

More Security For Kids Around Moving Vehicles On Farms

Elisabeth Quendler¹, Peter Veith², Alfred Pohl², Josef Boxberger³

¹Universität für Bodenkultur, Institut für Landtechnik, Peter Jordan Straße 82, 1190 Wien, Austria,
Elisabeth.quendler@boku.ac.at

²Siemens AG Österreich, Erdberger Lände 26, 1031 Wien, Austria, peter.veith@siemens.com,
alfred.pohl@siemens.com.

³Universität für Bodenkultur, Institut für Landtechnik, Peter Jordan Straße 82, 1190 Wien, Austria,
josef.boxberger@boku.ac.at

Abstract

Kids die or suffer serious injuries by moving tractors or other vehicles on farms. For this worldwide problem three reasons have been identified, these are the restricted view of the driver and the limited risk awareness of children and parents.

Experimental results show that there exist invisible areas next to the wheels, hitched up machineries and in front of the tractor bonnet. Small children cannot be detected from drivers in these areas. They are usually uninformed about the presence of children during machinery work. Keeping children away from farm activities as good as possible is not appropriate for every family. Therefore an alternative would be a driver assistant system which warns the driver about the presence of kids in invisible zones. The size of invisible zones is influenced by the moving speed of vehicles and kids which determine the total stopping distance. Test scores indicate that a driver assistant system must cover the area of at least 5 meters in front and beside a moving farm vehicle and at least 2 meters at the back side of a hitched up machinery to avoid collision. These requirements can be fulfilled by a combination of a microwave radar and a short wave field system, with an ultra low power transponder.

Keywords: driver assistant system, low power transponder, microwave radar and short wave field, kids, injuries, farm machinery, tractor, farmyard

Introduction

Agriculture has one of the highest fatal injury rates to children. The working places of adults are homes, playing and holiday areas of children on farms. The most common causes of death

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and major injuries were being struck by a moving tractor or another farm vehicle in farmyards or fields.

Three main reasons are responsible for these tragic accidents, the restricted view of drivers and the limited risk awareness of children and parents. The drivers are mostly uninformed about the presence of children near the moving or standing vehicle. It is difficult for them to provide constant supervision when performing farming duties with machines.

Driver assistance systems which could detect persons in hazardous zones around vehicles and warn drivers could be used to control these risks.

Accidents and their reasons

The risks to children from moving farm machinery are a world wide problem. On average one child is killed every month in incidents involving moving vehicles on Australian farms. In Austrian agriculture each year 5 to 10 children die and nearly 4000 children suffer serious injuries. Toddlers are most at risk. Par example, more than 40 percent of all farm machinery related deaths are among children ages 4 and under in Colorado, United States. Similar figures are known from other countries like England, Canada and Germany. About 50 to 90 percent of these fatal accidents are caused by forwards or backwards moving farm vehicles. Most of these accidents occur during working sessions in farmyards with relatively old tractors or trailers.

This existing danger and the market potential for preventive measures are strongly influenced by the number of running tractors and vehicles on farms. Worldwide 26,3 million tractors and 4,2 million other vehicles will be used. Agriculture of Germany, Austria and Switzerland own 1,5 million tractors together. Around 33.000 new tractors will be sold per year in these countries.

Reasons for these injuries and deaths are mainly the lack of adequate parental supervision, the absence of physical barriers between young children and farm vehicle hazards as well as the limited view of drivers. Many parents may not realise that children under seven have many limitations. They cannot mentally manipulate ideas, they need concrete situations and rely on perceptions, which can be inaccurate. Their ability to reason and use logic is immature. Kids cannot apply what is learned in one situation to another situation. This means, they do not take into account oncoming vehicles hidden by objects and have poor ability to judge speed, distance and danger.

Dangerous Zones

Drivers are confronted with a restricted field of vision, despite optimal visual acuity. The angle of vision is limited downwards by a horizontal plane passing through the eye position and upwards by planes containing the rays of vision form the eye position to the points of obscuration, caused by vehicle components. Additional, there exists a masking effect, caused by structural components, such as roof pillars and exhaust pipes.

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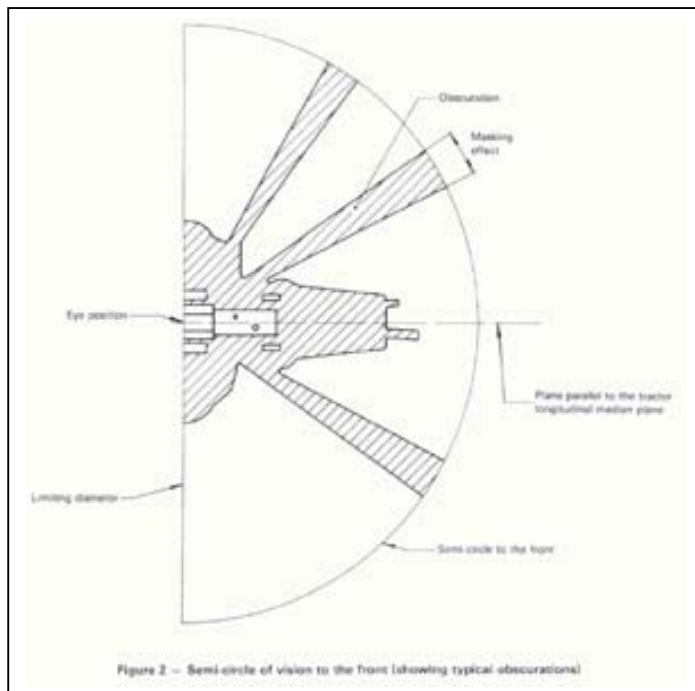


