SWOV Fact sheet

Blind spot crashes

Summary
Crashes involving lorries turning right and cyclists going straight ahead usually have very serious consequences for the cyclist. The cyclist, who has right of way, is often overlooked by the lorry driver. For his part, the cyclist is often unaware that the lorry driver has not seen him or that the driver wants to turn right. Despite a variety of measures, this type of blind spot crashes continues to occur. Each year they still cause approximately ten fatalities. This number could be reduced in the long term by banning heavy goods vehicles from town centres. In the short term, possible measures are: more information about the blind spot in the driver training and permanent public information for cyclists about how to behave in blind spot situations: the 'code of behaviour'. More research into the (far-reaching) separation of heavy freight traffic and cyclists in the long term is necessary, as well as into reliable detection systems to support the lorry driver in his driving task.

Background and content
Due to the size of a lorry the driver has poor vision around the vehicle and encounters difficulties in manoeuvring in the town/city. The size of the vehicle also means that if a crash occurs, the crash opponent usually is severely injured. More information about lorries in traffic can be found in SWOV fact sheet *Lorries and delivery vans*. Dangerous situations occur when the lorry wants to turn right in an urban area and cyclists are located to the right or in front of the vehicle. Legally speaking, the cyclists have the right of way but they are overlooked by the driver. Because blind spot crashes appear to be avoidable and the consequences for the casualties are very severe, this type of crash attracts considerable media attention.

This fact sheet will discuss the concept 'blind spot', look at the data in relation with the blind spot issue and suggest possible solutions for this problem.

Where is the blind spot of a lorry?
The formal definition of the blind spot is the area around the lorry which cannot be seen, directly or indirectly, by the driver. A direct view exists if the driver can see the area through one of the vehicle windows. An indirect view is what the driver can see via mirrors or cameras. Therefore, the size and position of the blind spot depends on the type of lorry, including the height of the cab and the presence of mirrors or cameras. This fact sheet will only deal with the blind spot which occurs when turning right. *Figure 1* shows the areas that must be visible to the driver according to current EU Directives. It also shows where different mirrors are attached to the cab of the lorry. Lorries marketed since 2007 are equipped with a front view mirror, a more convex kerb mirror and a more convex wide angle mirror than on older lorries. These mirrors can cover a larger area than the blind spot mirror (as shown in the photograph) and thus make it unnecessary.

A lorry driver who has adjusted his mirrors correctly will have the field of vision shown in *Figure 1*. The blind spot relevant to lorries turning right is, on vehicles built up to and including 2006, located on the right hand side, just in front of the cab. For lorries with a high cab, this spot is not visible through the window, nor by making use of the blind spot mirror or the wide angle mirror. For new lorries built after 2007, the largest part of the area to the right and the front right of the lorry is visible for the lorry driver when the mirrors are properly adjusted. This shifts the blind spot problem from physical visibility towards task burden or attention: it is impossible for the driver to look through all windows, in all mirrors and at the cameras simultaneously. This has the consequence that vulnerable road users still run the risk of being overlooked, despite all the mirrors. In addition, the direct view may also be obstructed by door posts, mirrors and objects that are placed on the dashboard.

