German Insurance Association

Compact accident research

Risk of tractors in road traffic

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Unfallforschung der Versicherer
GDV

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Content

1 Topic of the research work

Motorized agricultural vehicles (MAVs) are a relatively rare sight on Germany's roads, meaning that the incidence of accidents involving these vehicles is relatively low. According to data provided by the German Federal Statistics Office (Destatis), however, an above-average number of people are seriously injured or killed as a result of such accidents [1]. MAVs are also comparatively often the main cause of the accident (Table 1). This has prompted the German Insurers Accident Research (Unfallforschung der Versicherer - UDV) together with the insurance companies Allianz and Landwirtschaftlicher Versicherungsverein Muenster (LVM) to look into and analyse what kind of accidents involving MAVs happen and also where and under which circumstances these occur. An accident database covering 1,010 accidents was set up and analyzed for this purpose.

2 Accident database

The database comprises information to general accident data, to the persons and to the vehicles involved. All of the tractor accidents contained in the database are to real third party liability claims involving personal injury, which were reported to the two insurance companies, Allianz and LVM, between 2006 and 2008. Out of all of the personal injury accidents caused by MAVs, the cases associated with the highest claims expenditure were evaluated. Essentially, third party liability claims caused by MAVs all over Germany were recorded. This means that as a first approximation, the data provides an overview of the accidents caused by MAVs in Germany.

A whole range of vehicles can be licensed and insured as MAVs. In addition to tractors (Picture 1), these include combine harvesters, forage harvesters, farm loaders, trucks or quads. 98.3 % of the motorized agricultural vehicles in the database are tractors and the average vehicle age is 15.4 years.

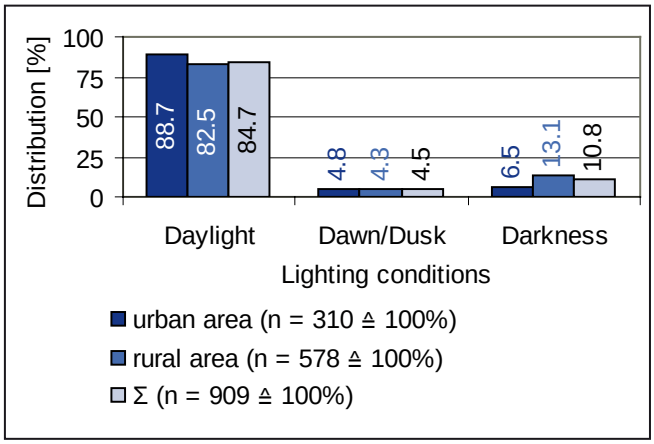
Accident concequences	Motorized agricultural vehicle is				Total	
	main cause for the accident		involved vehicle (third party)			
	Number	%	Number	%	Number	%
Accident with personal injury	938	65.2	570	37.8	1,508	73.0
Accident with fatalities	24	57.1	18	42.9	42	2.0
Accident with material damage	238	46.2	277	53.8	515	24.9
Total	**1,200**	**58.1**	**865**	**41.9**	**2,065**	**100.0**

Table 1:
Share of MAVs as the main cause of the accident within all accidents with MAVs in Germany for the year 2008 [1]

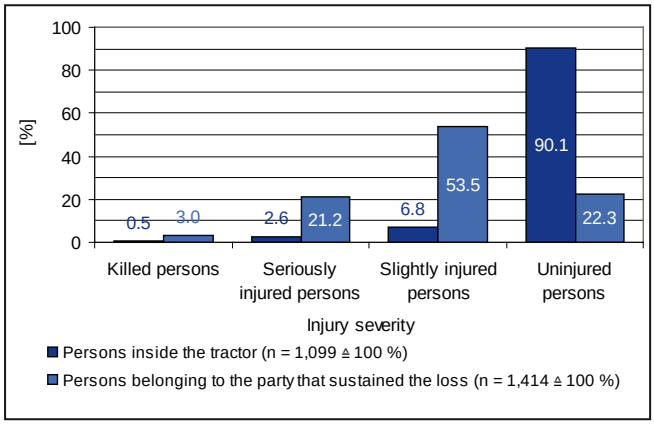
Picture 1:
Example for a tractor of the type Fendt 311 Vario [2]

