higher, 59 km/h (n=546, median 55 km/h, standard deviation 26 km/h) and quite similar in urban area, 37 km/h (n=181, median 35 km/h, standard deviation 17 km/h).

To sum up, there is almost no difference in impact speeds in urban area between LGV and the reference all IDAS, whereas outside urban area impact speeds are lower for LGV than for all IDAS.

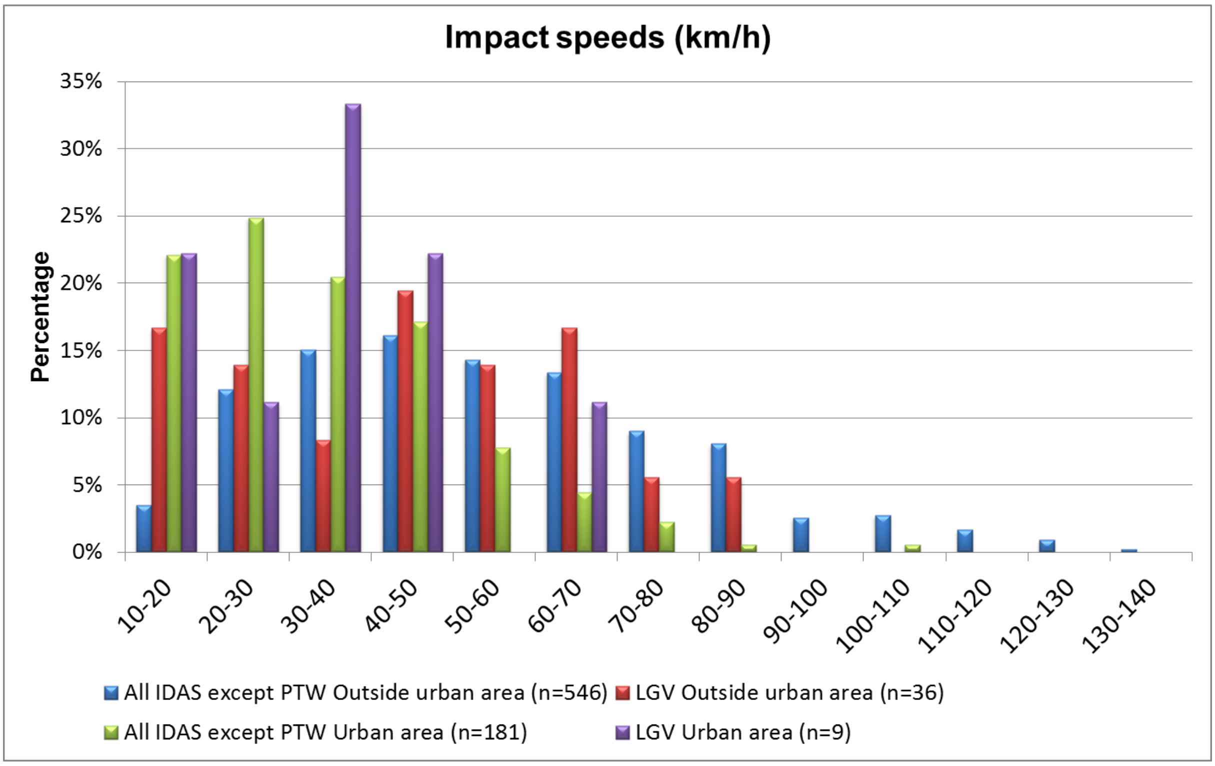


Figure 5. Distribution of accidents according to the impact speeds

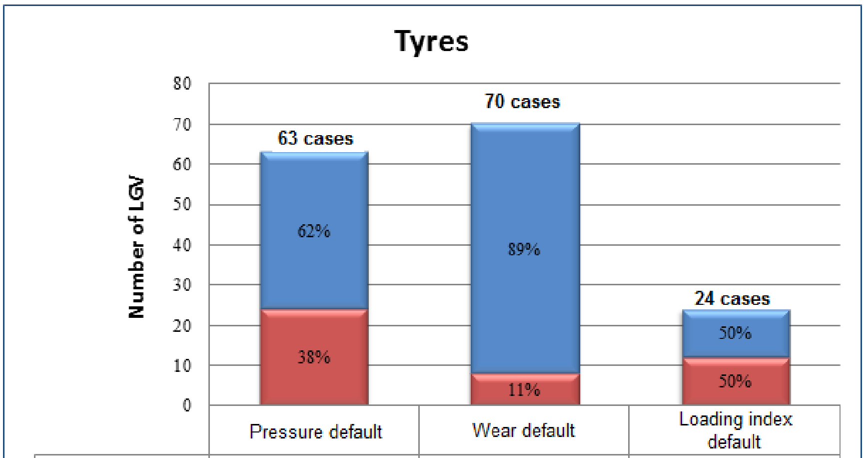
Tyres

Concerning the state of the tyres, the following rules have been taken into account:

- There is a pressure default when the measure on one or several tyres differs by more than 0.3 bars from the recommended specification of the manufacturer.
- There is a wear default when the sculptures depth is lower than 1.6 mm (regular wear, significant crackle, hernia, etc.),
- The loading index of a tyre corresponds to the maximal loading that a tyre can support at the maximal speed given by the speed code. It is given by the manufacturer. If the loading index is lower than the one specified by the LGV manufacturer, there is a default.

Figure 6 presents the frequency of appearance of these defaults.

These results lead to the fact that the maintenance of LGV is insufficient concerning tyres. Indeed more than one third of LGV presents an under-inflation problem. Nevertheless few wear defaults are recorded. It could indicate that the regulatory maintenance is well done, but much less the basic maintenance such as the check