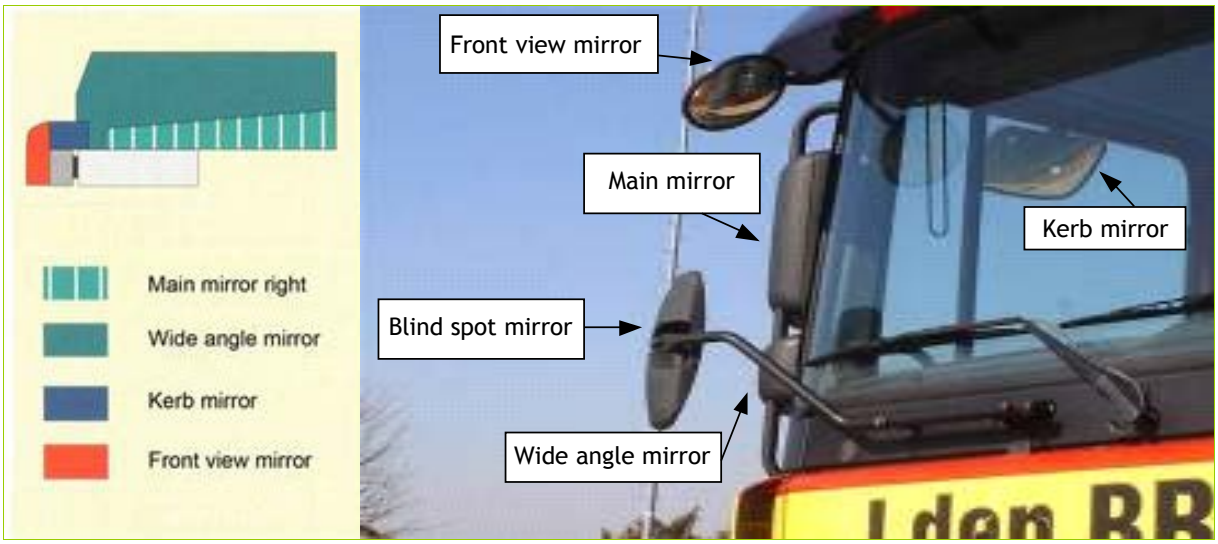

Figure 1. *On the left a top view of the required field of vision for lorries according to the new EU requirements for new lorries from 2007 (Ministry of Transport, Public Works and Water Management, 2006). On the right a mirror configuration of a lorry before 2007 with a blind spot mirror (Schoon, Doumen & De Bruin, 2008).*

What is the size of the problem?

During the period 2005-2013, fatalities among cyclists due to crashes in which a lorry wanted to turn right and the cyclist wanted to go straight ahead - the typical blind spot crash - averaged 9 per year. *Figure 2* shows the development of the number of blind spot crashes in the period 2005-2013. It may be observed that since 2007 the number of fatalities has remained below 10.

A crash has more serious consequences for a cyclist when the crash opponent is a lorry than when the cyclist collides with a different type of crash opponent. Serious crashes (with at least one fatality or serious road injury) involving cyclists and lorries are fatal in 36% of the cases; for crashes involving passenger cars and cyclists this percentage is 8%. With 41% the fatality rate is even higher for serious blind spot crashes.

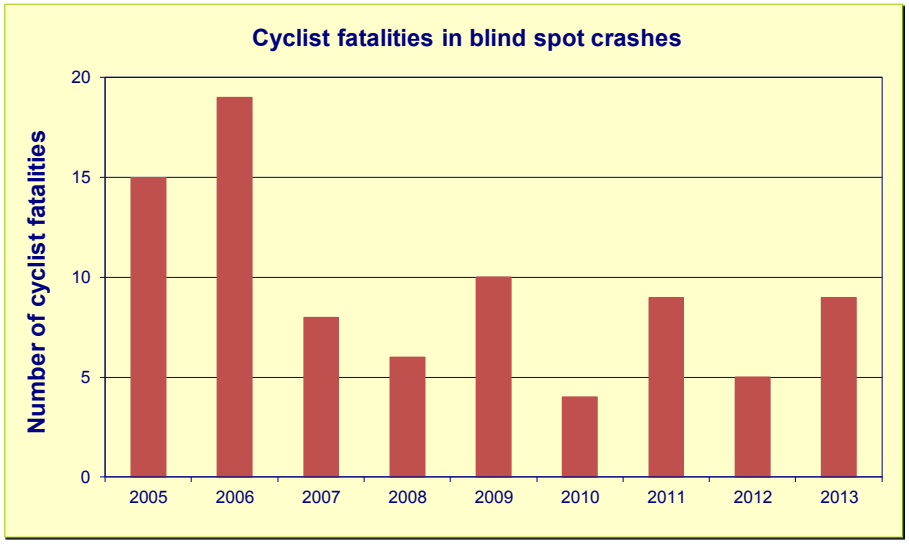

Figure 2. *Source: Ministry of Infrastructure and the Environment.*

Where do most crashes involving lorries turning right happen?