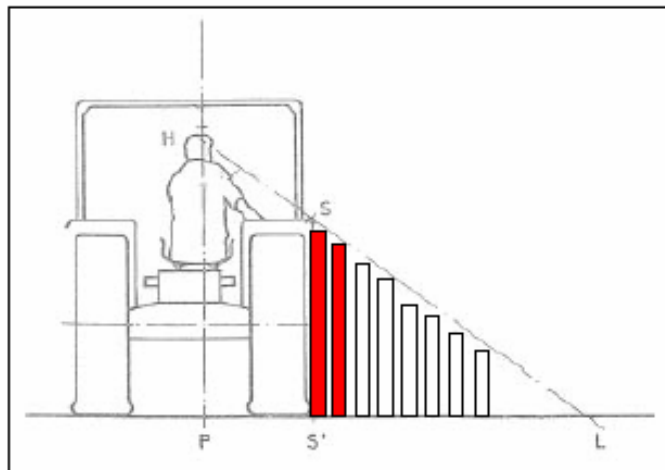
Figure 1: Semi-circle of vision to the front
Source: ISO 5721, 1989, S 5

Therefore drivers do not realize young persons in some zones of these shadowed areas. An experiment has been done with a tractor (Steyr 8090 Turbo) and trailer to detect the most dangerous invisible zones. The tractor has a length of 3,7 meters and a width of 4,2 meters. The trailer is 6,6 meters long and 4,3 meters wide. The back wheels measures 1,5 meters and

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the front wheels 1,1 meters in diameter. Most of the accident tractors in Germany and Austria have this size and the dimension of the trailer covers the sizes of all other hitched up machineries.



■ Lengths of objects which cannot be seen

Figure 2: Geometry of rays

Source: modified after Auernhammer et al., 1977, S 119

The sight lines were emulated with bands to demonstrate the invisible space under the band where children are hidden. The most dangerous zones are next to the wheels with their wings, in front of the engine bonnet and at the back of a hitched up machinery. The shaded zones reach distances of some metres. The distances can be calculated with a well known geometrical principle called intercept theorems. The invisible area next to a wheel, as worst case, is defined by S, S' and L. Par example, the invisible area of Steyr 8090 Turbo has a distance of 2,84 meters next to the back wheels and 1,6 meters in front of the engine bonnet. This result means that one year old children with sizes of 75 cm need a security distance of 1,58 meters in standing and 2,3 meters in lying position to become seen form the driver next to the back wheels by looking aside.

The invisible field around the trailer is 100 % in the back and increases to the left and the right of the hitched up machinery with the length (to some meters) as well as can only be partly compensated by mirrors.

Additional, driving farm machinery is visually highly demanding, since it includes searching for, detecting and reading information. Sometimes the amount of information exceeds the capacity of the driver which increases the risk of an accident by limited vision.

Formula to calculate approximate worst case of the invisible distance:

L : driver's line of sight
 a: distance PS': measurable
 h: distance PH: measurable
 k: distance S'S: measurable
 l: S'L: to calculate

Steyr 8090 Turbo:

$$l = \frac{a \times k}{h - k} = \frac{1,03 \times 1,66}{2,27 - 1,66} = 2,84 \text{ m}$$

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Moving speed influences size of security zone

The common speeds of vehicles in farmyards and during field work are 4 to 10 kilometers per hour by driving forwards and 1,4 to 3,8 kilometers per hour by driving backwards. Children up to seven years approach standing or driving vehicles with speeds of 1 to 7 kilometres per hour.

The time to stop a vehicle safely depends on the vehicle moving speed and the reaction time of the driver at the stopping moment. It takes the driver 0,35 to 0,75 seconds to react before actually stepping on the brake pedal. Once the brake has been depressed, the stopping distance is determined by physical forces.