of tyres pressure. Actually these vehicles are often used by several drivers which can result in negligence in usual maintenance. Moreover, even if the sample is small with 24 cases, 50% of LGV have a loading index lower than the manufacturer recommendation.



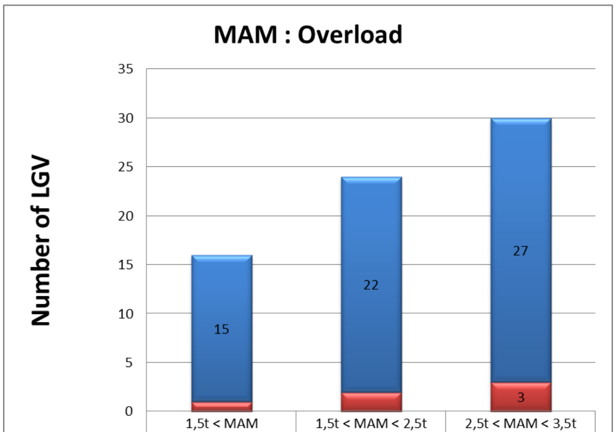
	Pressure default	Wear default	Loading index default
No default	39	62	12
Default	24	8	12

Figure 6. Repartition of tyres defaults

Among the 90 LGV listed, 7 have a tyre technical default which played a role in the proceedings of the accident, one was a blow-out, 4 were pressure defaults, one a wear default, and one a combination of pressure and wear default. It could be useful to encourage manufacturers to equip LGV with tyre pressure sensors as it exists for some passenger cars) in order to prevent this technical problem.

Loading

Most LGV of the sample (77%) have a Maximum Authorised Mass (MAM) higher to 1.5t and lower than 3.5t (Figure 7). Generally the loading restrictions applied to the vehicle are respected. However when these restrictions are overstepped, it is by far. Indeed the 6 vehicles overloaded have an excess between 200 and 500 kg.



	1,5t < MAM	1,5t < MAM < 2,5t	2,5t < MAM < 3,5t
Not overloaded	15	22	27
Overloaded	1	2	3

Figure 7. Number of LGV overloaded according to the MAM

Concerning the load thrust, which means when pieces of goods got into the passenger compartment, it has been observed in only 7 cases by 82. But these load thrust had no consequence in terms of injuries on the occupants.

