Agricultural Vehicles and Rural Road Traffic Safety: An Engineering Challenge!

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Abstract

Road collisions are a problem world-wide. Related to the kilometers traveled on public roads agricultural vehicles (AVs) are over represented in reported numbers of traffic victims. We aim to investigate how agricultural engineering can reduce accidents with AVs involved on public roads. We therefore relate so-called accident factors to the 3 road system components; driver, vehicle and road. We summarize the significance of 10 accident factors and describe possible preventive measures from an engineering perspective. We show that all road system components may attribute to a structural improvement of traffic safety with AVs on public roads. Agricultural engineering can play a role in each of them.

Key words: accident analysis – accident prevention – farm vehicles - public roads – The Netherlands

1. Introduction

Injuries due to road collisions impose an enormous social and economic burden on society (WHO, 2004) and are therefore declared a major global problem by the UN in the "2011-2020 Decade of action for road safety". The role of agricultural vehicles (AVs) in this road safety problem is somewhat "hidden". This position is a result of most statistics as they do not report AVs' collisions explicitly. Worldwide collisions with AVs are included within a general category such as "other vehicles". However, the scarce specific data indicate that AVs are over represented in reported traffic accidents if we relate accident figures to the kilometers traveled on public roads by AVs (Costello et al., 2009). These data are not surprising considering the deviating dimensions, mass, and speed of AVs compared to other traffic participants on minor as well as major rural roads (Jaarsma et al., 2003). On minor roads AVs may conflict with vulnerable road users such as pedestrians and cyclists, where on rural highways differences in speed between AVs and cars and trucks is the main safety problem (Jaarsma, 2006a and b). Where AVs appear in urban areas the livability of residents is threatened.

This paper aims to investigate how agricultural engineering can improve rural traffic safety with AVs. We therefore first present a method section, with a conceptual model, relating so-called accident factors to the three road system components; driver, vehicle and road. These system components are the basis for a further elaboration in the next three sections. Finally, a discussion section with conclusions is presented.

2. Method and material

A usual approach in transport safety analysis is to attribute road collisions to failures in at least one of the three road system components – driver, vehicle and road (Wei & Lovegrove, 2012). In an in-depth study the Dutch Safety Board (DSB) first analyzed police reports related to 11 serious accidents with AVs in the period 2008-2010 and then interviewed the drivers involved who had survived the incident. Additionally the police reports of another 73 fatal accidents were analyzed. From this study DSB derived a list with 10 “accident factors” assigned to the three road system components. We use this 3-layer conceptual model (Fig. 1) as a basis for our engineering approach. We consequently summarize the significance of the accident factors as analyzed by the DSB (2010) followed by a description of possible preventive measures, either proposed by DBS (2010) or from other international literature.