Table 2: Stopping distance by different speeds

Reaction time:	0,75 s		0,35 s	
Speed (km/h)	Total Stopping Distance (m)	Total Stopping Time (s)	Total Stopping Distance (m)	Total Stopping Time (s)
10	4,43	2,12	3,20	1,63
8	3,30	1,94	2,34	1,45
4	1,35	1,57	0,94	1,08
2	0,53	1,38	0,39	0,89

Almost half the distance is created by the driver reaction time. The total stopping distances is approximately 1,3 to 0,9 meters by a speed of 4 kilometers per hour and 2,3 to 3,3 meters by a speed of 8 kilometers per hour for each object during the approaching process under unfavourable road conditions. Therefore the warning area of a driver assistant system around working or moving farm machinery must take into account invisible regions of the vehicle and total stopping distances of common speeds to avoid collision between farm vehicles and a child. This means that a driver assistant system should warn over distances of at least 5 meters in front and beside of a farm machinery as well as at least 2 meters at the back of hitched up machineries.

Technical solutions

A technical solution could help to avoid accidents which occur when children

- run into a moving farm machinery or
- hide themselves behind or under a farm machinery.

No security system is on the market available which could warn the driver about the presence of a child from each position around and under the farm machinery, even behind obstacles like walls. The recommended systems like cameras, reversing assistant systems or parking assistant systems with ultrasound sensors are expensive; they require an installation of cables and can only cover the field behind the vehicles.

The primary aim is to find an electronic system, similar to a keyless entry system, which warns the diver when a person reaches the hazardous field around and under ignited and

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driving farm machinery. The transmitter receiver which is mobile must detect the child with a slumbered transponder over a distance of at least 5 meters in front of and beside the farm machinery, also by obstacles. The driver should receive acoustic and visual warn signals as well as be informed about functional disorder. An individual response must also be guaranteed for situations when more than one child leave the hazardous zone and come back again. For supervised presence of children over a longer time on or next to a farm machinery could be foreseen the possibility of switching off.

By searching for technologies there has been found an appropriate solution not in one unique technology but in the combination of two: A slumbering microwave transponder can fulfil the requirements of recognition in a larger distance but only in direction of movement (yellow zones). The second one, a short wave transponder (blue zone), covers all the dangerous positions during start and working situations.

The fundamental principles have been proved experimentally and encourage the partners in the development of a prototype system.

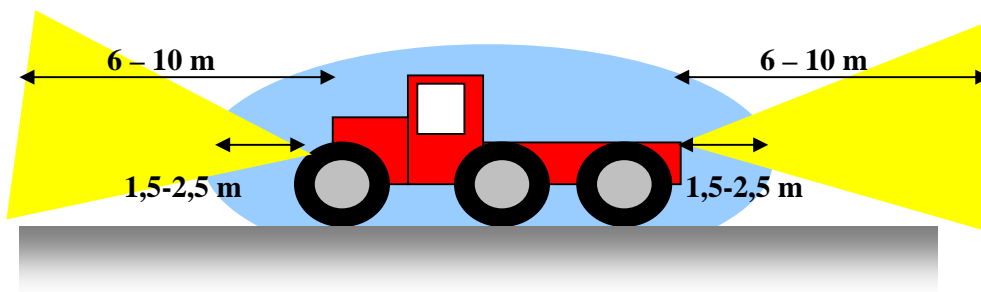


Figure 3: Functioning principle of a driver assistant system

The features and field activities of these technologies has been tested on a tractor in an open field. Persons wear the slumbered micro wave transponder which can be integrated in clothing, a watch, a bracelet or a necklace. This transponder is quasi inactive outside of the hazardous zone and will be activated in the hazardous zones and communicates with the reader transmitter of the farm machinery.

The microwave section can be successfully used for the driving direction which requires a greater range and cannot be covered by the low power short wave section. The recognition of the person in the first test was verified by a light emitting diode. This signal was also active when the amulet (the dual technology transponder) was carried under clothing. The achieved signal distance in front of the tractor bonnet was 5 meters. Beside the tractor bonnet, over a angle of 45 degree, the signal burned over a maximum distance of 3 meters. The activity field was a tear shaped ellipse. The range should be extended to 8 meters, which is feasible by simple electronic tuning measures.

The second transponder utilizes a short wave field with relatively small antennas, therefore the recognition area is flowing around the whole machinery. The range covered includes all areas around the tractor and all kind of trailers, etc., and also below these. The coverage is about up to 2 meters around machineries and goes through each barrier and provides secure

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recognition. The transponder can communicate with the receiver and transfer data as well as signals to inform about the presence of children under machineries.

The roughly estimated costs per units for a driver assistant system, called Life Saver system for children (LiSa), based on these technologies could even be below approximate 150 EUR with professional partners for development, manufacturing and sales.

Conclusion

Worldwide many kids die or suffer serious injuries caused by a moving tractor or other farm vehicles. The main reasons are the limited view of the driver and missing risk awareness of parents and children. For drivers it is difficult to guarantee a constant and perfect supervision of kids during work. A driver assistance system could help to close this supervision gap. A technology potential which fulfil the strict requirements and sphere of activity is available. Test results indicate that slumbered transponders with both, directed microwave and almost unidirectional short wave field, can fulfil the mentioned requirements. The unit cost could be moderate so that nearly everyone can afford to install such a system on farm machinery to protect the life of children.

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