3 Accident structure for tractor accidents involving personal injury

Out of the 1,010 accidents recorded, the section below will look only at the 926 accidents that happened on the roads (92 %). 91 % of these accidents were reported to the police. One third or so of the accidents involving tractors happen in built-up areas (urban), meaning that two-thirds occur outside (rural) of built-up areas. 85 % of accidents happen during the day, 11 % at night and the rest occurs in the hours of dawn. Outside of built-up areas, however, accidents are twice as likely to happen when it is dark than in build-up areas (Picture 2). Furthermore, the consequences of accidents that happen in the hours of darkness are more severe for the persons involved: the proportion of fatalities and serious injuries is above-average. As far as the injured parties are concerned, however, a distinction has to be made between the persons inside the tractor (i.e. the policyholder) and the party sustaining the loss: while 90 % of the persons inside the tractor survive the accident without sustaining any injuries, the same figure stands at only 22 % for the party sustaining the loss (Picture 3). 3 % of the parties sustaining the loss are killed, 21 % are seriously injured and a further 54 % sustain minor injuries. If we analyze accidents caused by tractors by the month of the accident, it is clear that the majority of accidents involving tractors happen in September (15 %). A particularly large number of accidents involving tractors also happen in the summer months of July and August (13 % in each case).



Picture 2:
Accidents with MAVs broken down by lighting conditions and by accident location [LZM-Database]



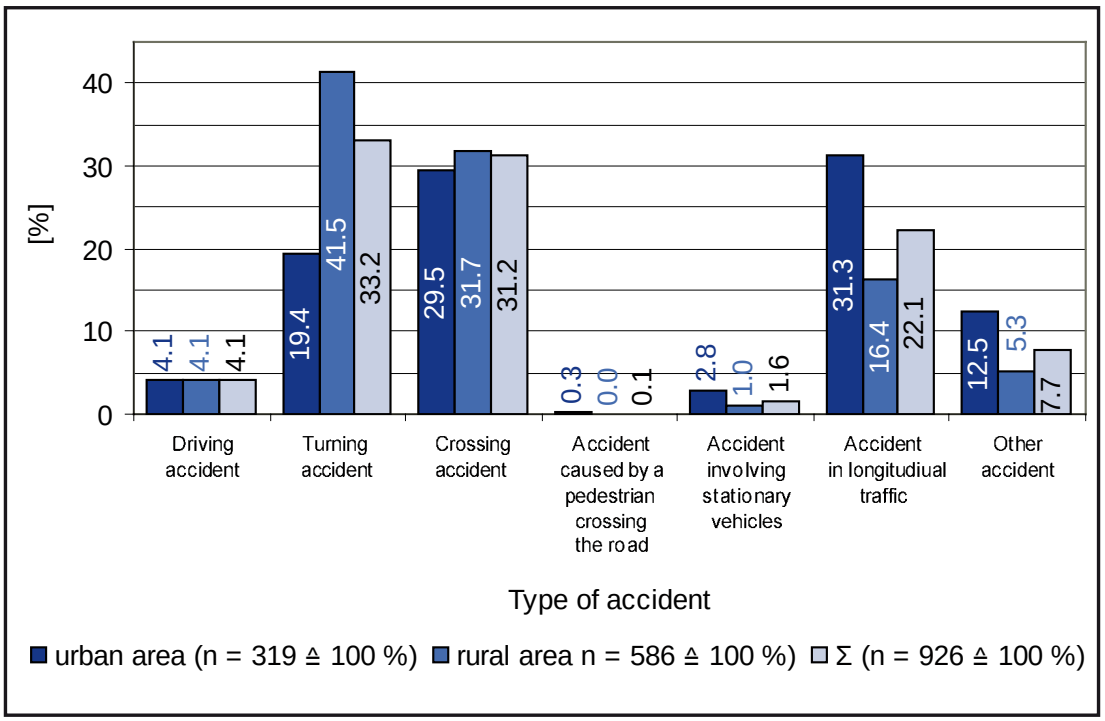
Picture 3:
Distribution of the injury severity for the involved parties (including MAV occupants) in accidents with MAVs [LZM-Database]

The driver of the tractor is extremely likely (98 %) to be male. If we look at the age of the tractor driver, the distribution is similar to the

data from the official German accident statistics in a very good approximation. What is striking is the fact that young tractor drivers (aged 15 to 24) account for an above-average proportion of accidents compared with this age group's share of the population as a whole (22 % as against 11 %).

