Aerodynamic and Flexible Trucks for Next Generation of Long Distance Road Transport

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Publishable Executive Summary

In 2015, there were more than 1 million crashes within whole Europe, out of which 24,000 resulted in fatalities. Out of those overall crashes, 49,000 involved a heavy goods vehicle (HGV) as one of the crash partners. Around 3,400 of those crashes resulted in fatalities, leading to 3,800 fatally injured persons. Although crashes involving HGV's account for only 4.5% of all crashes on European roads, their share of fatal crashes with 14.2% percent is much higher. The overrepresentation of HGVs in fatal crashes calls for actions. This is especially relevant for vulnerable road users (VRUs), that do not have a protective shell around them like occupants of a vehicle. Furthermore, in crashes involving HGVs and VRUs, there is a high risk of fatal or severe injuries already at low speeds, e.g. in intersection conflicts, due to the huge weight difference and therefore higher possible energy transfer.

This deliverable provides detailed analyses describing and evaluating fatalities and injuries arising in crashes, the most frequent crash scenarios and investigating the critical safety factors and causes of crashes. The scope of the analysis are trucks with a combination weight above 16t, and the effect of combination weight on crash rates is investigated as well. This deliverable is rounded up by providing information on key performance indicators (KPIs) that can be used to assess the improvement of proposed and taken countermeasures.

Crash databases for Sweden, Spain and Italy have been analyzed for 16t+ truck as well as the European crash database CARE for crashes with trucks with a weight above 3,5t. Most HGV crashes in Europe occur during daylight with dry/clear weather conditions and dry road surfaces. Crashes in rural areas (outside city limits) have a slightly higher share compared to urban areas (inside city limits). There are slight deviations within the analyzed countries, but the overall trend is similar (e.g. Spain shows an even higher share of rural crashes).

A study on Swedish National Crash Data shows, that heavier trucks (weight above 44t) show a significantly lower KSI crash rate per vehicle kilometer travelled compared to today's trucks up to 44t. The results of this study are further supported by a study previously conducted by (Bálint et al., 2014) on the influence of the combination length. The authors conclude that extra-long vehicles (18.76m – 25.25m) are involved in less KSI crashes than today's long combinations (12.01m – 18.75m), although the difference in crash rate between length categories is less prominent than for the weight categories. If the assumption holds true that the category of long combinations has a large overlap with the category of heavy trucks and similar for extra-long and extra-heavy trucks (meaning a truck that is coded in the extra-long category with a length of 25.25m would very likely also fall into the category of extra-heavy trucks with a weight up to 60t) is part of further research and investigations within the ongoing project.

According to the cases in the German in-depth database GIDAS, the most frequent crash opponents of 16t+ trucks are passenger cars (45%), followed by commercial vehicles (at 23%). Crashes with vulnerable road users occur less often at approximately 9% for cyclists, 5% for pedestrians and 3% for powered two-wheelers.

The most frequent scenario of accidents with cars are crashes in longitudinal traffic such as rear end collisions and collisions due to changing lanes. These conflicts often occur on motorways where 16t+ trucks are often found in the GIDAS data collection regions.

Crashes with commercial vehicles (which mostly also consist of trucks) show a similar crash scenario: Again, accidents in longitudinal traffic on motorways are most common. Compared to conflicts with cars however, these are rear-end crashes in the vast majority of cases and rarely lane changing conflicts. Thus, the direction of force in the crash is nearly always directly from the front or from the back of the truck. Because the crashes are often motorway-crashes, the travelling speed of the 16t+ trucks in these cases is higher compared to crashes with VRUs.

The most prominent crash opponent among the vulnerable road users are cyclists. These conflicts often occur at junctions inside city limits with lower travelling speeds. Here the most frequent scenarios are crashes with a cyclist at a crossing or junction. Among these, the most common accident type is when a truck turns off to the right and has a conflict with a bicycle travelling alongside in the same direction on a bicycle path on the right side of the road. The crash mostly occurred on the front or right side of the truck.

Crashes with pedestrians often resulted from a pedestrian crossing the road on which the truck was travelling. Another frequent scenario is (similar to the crashes with cyclists) when a 16t+ truck turned right or left and had a conflict with a pedestrian walking on a sidewalk in the opposite or same direction. As with cyclists, crashes with pedestrians occur mostly in urban surroundings at lower travelling speeds of the truck.

The analysis of crashes with powered two wheelers resulted in a more diverse accident situation. These crashes occur outside and inside city limits and at crossings/junctions as well as on straights. Due the relatively low numbers of cases, significant scenarios which are more frequent than others are difficult to identify among truck-PTW-crashes.

After reviewing current state of the art R&D projects and current technologies on the market, the main outcome are the most relevant active safety systems that should be used and improved to achieve a safer HGV for VRUs and other road users. For frontal or turning collision avoidance systems such as Autonomous Emergency Breaking (AEB), Autonomous Emergency Steering (AES). For side crash avoidance, Lane Departure Warning Systems (LDWS), Lane Keep Assist (LKA) and Blind Spot Detection (BSD) should be implemented.

Looking at the passive safety point of view, for VRU scenarios where the pedestrian is in front of the truck and its run over, due to the speed is too low for an energy-absorbing front to be effective, virtual testing is probably the best method to pursue. General guidelines for virtual testing procedures had been considered in previous projects, such as a moving deformable barrier or – simpler still – a rigid impactor test similar to those used for the truck cab front in ECE-R 29.

Also is mentioned that an extended flexible front underrun protection (EFFUP) in addition to offering protection to car occupants, could also be beneficial to Vulnerable Road Users (VRUs) reducing the overrun risk and secondly, reducing the impact forces by offering a softer structure. Only a few centimeters are needed to significantly reduce the risk of serious head injuries due to impact with the truck front. The state of the art review stated that further analysis of these systems would be beneficial.

For the KPIs, at the APROSYS project it was developed a KPI on the Heavy Vehicle Aggressivity Index and also the run-over index evaluation will be taken into account in order to define Aeroflex's WP5 KPI. The KPIs related to Active safety systems that will be taken into account are Activation ratio, Time To Collision (TTC), Last Time To Reaction/Break and Level of redundancy of the system.

Having in mind that some of these systems are required by the regulation, so that the truck can be driven in public roads, the regulation should be used in the virtual testing phase as a baseline for what the AEBS and LKAS systems and frontal end performance must be.

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Project partners:

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1	MAN	MAN TRUCK & BUS AG
2	DAF	DAF Trucks NV
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4	SCANIA	SCANIA CV AB
5	VOLVO	VOLVO TECHNOLOGY AB
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