

## Proposal of the semi-trailer additional lighting reducing road traffic risk

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**Key words:** road traffic participants safety, lighting, exceptional transport, intermediate vision

### Abstract

The interviews conducted with the drivers and analysis of possible sources of collisions and accidents show that at night, on unlit areas, truck drivers towing trailers or semitrailers have insufficient observation area around the vehicle. This insufficient amount of information reaching the driver is the cause of many accidents and collisions. The article describes the risks associated with the lack of visibility of the area around the semi-trailer and presents solutions allowing to reduce the identified risks. The solution is to use additional contour lights, and lights illuminating the road in the area, which is run over by the semi-trailer wheels. Based on the simulation studies and laboratory studies of light distribution, the appropriate lamps have been selected and installed on the trailer. Then the field tests were carried out on the real object, which confirmed the usefulness of the proposed lamps and showed that it is possible to support the vehicle driver in obtaining information from areas previously invisible.

### Introduction

Adequate lighting and marking of the vehicle have a large impact on traffic safety. The analysis of possible collisions sources and accidents indicates limited visibility as an important cause of their occurrence [1, 2, 3]. Many accidents and collisions are caused by the truck drivers who are not aware of other road users and various other obstacles being in very close proximity to the vehicles driven by them. Accidents or collisions occur during the change of direction at crossings, junctions or roundabouts when drivers fail to notice the obstacles in the blind spot area immediately around their vehicles [4, 5, 6, 7]. Accidents also occur during passing or overtaking, when the driver has difficulty in defining the position of the side of his truck in relation to the unlit objects. This problem is particularly great in Poland, where the main roads, used by trucks are at night also frequented by the unlit pedestrians, cyclists, horse-drawn carts.

The interviews with drivers indicate that a large number of collisions, unreported to the police takes place during the night on unlit manoeuvring squares and parking lots. As the cause of these collisions

the drivers indicate the difficulty in determining the position of their own vehicle in relation to the unlit objects. The dangers are the greater, the longer is the vehicle set: tractor-semi-trailer, and therefore especially large in the case of a semi-trailer for oversized cargo.

Therefore, an attempt was made to evaluate the needs and possibilities to reduce the risks associated with the operation of semi-trailers at night and the proposal was prepared for a technical solution to enable illumination of areas around the semi-trailer, critical from a safety standpoint.

### Evaluation of the situation

The driver of a vehicle or vehicle set should be able to observe the surroundings of the vehicle together with the elements of the vehicle contour (Fig. 1). Due to the design of the cab and the vehicle body, the area that the driver can directly observe is insufficient to drive safely. However, the use of mirrors required by law [8, 9], causes the area invisible to the driver to be much smaller (Fig. 2) and allows the driver to observe the surroundings of the vehicle in sufficient detail to

enable safe movement on roads in the most situations in a day or under street lighting. But at night, in the absence of street lighting, the driver does not receive adequate direct visual information, especially the intermediate one, although it is valid for collision-free traffic movement.

The area invisible around the vehicle at night is significantly enlarged, compared to a day time. The headlights illuminate the road ahead. Reversing lamp illuminates the road when driving backwards. If there are no street lights the remaining surroundings of the vehicle (if it does not emit light itself) is dark. The obstacles located in these areas, are not visible to the driver.

Truck with a semi-trailer when negotiating a curve has considerably extended corridor of movement. During cornering, the semi-trailer wheels are running along quite a different track than the wheels of the tractor (Fig. 3). In such a case, at night (no street lighting), the driver has unlit area, which is run over by the semi-trailer wheels. Although he may look in the mirrors he is unable to see the side of his vehicle and where and what his semi-trailer wheels are running over. Neither the tractor nor the semi-trailer is equipped with lights that would light up the area, on which the semi-trailer's wheels run when driving on the curve.

The biggest risks associated with this occur during manoeuvring in the unlit areas where often the obstacles are run over with the consequences of damage to the invaded object, or semi-trailer. The lack of such visibility can also be the cause of a collision or accident in the road traffic scenarios. At least three typical cases for this can be extracted:

- driving the vehicle set on the intersection when turning left or right;
- driving the vehicle set on the road curve;
- passing by pedestrians or cyclists who are moving along the road at night and are unlit.