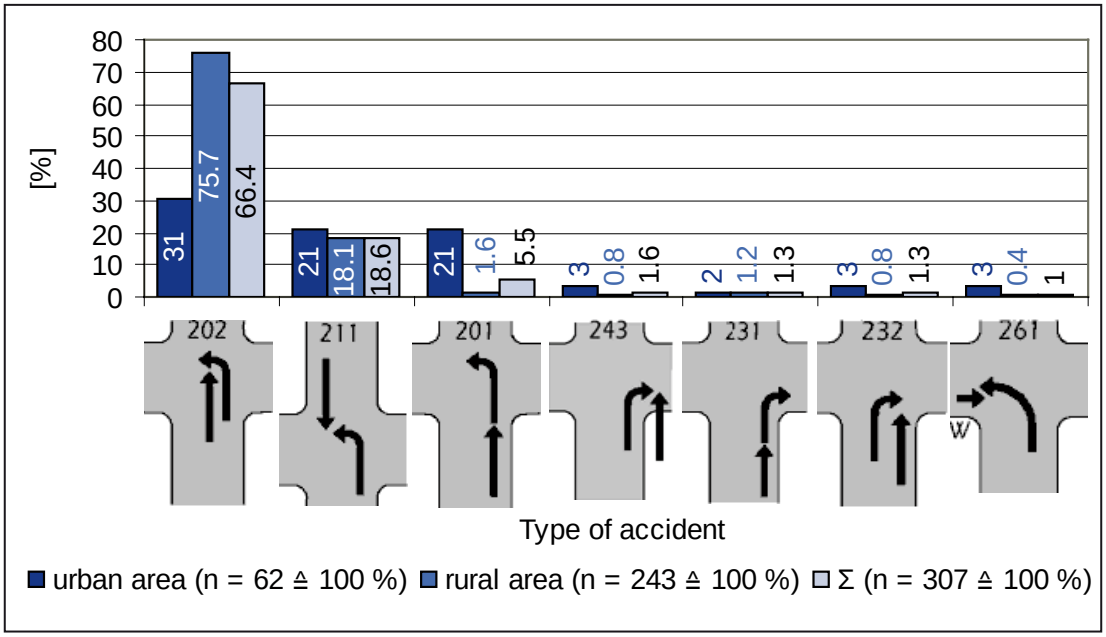
The course of accidents can be described in a first approximation by using the type of accident. It describes the first conflict that led to the accident. In the case of accidents involving tractors, turning accidents account for the largest proportion, at one third. Crossing accidents account for a similarly high proportion at 31 % (Picture 4). At 22 %, accidents in longitudinal traffic account for the third-largest share of all accident types.

By far, the most common accident subtype within turning accidents is a collision between a tractor that is turning left and a vehicle overtaking from behind (accident subtype „202", 22 % of all accidents, 66 % of turning accidents account) (Picture 5). Young tractor drivers (aged 24 or below) are most likely to be involved in a turning accident, whereas tractor drivers aged over 64 are most likely to be involved in a crossing accident. In the case of tractor drivers, the accident causes very often involve mistakes made when turning off a major road into a minor one (41 % of n = 802 known accident causes) or failing to comply with the rules governing right-of-way (28 % of n = 802 known accident causes). As far as the party sustaining the loss is concerned,



Picture 4:
Accidents with MAVs distributed to the different accident types and by the accident location [LZM-Database]

1) Turning accident: accident caused by a conflict between a vehicle turning off and another road user approaching from the same or opposite direction (incl. pedestrians) at crossings, junctions etc.
2) Crossing accident: accident caused by a conflict between a road user turning into a road or crossing it and having to give way and a vehicle having the right of way at crossings, junctions etc.
3) Accident in longitudinal traffic: accident caused by a conflict between road users moving in the same or opposite direction, unless this conflict belongs to a different type of accident.