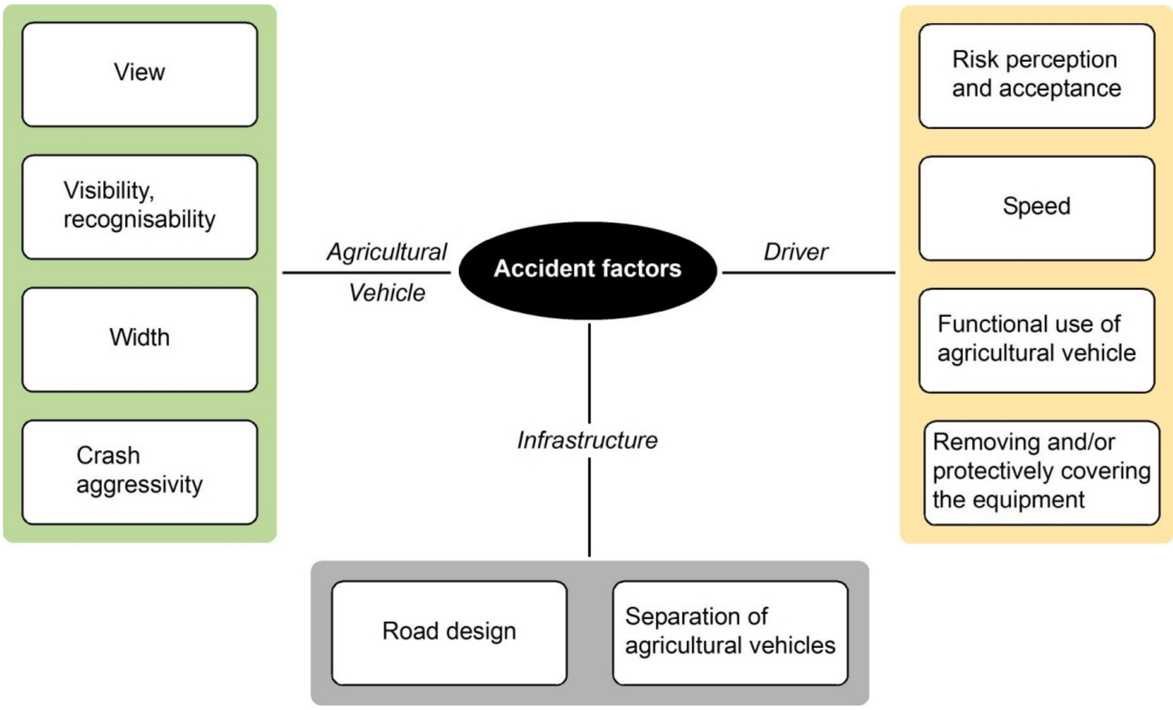

FIGURE 1: Conceptual model for 10 accident factors in 3 system components (Source: DSB, 2010)

TABLE 1: Overview of legal regulations for agricultural vehicles on public roads in 11 European countries. Source: DSB (2010)

	Nether-lands	France	Belgium	Portugal	Sweden	Germany	Denmark	United Kingdom	Poland	Slovakia	Italy
Maximum width (m)	3.00 a)	2.55	2.55	2.5 b)	2.10 c)	3.00 d)	2.55 e)		< 3	f)	2.55 g)
Maximum weight (ton)	50	40 h)	10 per axle	60	18		44	24			6 per axle
Maximum speed (km/h)	25	40	40	20	40	40	30	20			40

a) If an exemption has been granted: 3.50 m
b) 3.0 m if registered and > 3 m with special permission
c) A vehicle towing an agricultural machine may be wider than 2.6 m
d) Special permission is required for wider vehicles
e) 3.3 m or more between a farm and farmland
f) Permission required for ‘large’ vehicles
g) Permission required for vehicles > 3.2 m
h) Depending on the number of axles and trailers

DSB (2010) puts their findings for the system components also in an international context, by comparing laws and regulations governing AVs on public roads in 11 European countries, including the Netherlands. The information concerning the AVs is gathered in Table 1.

The farming machinery industry is operating on a global scale. However, the table shows considerable differences between the countries for permissible weights and dimensions. The permissible weight of AVs varies between 18 tons in Sweden and 60 tons in Portugal. The maximum in the Netherlands is 50 tons. In most countries the permissible width on public roads is 2.55 m or less (France, Belgium, Portugal, Sweden, Denmark and Italy). For Germany and the Netherlands this is 3.00 m. In most countries, including the Netherlands, road authorities can give a special permission if individuals wish to drive AVs exceeding a width of 3.00 m on public roads. Additional to the table it is worth mentioning that in the Netherlands there is no registration system for AVs and no registration numbers are issued. This is an exception in Europe, where most countries have a mandatory registration system for either agricultural tractors, self-propelled equipment, or both.

The exceptional situation in the Netherlands also holds for driving licenses: so far such a document is not mandatory at all. In other countries a driving license is mandatory. The requirements for the licenses differ per country and are not always AV specific. For example, in France, Sweden, Denmark, Poland and Italy a category B license for cars is enough for AVs weighing less than 3.5 tons.

3. The agricultural vehicle

Four accident factors are related to the AV: view, visibility and recognisability, width and crash aggressivity (Fig. 1).

It is undisputable that drivers must have a good view of the situation surrounding their vehicle from their seat to drive a vehicle safely on a road. However, this is a weak point for AVs, where this view is frequently obstructed through interchangeable parts and/or loads, both possible at the front and in rear of the AV. DSB (2010) found that view played a role at 24% of the serious accidents investigated. In which this percentage was equally distributed for obstructions related to front view and rear view. From the viewpoint of traffic safety, driving with obstructed view on public roads is not acceptable.