In the first and second case, the driver is controlling the tractor "by feel" along such a curve, so that the semi-trailer wheels missed a curb or other obstacle. The third case is similar. However, on a narrow road, where the driver of the vehicle set has to quickly return to his lane, e.g. due to the on-coming vehicle, the collision may occur between his semi-trailer and pedestrian or cyclist. The driver is unable to observe the relative position of his vehicle to a pedestrian or cyclist, as they are in an unlit area. In such a situation of potential collision can occur and the driver may not be able to obtain information about the accident. He may leave the scene of the accident without being aware that he should provide assistance.

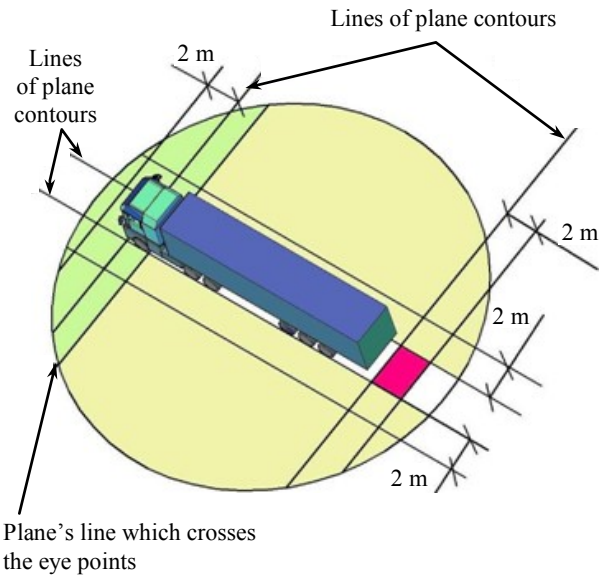


Fig. 1. The extent and location of areas around the vehicle, which should be seen by the driver of the tractor with semi-trailer

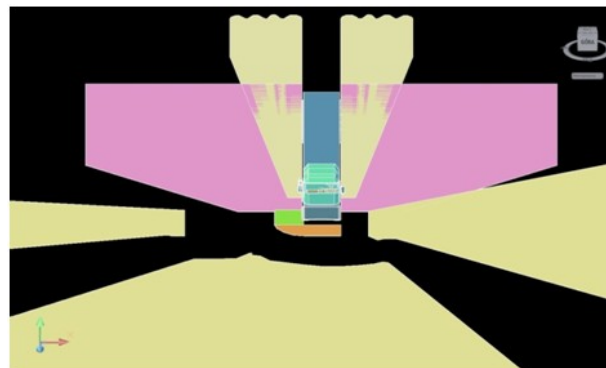


Fig. 2. The areas directly visible, visible indirectly (mirrors) and hidden areas (black areas) from the position of the vehicle set driver

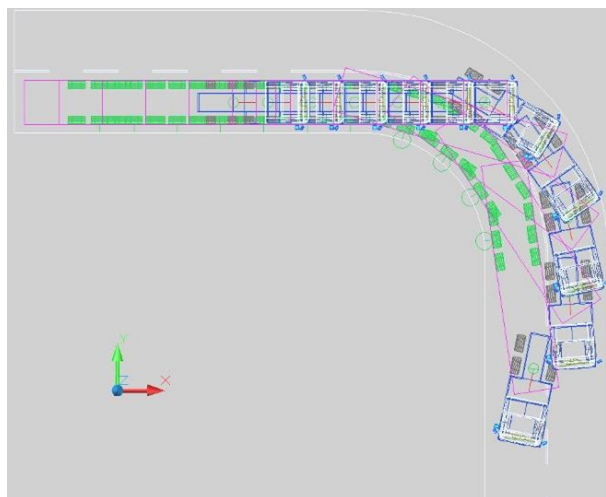


Fig. 3. Trajectories of the vehicle with a semi-trailer while taking a corner – on a road curve

## Proposals of additional lighting

In order to avoid the above situation and reduce the risks associated with the operation of semi-trailer, the attempt was made to use extra lighting which:

- would allow the driver to observe the contour of his vehicle;
- would illuminate the road surface, which is run over by the semi-trailer's wheels, when the vehicle set is driving along the curve.

At first, there were computer simulations carried out, based on which, the additional lighting distribution was selected and the area which should be illuminated was designated. It was considered that there should be additional white marker lights placed at the end of the semi-trailer in the top and bottom (in the case of the low platforms, only at the bottom). Moreover, on both sides of the trailer, in front of the wheels, there should be white light lamps installed facing down onto the road (Fig. 4). Light from these lamps should not dazzle other road users, and should not distract the driver of the tractor towing semi-trailer.