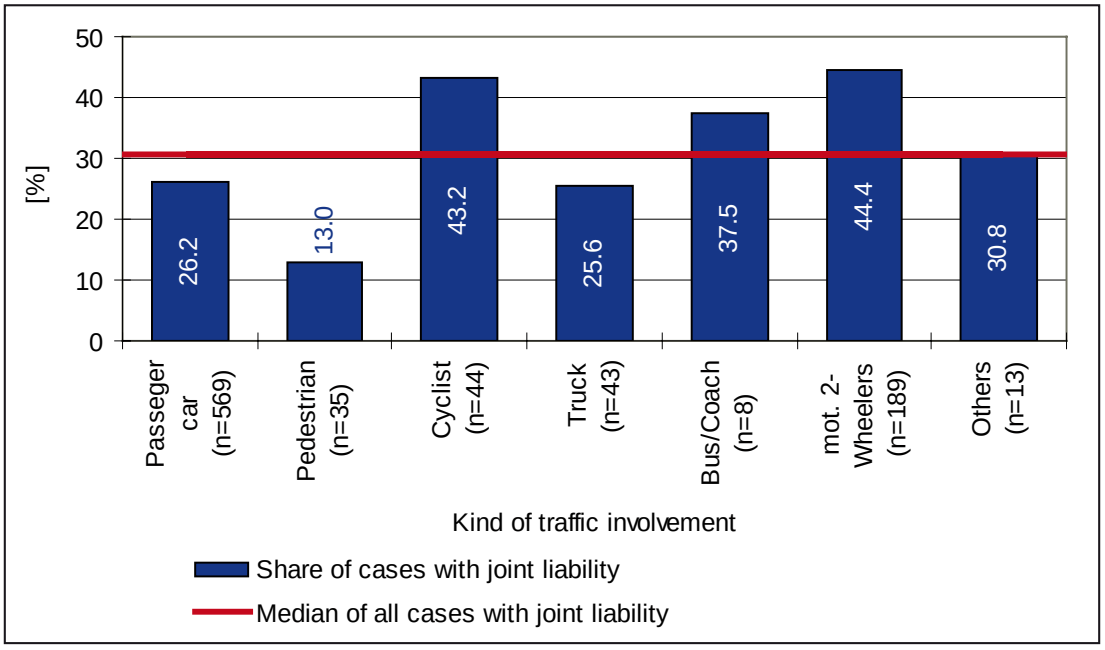
Picture 5:
Turning accidents with MAVs distributed by the subgroups of this accident type and by the accident location [LZM-Database]

accidents are most likely to be caused by mistakes made while overtaking (45 % of n = 204 known accident causes).

Since turning and crossing accidents account for the highest proportions of all accident types, it is plausible that, in terms of all accidents, accidents often happen at side road intersections (50 %), at junctions (19 %) and at entrances/exits to property (10 %). If we analyze the accidents that occur at side road intersections more closely, we can see that one quarter of all accidents happen where a farm track meets a major road and that, at the intersection between a farm track and a major road, almost the only types of accident that ever occur are turning accidents (61 %) or crossing accidents (36 %).

The most common other party in an accident involving a tractor is a car (64 %), followed by motorbikes, which account for an above-average share of 22 % because the annual distance traveled by these vehicles is only less than two percent of the total annual distance traveled by all vehicles. Cyclists (5 %) and pedestrians (3 %) account for a very small share of accidents involving tractors. Accidents involving tractors are characterized by a high share of joint liability on the part of the party sustaining the loss. Thus, the analyses revealed a total of 31 % of all parties sustaining a loss in an accident with a tractor that had to bear joint liability. Especially in the case of motorbikes, these parties' claims to compensation are very often limited (44 %), as is the case for cyclists (43 %). It is less likely for cars, trucks (26 % each) and pedestrians (13 %) to be proven to have joint liability in the event of an accident (Picture 6).