About the presence of a partition between the driver and the load, it has been observed in 56 cases (65%) among 86 LGV for which this information is known. This partition can be a sheet steel or Plexiglas® plate, a grill, a wooden panel, etc. By these 56 cases, 37 have a load not fixed. Deformations of the partition were observed in only 3 cases. In one of these 3 cases the partition gave away on the passenger side. But in this last case, the driver was alone in the vehicle and was not injured, so it had no consequence in term of injury. For all the other accidents the partition was efficient and not damaged.

It is important to notice that on the 56 cases with the presence of a partition, 25 vehicles had no rear visibility at all (that is to say no inside rear-view mirror or back radar) while this type of vehicles is often brought to manoeuvre, especially to go backward.

Safety equipment

Almost a third (36%) of the drivers in LGV accidents did not use their seat belt at the moment of the accident. This result is in accordance with [9]. In comparison the seat belt ratio at front places in the passenger cars involved in an accident is 97.4% [4]. It seems thus necessary to encourage the LGV drivers to wear their seat belt by all available means: sound warning, communication, awareness, control, etc.

Furthermore, the driver airbag is a safety device that can highly reduce the severity of driver injuries. It is nevertheless observed that there is a significant gap between the LGV equipment ratio and other types of vehicles in the IDAS database. Indeed 76% of LGV vehicles are not equipped with driver airbag against 66% for the other vehicles.

This ratio of LGV equipment is improving for several years because it was 24% for the accidents since 1992 and 48% for the accidents of the last ten years (Figure 8).

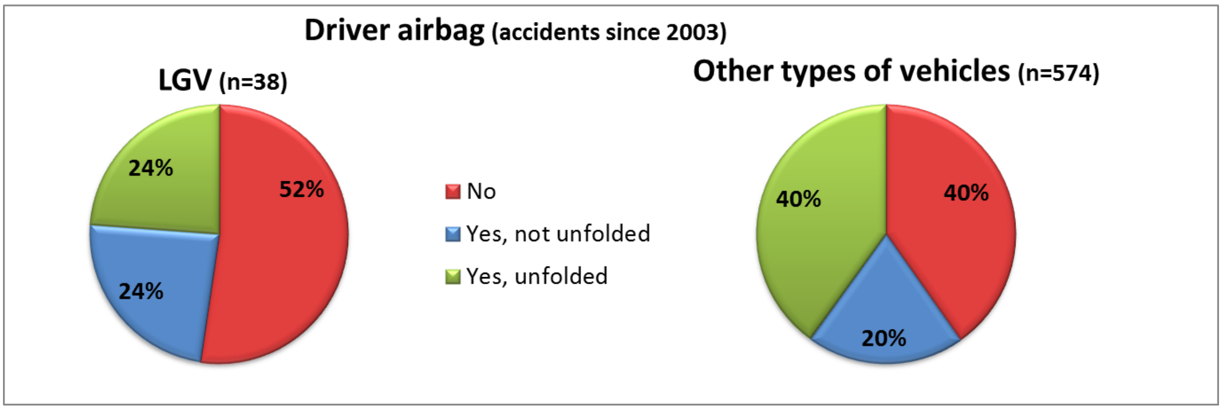


Figure 8. Presence and trigger of the driver airbag (accidents since 2003)

Severity of accidents

By the 88 LGV accidents, 64 involved another vehicle. 175 persons altogether were involved in these 64 accidents: 91 in a LGV and 84 in another vehicle. Almost half of them are unharmed, about 40% are slightly injured, nearly 11% seriously injured and 4 deceased (Figure 9). It can be noticed that there are nearly twice injured and deceased persons in the other vehicles than in LGV, and on the contrary there are twice unharmed persons in LGV than in other vehicles.

These observations seem to show that LGV are more aggressive and raise questions about the compatibility between LGV and other vehicles: mass, stiffness, height, etc.