## The choice of lamps to illuminate the road around the wheels – laboratory tests

Based on the results of simulation tests, the requirements were determined for the lamp to illuminate the road around the semi-trailer wheels. The catalogues of the lamp manufacturers were analysed and the lamp was selected, whose technical specification met the requirements. This was followed by laboratory tests of this lamp beam. The purpose of laboratory tests was to verify the catalogue data and the preliminary determine suitability of the lamp to illuminate the area of the semi-trailer wheels.

The Minolta model T 10 light meter and a stabilized power supply ZS-20 were used for the measurements. The measurements were made with the lamp fitted at a height of 100 cm on the frame (Fig. 5). Beam spread measurement results are shown in figure 6. Based on the results obtained it was concluded that the technical parameters of the lamp are adequate.

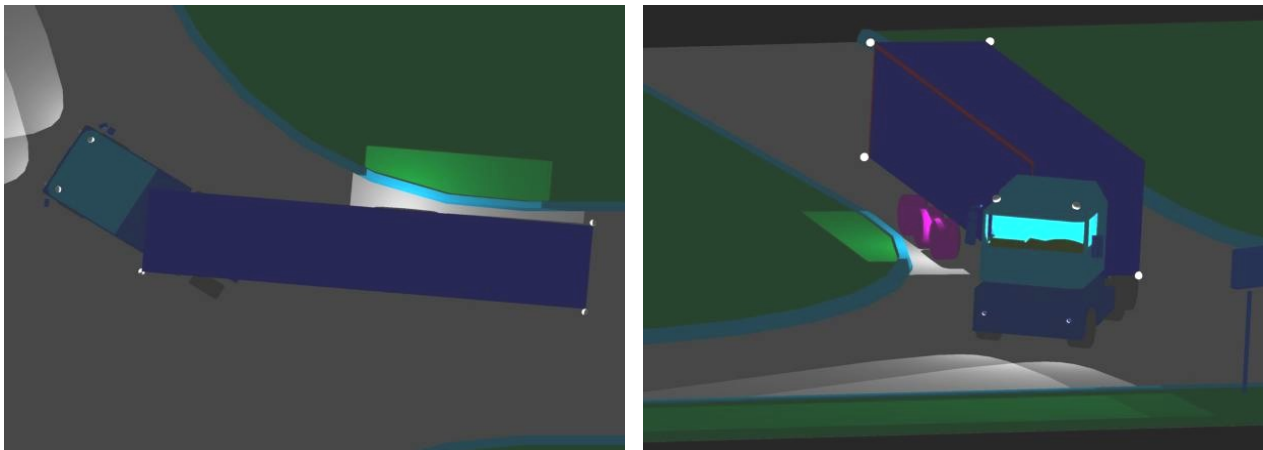


Fig. 4. View of the model of the tractor with semi-trailer at the intersection, and the distribution of additional lighting, including that illuminating road surface around the semi-trailer wheels

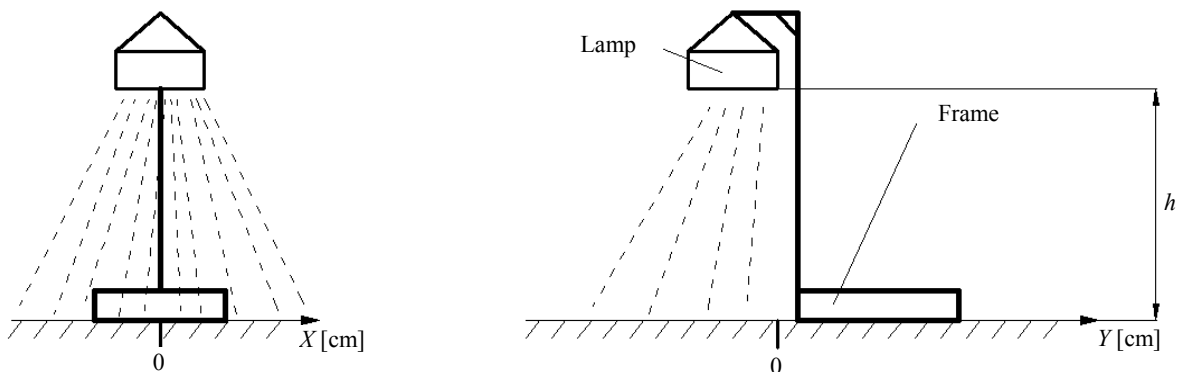


Fig. 5. Diagram of the light intensity measuring stand with the lamp installed at a height of 100 cm above the ground (front view and side view)