With respect to the tractors, the accidents mainly involve tractors produced by Case New Holland (23 %) and Same-Deutz-Fahr (16 %), in addition to Fendt (26 %) and John Deere (16 %) tractors. 58 % of tractors have a trailer attached, 13 % are involved in an accident with equipment attached to the three-



Picture 6:
Share of the cases with joint liability of the party sustaining the loss, broken down by the kind of traffic involvement in accidents with MAVs [LZM-Database].

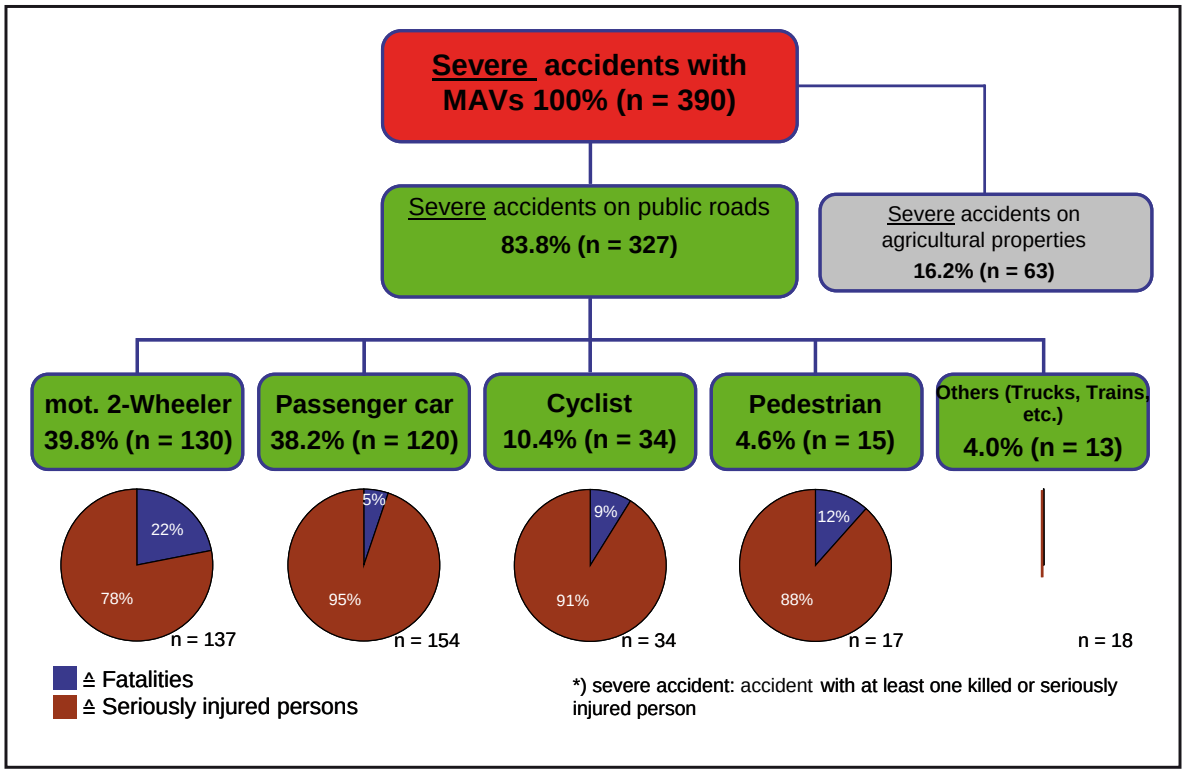
point hydraulic lift, 9 % of the vehicles have two trailers attached and 16 % are involved in an accident without having a trailer or any accessory equipment. Despite the considerable increase in the engine power of tractors over the past few decades, the driving speed of the tractors involved in accidents is low. In 53 % of the cases, the tractor was traveling prior to the accident at a maximum speed of 20 km/h, in 4 % of the cases it was stationary. 3 % of the tractors were reversing and only 4 % of them were involved in an accident when traveling at a speed of more than 41 km/h.