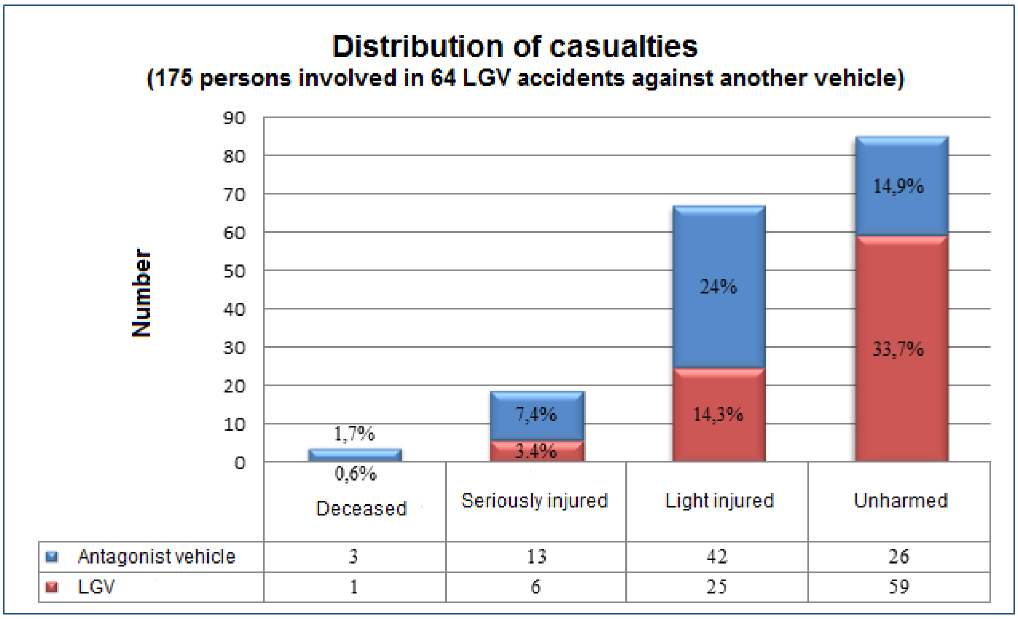


Figure 9. Distribution of the casualties in 64 accidents involving a LGV and another vehicle, according to the type of vehicle

CONCLUSION

The added value of this research work was to provide an in-depth analysis of the proceedings of 88 accidents involving LGV extracted from the In-Depth Accidents Studies (IDAS) of the IFSTTAR-LMA laboratory. Indeed it was about identifying features playing a key role and sometimes distinctive for this type of vehicle. The main results of this study are:

- Half of LGV in the sample are light goods cars (such as Renault Kangoo, Peugeot Partner…).
- LGV seem to be less involved in loss of control and more in accidents in intersection, possibly because of perception problem of the others due to internal obstacle to visibility.
- There were few technical defects and almost only defaults of pressure or loading index on tyres. Therefore checking pressure of tyres should be reinforced as well as the good adaptation to the loading index.
- Load thrust is not decisive in the accident thanks to a partition when present.
- There is a low rate of ADAS for LGV like radar or backup camera even though their rear visibility is very low.
- There is still a low rate of passive safety equipment (Airbag…).
- Few drivers of LGV wear their seat belt. Thus an incentive is necessary by all means: sound alert in the vehicle, communication, raising awareness, control, etc.
- Impact speeds seem equivalent to other vehicles.
- Impacts are mostly frontal for LGV.
- Aggressiveness of LGV appears to raise problem and compatibility with the other vehicles should be better taken into account.

Even though this study is limited in term of representativeness of the LGV involved in road accidents in France, it provides preliminary results that could orientate a following study on a bigger sample. For instance future works based on the analyse of a bigger sample of accidents police reports could let know if the LGV aggressiveness is simply due to a larger mass or to other factors such as differences in stiffness, in height, or in shape, etc.

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