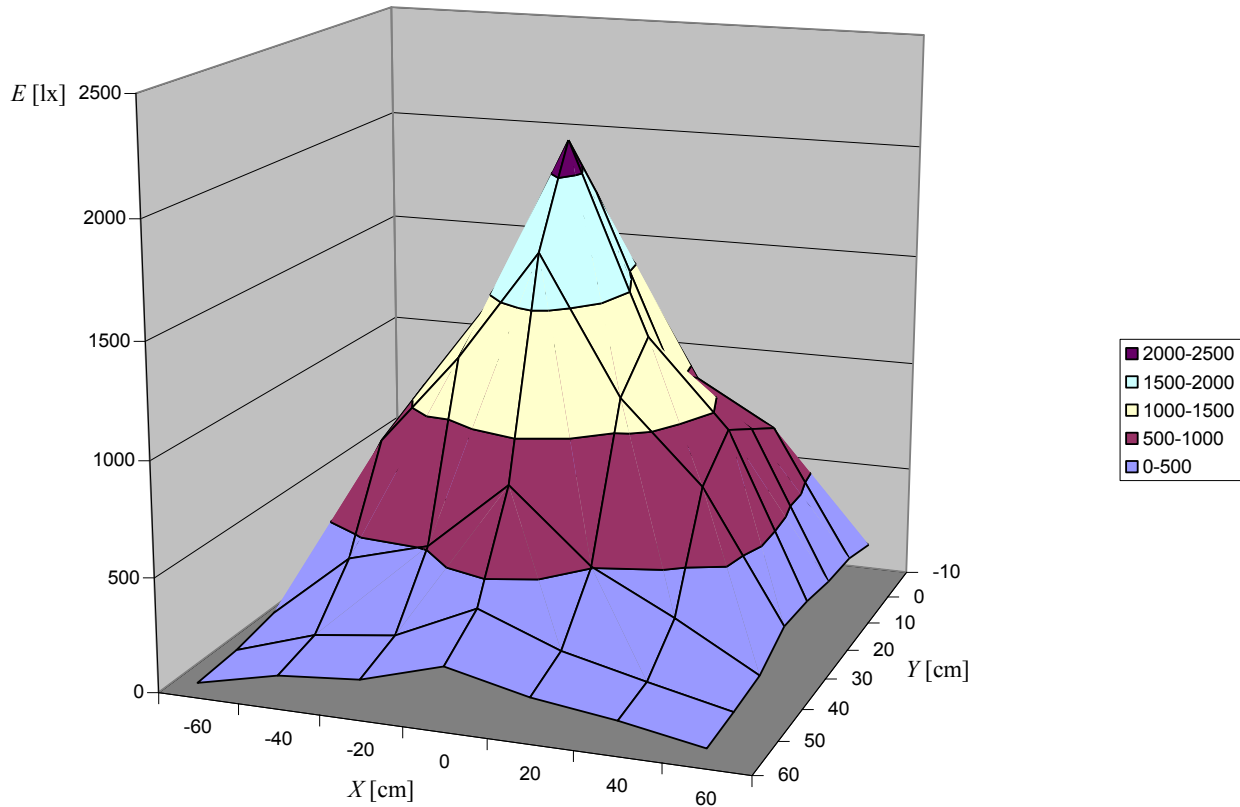


Fig. 6. The spatial distribution of light spread (light intensity) on the plane at the ground level

### Operational tests of semi-trailer with additional lighting

Selected lamps have been installed on the trailer. Additional lamps illuminating the road around the semi-trailer wheels were connected to the position lights. They were turned on together with the position lights of the vehicle. Similarly, the additional contour lights were connected. Figure 7 shows the effect of the use of additional lighting on the trailer – thanks to the additional light, the driver can observe the area which is run over by the semi-trailer wheels. Without the use of additional lights the curb, visible on the photo, would be completely invisible to the driver.

Risks associated with the wheels of the semi-trailer running over the obstacle invisible to the driver are the greater the longer the trailer. These risks are therefore particularly important in the case of trailers with more than the standard length for the transport of oversized cargo. Therefore, having manufactured a prototype semi-trailer for transporting oversized cargo [10], also this trailer was equipped with additional lights. Figures 8 and 9 show the additional lighting installation location on the semi-trailer and the area illuminated.