4 Sefere accidents involving tractors

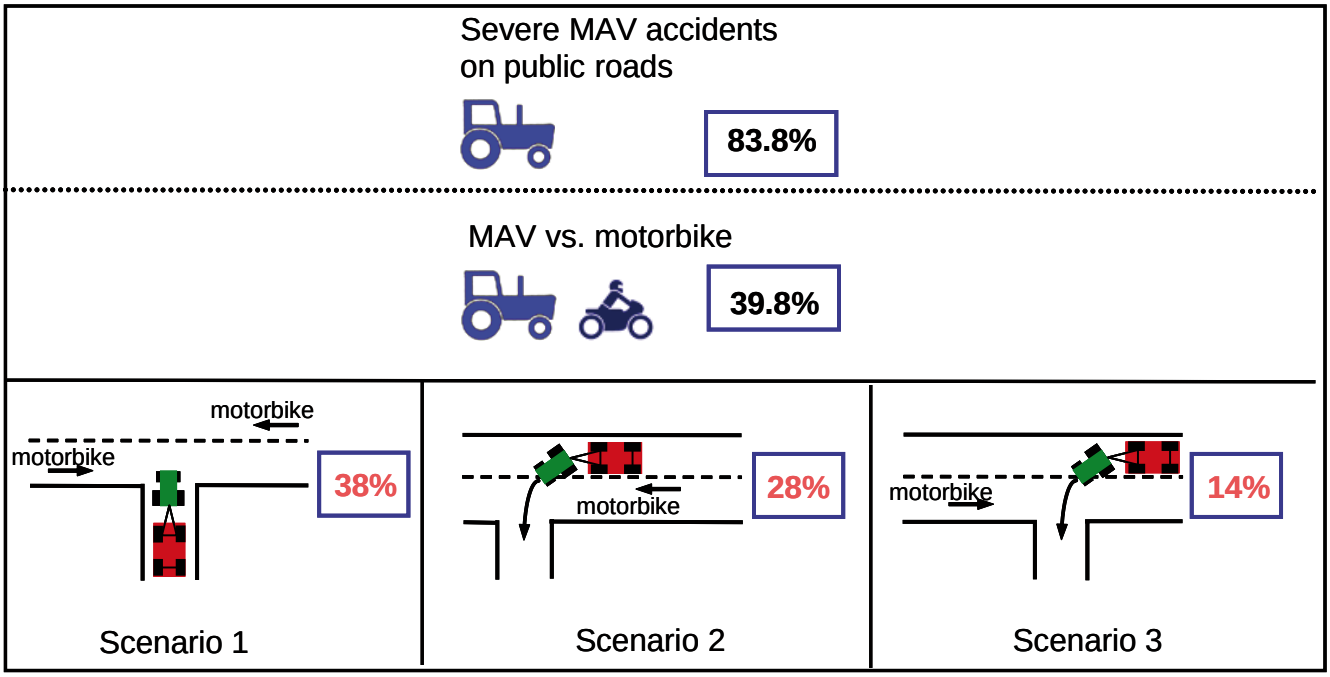
If we only look at the 390 severe tractor accidents involving 441 fatalities and/or serious injuries, there is a - in some cases considerable - shift in the proportions described above. The above-average involvement of motorbikes is particularly exacerbated: accounting for 40 % of all parties sustaining the loss, this is the largest group, followed by cars (38 %) and cyclists (10 %). Furthermore, 22 % of the parties sustaining a loss die in severe accidents involving a tractor and a motorbike, compared with only 5 % in accidents involving cars and 9 % in accidents involving cyclists (Picture 7).

In the case of severe accidents involving tractors and motorbikes, there are three scenarios (Picture 8) to which 80 % of the fatalities and serious injuries are attributable. These include crossing accidents (39 %), a collision between a tractor that is turning left and an overtaking motorbike (accident subtype „202“, 28 %) and a collision between a tractor that is turning left and an oncoming motorbike (accident subtype „211“, 13 %).