During darkness the visibility and recognisability (i.e. interpreting and responding correctly to the traffic situation) of the AV proved to be problematic for car drivers. Car drivers do not immediately recognize the AV they are approaching as such. Consequently, they don’t realize that this vehicle’s dimensions and speed deviate from what they would normally expect, namely another passenger car. This misperception causes head-on as well as rear-end collisions. To improve the recognisability of the AV’s front during darkness the legal configuration of headlights and wide-beam lights and their maximum luminous intensity should be re-designed. Also the use of a flashing light (in the Netherlands only permitted for AVs exceeding a width of 2.60 m) during darkness should be considered. For the rear end additional retroflective markings might be considered.

The previous accident factor, visibility, is the more important because AVs are allowed in the Netherlands to be wider (with granted exemption 3.50 m; see Table 1) than other vehicles (limited to 2.60 m). In half of the cases where vehicle width played a role in accidents analyzed by DSB this is caused through an insufficient road width, not suited for AVs wider than 2.60 m. In the other half of the cases this is caused by the AV (width > 2.60 m). Therefore DSB (2010) proposes to decrease the Dutch legal limit for vehicle width to the more common 2.60 m (Table 1). This is too small for many activities in a modern mechanized agriculture, calling for a design of ‘flexible’ machinery that quickly can be transformed from a wider labor situation to a smaller transportation mode.

In the event of a crash AVs form a hazard to other road users. They have a high aggressivity by their weight, stiffness and vehicle design, including sharp parts of protrudes. The latter played a role in 12% of DSB's cases. In 10% of the cases a counterweight was mounted on the AV. This increased the severity of the crash in half of these cases. Again, the engineering design is challenged to find solutions for a quick transformation between labor and transportation activities with the same AV.

It should be noticed that even an AV constructed conform high safety standards may become unsafe through the way it is used by its driver. It is a driver's decision to accept limited view from the seat and vehicle width. As it is also the driver's decision to protect sharp parts of protrudes before entering the public road. In the next section we further focus on the driver.

4. The driver of the agricultural vehicle

Four accident factors are related to the driver of the AV: risk perception and acceptance, speed, functional use of the AV and removing and/or protectively covering the equipment (Fig. 1). As mentioned in section 2, in the Netherlands no driver license is required for driving an AV. The only precondition for driving an AV is that the driver must be at least 16 years old.

Risk perception means that drivers perceive and assess dangers. Next, they decide to accept the perceived risk or not. Finally, if not accepted, they must take timely action to avoid the risk. The group of young and inexperienced (male) drivers is well-known to have a poor risk perception as well as a high risk acceptance. However, this accident factor is important for all ages (DSB, 2010). Therefore training in driving including examination and procuring a driver license should also include courses on risk perception. This can make drivers of AVs more aware of the risks they form for other road users (Wildervanck, 2012).

Most of new tractors sold are designed for speeds over 40 km/h (DSB, 2010) and can easily exceed the Dutch legal limit of 25 km/h. Speed figures show that this is happening widely; on an arterial highway observed average speeds vary between 30 and 40 km/h and only 6% respects the legal 25 km/h (Coffeng et al., 2006). The higher the speed, the more severe the consequences are in case of a collision. Training in risk perception may also be helpful here, as well as speed reduction by campaigns, public information programs, infrastructural measures and –finally- enforcement by the police.

Functional use of public roads by AVs means that the trip is necessary for performing agricultural activities. In the Netherlands AVs are used as well for the transportation of materials such as sand by the building industry as a cheap alternative for trucks. In addition, it is even seen that AVs are used by youngsters to go to school (replacing a bicycle or moped). This dysfunctional use results in AVs generating more kilometers traveled on public roads. Not surprisingly, dysfunctional used of AVs was found in some of the serious accidents studied (DSB, 2010). Related to dysfunctional use we should notice that this is the responsibility of the owner of the AV or the company hiring AVs for other purposes then agricultural activities.

It is a driver's decision to protect equipment with protrudes, or to remove equipment, such as a contra weight in front, before using a public road. To do so, in practice, this may need two persons or specific machinery (only available on the farm building, not on the land). Engineering design should be aware of such problems.