To evaluate the usefulness and shortcomings of the additional lighting, the field tests have been carried out. The semi-trailer equipped with addi-



Fig. 7. The area on the side of the road illuminated by the extra trailer lights when cornering

tional lights, towed by a tractor had been used in the Wielton company. A vehicle set was driving on the roads in daylight conditions and at night, even in the absence of artificial illumination.

Several drivers participated in the experiment, who drove such equipped vehicle. After the experiment they evaluated the proposed solution and filled in the questionnaire.

All of them unanimously concluded that the proposed solution is useful when driving after dark, especially when manoeuvring with the vehicle set



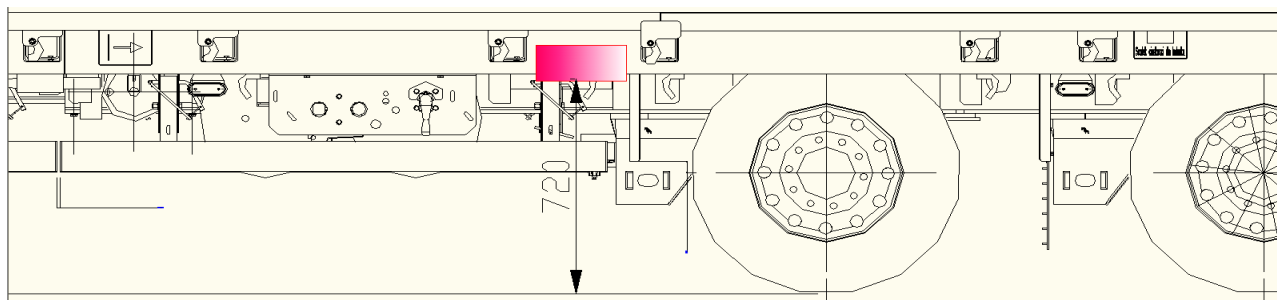


Fig. 8. Location of additional lighting in the Wielton semi-trailer for transporting oversized cargo



Fig. 9. View of the lamp and its mounting on a Wielton trailer for transporting oversized cargo and the area around the wheels lit up by the extra lamp

in the dark on unlit squares and parking lots. None of the participants has identified any nuisance arising from the fact that the installation of additional lights illuminated the area around the wheels of the semi-trailer. Directing the light beam down on the road, next to the front wheels of the trailer did not prevent the observation of other vehicles participating in the road traffic.

It was also examined whether additional lamps do not dazzle other road users. This evaluation was made from the position of the cyclist, motorcyclist, driver of a small car and the truck, by the drivers involved in the road test of the semi-trailer with additional lighting. They subjectively assessed that additional lighting did not dazzle them, and did not worsen the possibility of observing road.

## Conclusions

Information obtained from the drivers indicate that during the night in the areas unlit by the street lights the drivers of the vehicle sets – tractor with a semi-trailer, are unable to observe the areas immediately to the right and left side of the vehicle, as these areas are unlit and therefore invisible in the mirrors. The lack of possibility to observe these areas, especially in the case of long vehicle sets, which significantly run over while turning, causes discomfort to the drivers and is the cause of collisions, and even traffic accidents.

The proposed solution is to use additional contour lights and the lights illuminating the area which the semi-trailer runs over. The preliminary road tests have been conducted, which confirmed the usefulness of such a solution. The results indicate that there is a possibility of assisting the vehicle driver in obtaining information from areas previously invisible.

However, the use of these lamps in the semi-trailers is inconsistent with the relevant applicable law in Europe, namely Rules 48 ECE (UN ECE) [9]. The creators of this regulation did not take into account the need for lighting up these areas, so that the driver could observe what the vehicle runs over and this Regulation did not envisage the possibility of using such lamps.

Since the opinion of the users of vehicles with additional lighting, as to the suitability of such a solution under normal operating conditions, is positive, in the authors view further work on developing the proposed solution should continue.

The aim of further research should be: fine-tuning technical solutions that increasing the effectiveness of the lamps used, assessment of the impact of additional lighting on other road users, determining whether additional lighting should be optional or mandatory, or turned on permanently, or as required by the driver, or should attempt be made to amend the existing rules in this area.

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