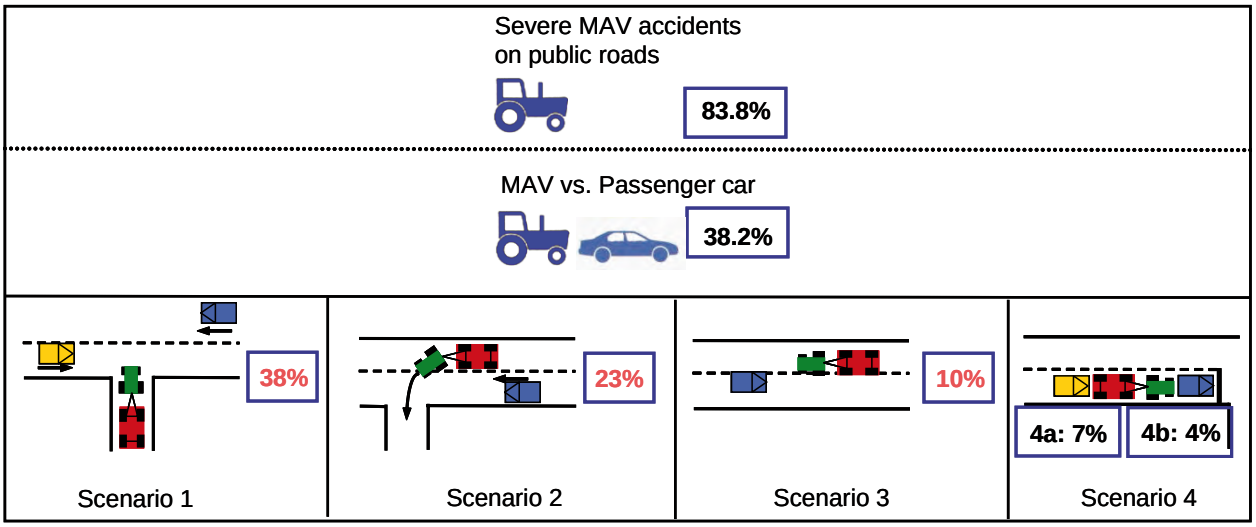
In the case of severe accidents involving tractors and cars, there are four characteristic scenarios (Picture 9) to which 85 % of the fatalities and serious injuries are attributable. Here, too, crossing accidents (41 %) and the accident type



Picture 7:
Severe accidents with MAVs broken down by the accident opponents and by their injury severity [LZM-Database].



Picture 8:
Main accident scenarios in collisions between MAVs and motorbikes and their share of the accident occurrence [LZM-Database].



Picture 9:
Main accident scenarios in collisions between MAVs and passenger cars and their share of the accident occurrence [LZM-Database].

„202“ (23 %) are represented as two of the scenarios. The two other scenarios are collisions between tractors and oncoming traffic (accident type „68x“, 12 %) and rear-impacts against the tractor (accident types „60x“ and „62x“, 9 %).

5 Crash tests

In order to illustrate the results of the research work, two crash tests have been performed at the crashtest-center in Neumünster. The test scenarios were selected in accordance to the blackspots derived from the accident occurrence of MAVs, as already described in the previous chapters.

The first test scenario describes a collision between a tractor that is turning left and an overtaking motorbike. In order to simplify the test, the tractor was stationary. The motorbike had an impact speed of 70 km/h. Furthermore, an impact angle of 30° between the motorbike and the tractor and an overlap of 100 % were chosen.

In this test, the motorbike was almost completely damaged. The rim, the fork and the stanchion tubes were broken and the handlebar was bent badly. The fairing, the cockpit and the lights were completely destroyed. However, the tractor sustained only minimal damages. The rear left rim was dented, the tire was cut in and the axle mounting was broken. The loads applied on the motorbike-dummy during the crash were not measured. The kinematic analysis of the crash videos and of the forces at this high impact speed leads to the conclusion that a motorcyclist would not have survived in such a situation.

The second test configuration describes the typical accident scenario where an overtaking pas-senger car impacts a left turning tractor. In this test configuration, the impact speed of the car was 75 km/h. The car hit the side of the tractor at an angle of 30° with an overlap of 100 %.

In the car, two 50 % Hybrid III-Dummies were each placed on the driver seat and on the front passenger seat. After the crash, the front crumple zone of the car was highly damaged. The passive safety features of the vehicle were efficacious during the crash so that the measured dummy loads remained under

Picture 10:
Crash test with tractor vs. motorbike (before the impact)

Picture 11:
Crash test with tractor vs. motorbike (after the impact)

Picture 12:
Crash test with tractor vs. passenger car (before the impact)

Picture 13:
Crash test with tractor vs. passenger car (after the impact)

the critical levels. However, it must be assumed that car passengers would suffer serious injuries in such an accident configuration. The damages on the tractor were also considerable.