5. The network of public roads

Two accident factors are related to the road infrastructure: technical road design and separation of AVs (Fig. 1). For this purpose a distinction between minor rural roads (MRRs), rural arterial highways, and urban roads is relevant. MRRs give direct access to farms and farmland, and as so, MRRs are the “natural habitat” for AVs. However, arterials as well as urban roads are also used by AVs, especially for longer trips. Then these road categories may be part of a logical route between farm, farmland and/or agricultural services, for example to deliver harvested products. Given the necessity for AVs to use public roads, this use may be reduced by shortening the distances between farmstead and scattered parcels. This can be achieved by re-allotment (land consolidation) or an exchange of parcels between farmers (on a voluntary basis).

Road design decides a driver’s experience (i.e. “which other types of vehicle are to be expected here”) and behavior (i.e. “which speed is justified here”). Against this background a wide range of infrastructural measures is possible, focusing on either the car driver or the driver of the AV, or both, and depending on the road category. For arterials passing bays for AVs may considerably decrease delays for other vehicles (Jaarsma, 2006b). As a warning signal to indicate the actual presence of an AV on such a major road for other drivers, specific ITS solutions might be developed. For MRRs and urban roads the permissible width of an AV related to this generally narrow infrastructure is considered as the main problem (DSB, 2010). Paved or sealed shoulders improve the accessibility for AVs, just as a widening of the road, either on selected locations or on its full length. Speed reducing measures also may be necessary, either horizontal (extra bends and narrowed passages) or vertical, such as rumble strips and/or speed humps (Jaarsma, 2006a).

A full separation of AVs is only possible for arterial highways. Therefore an alternative route on minor roads or a parallel road must be available. And then the next two problems appear: these alternative routes generally have a narrow road width and are used by vulnerable road users. A partly separation can be realized by a concentration of AVs on a network of a limited number of roads, arterial as well as MRRs. Therefore a tailor-made solution has to be designed, with the commitment of all road authorities and the agricultural industry in an area (Louwerse et al., 2012).

6. Discussion and conclusions

Trip lengths on public roads with AVs to access the farmland are getting longer through an ongoing enlargement of scale in agriculture (Gkritza et al., 2010). At the same time “[f]arms are sharing once quiet rural roads with a growing population of non-farm vehicles” through urban developments and other new economical functions in the rural area (Costello et al., 2009). The combination of longer trip lengths of AVs and more non-farm traffic considerably increases the risk of collisions between AVs and other road users. The unsafe traffic situation also threatens the attractiveness of the multi-functional rural area for recreation and agro-tourism. Soft green modes (walking, cycling) are most sensitive for these threats.

Road crashes with AVs involved are a major safety concern for farmers (Costello et al., 2009). A key problem for road safety is that AVs primarily have been constructed for use on agricultural land. Therefore requirements on vehicle design to ensure vehicle safety that have been imposed on other motor vehicles have not been stipulated for AVs (DSB, 2010), making AVs on public roads dangerous for other road users. Also the standards for lighting of AVs are reported as a problem for car drivers, because they do not recognize the AV as such during darkness (Gkritza et al., 2010).

In a decade of action for road safety it is a big and double challenge for agricultural engineering: (1) to make a turn downwards into the number of AVs involved in traffic accidents, despite an increasing number of vehicle kilometers travelled on public roads, and (2) to reduce the severity of accidents that still happen, despite the aggressiveness of the AV in a collision with other road users through its specific vehicle design.

In conclusion, all three road system components may attribute to a structural improvement of safety and agricultural engineering can play a role in each of them. Related to the driver of AVs a better education is possible, more focusing on risk perception. Related to the vehicle a safer design is needed, including possibilities for an easy reduction of machinery width during transport on public roads as well as outside daylight hours a lighting better identifying the AV as so for other drivers. Related to the road, a wide spectrum of measures is possible, starting with a reduction of the need for transport by a concentration of scattered parcels near the farm building and to the designation of specific routes, with road characteristics adapted to AVs. For road infrastructure measures tailor made solutions are needed: due to differences in national legislation as well as in initial situations, a different mix of measures should be developed for different countries. Such solutions may even differ between regions.

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