The crash movies can be seen at
www. youtube.com/unfallforschung.

For educational purposes, such as for driving schools or for advanced training programmes, the UDV has produced three instructional films, which can be ordered for free as a DVD at **unfallforschung@gdv.de.** These can be seen in advance on the UDV-youtube-channel.

6 Loss prevention measures

Although the number of people killed on the roads is at its lowest level since the 1950s, the aim has to be to further reduce the number of fatalities and injuries in road traffic. In order to achieve this, one must also take a look at the accident situations which occur less frequently. Consistently, due to its highly severe accident outcome, the accident occurrence involving tractors should be part of this consideration. In this respect, a whole range of loss prevention measures, such as infrastructure and driver-related measures, can increase road safety in respect of accidents with tractors, too. Furthermore, loss prevention measures also relate to the individual vehicles. Since accidents involving tractors are rare, but often serious and tend to vary considerably in terms of the circumstances involved, there is no sweeping single measure that could reduce the severity of these accidents or prevent them entirely. Nevertheless, a precise analysis of the accident circumstances in the study identified numerous potential approaches that could help prevent accidents or at least mitigate their consequences.

- In order to help drivers of tractors during turning manoeuvres, tractors can be fitted with a driver assistance system similar to the lane change assistant system that is already available for cars and which can adapted to suit the special needs of tractors. The the lane change assistant system warns the drivers of tractors of a potential collision with overtaking vehicles when these are approaching the tractor from behind. This addresses 23 % of accidents, involving 21 % of the killed or seriously injured, that occur on the roads.

- By optimizing the tractor signal image (e. g. retroreflective foil on the rear and sides of the vehicle, trailers and attachments, anti-glare headlamps, bright rear lights, beacon lights etc.) [3], 16 % of accidents involving 17 % of the killed or seriously injured can be addressed.

- In order to hinder cars from under-running the tractor trailers, they should be fitted with an underrun protection device. In this respect, 7 % of the accidents involving 7 % of the killed or seriously injured could be addressed.

- For traffic coming from behind (and also oncoming traffic) the tractor, it is of fundamental importance that the indicator lights are functional and can be identified. Appropriate measures (e. g. robust cable connections, shock-proof indicator housing, beacon lights as indicators, etc.) can address 7 % of the accidents involving 4 % of the killed or seriously injured.

- Since newer tractors are very powerful, meaning that they can reach considerable speeds even when carrying the maximum load, it is recommended to fit tractors with an Anti-lock Braking System. This would

result in 4% of the accidents with 1% of the killed or seriously injured that could be addressed by the system.

- Drivers of tractors find it easier to turn onto a major road or to cross a major road if their field of visibility from the farm track or the property is not obstructed to either side of the road with right-of-way (e.g. by trees, bushes or a nearby curve in the road). The removal of any visual obstructions can address 3% of the accidents with 5% of the killed or seriously injured.

- Accidents involving tractors driving in reverse can be addressed by way of a rear view camera. This would result in 1% of the accidents with 1% of the killed or seriously injured that could be addressed by the system.

- Training particularly for young drivers of tractors could be a very effective step here. It should sensitize young tractor drivers especially in terms of turning into and off major roads properly and in terms of assessing speeds and distances better.

Counter-measures designed for loss prevention can clearly increase their effect if these address the other accident involved party as well.

- An Anti-lock Braking System for motorbikes addresses 6% of accidents and 9% of the killed or seriously injured. With motorbike Anti-lock Braking System, the bike remains stable, can still be steered and does not crash even when the brakes are applied in full. Motorbike users may still be able to perform an evasive manoeuvre, or at the very least, the speed is reduced to the greatest extent possible to reduce the accident severity [4].

- A further crucial contribution to the avoidance of an imminent accident can be made by increasing the perceptibility of motorbikes, for example by way of lights for use during daytime, retro-reflective foil or protective motorbike clothing in colors that act as a signal.

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