Many - the characteristic - blind spot crashes occur at junctions in urban areas when a lorry wants to turn right from stationary and a cyclist riding to the right of or diagonally in front of the vehicle wants to go straight ahead (*Figure 3A*). This frequently happens at junctions with traffic lights where cyclists get

the green light simultaneously with other traffic. In principle the cyclist has the right of way, but is overlooked by the lorry driver. As long as the lorry driver can continue driving and does not need to accelerate from stationary he has a better overview of the presence or absence of cyclists (Schoon, Doumen & De Bruin 2008). In many cases the lorry driver does notice the cyclists waiting at the lights because he has seen them approach. However, the problem is often caused by a cyclist who has approached from the rear and wants to continue just ahead of the lorry (BVOM, 2008).

A separate category of blind spot crashes concerns lorries that approach a priority road and cross a priority cycle path, especially if the cycle path has two-way traffic (*Figure 3B*). The lorry driver often fails to notice cyclists coming from the right because he apparently does not expect them.
Both these types of blind spot crashes also happen on roundabouts where cyclists have right of way (*Figure 3C*).

Most crashes involving lorries turning right concern vehicles with a high windscreen. In 98% of such crashes (in 2006 and 2007) the windscreen was higher than 1.50 to 1.60 metres, while 70% of the lorries driving at those locations during this period were found to have a high windscreen. Therefore lorries with a high windscreen are relatively often involved in blind spot crashes (Schoon, Doumen & De Bruin, 2008).

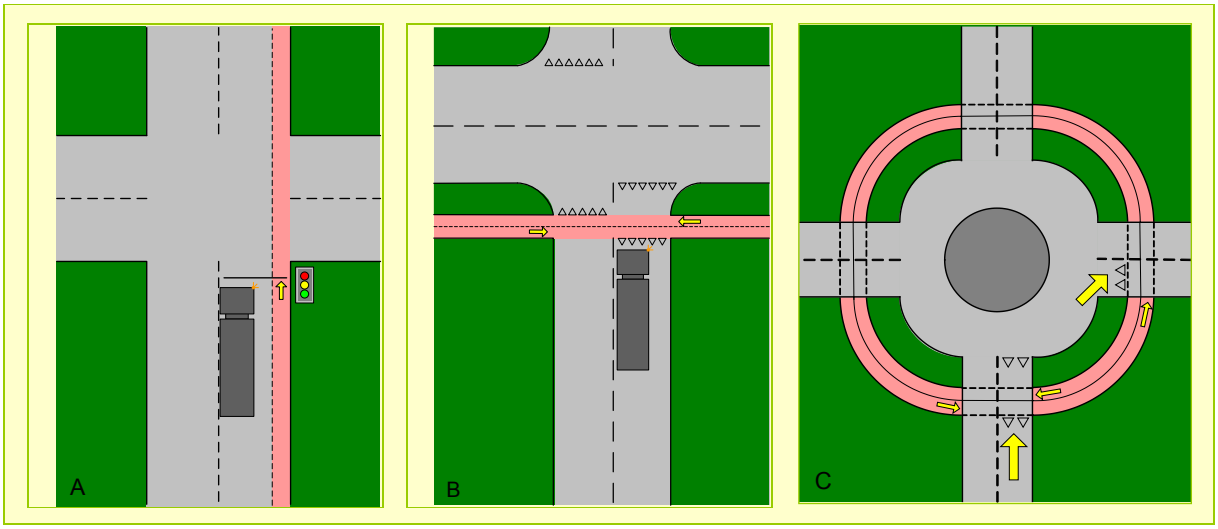

Figure 3. *Three frequent situations in which conflicts arise between lorries and cyclists. A. At a junction (with traffic lights) the lorry accelerates from stationary and turns right; the cyclist goes straight ahead. B. The lorry approaches a priority road with a separate cycle track (two-way traffic).C. Entering and leaving a roundabout where cyclists have priority. When a lorry enters the roundabout, the situation corresponds with situation B, or with situation A when the lorry leaves the roundabout.*

How do crashes involving lorries turning right and cyclists arise?

It is not easy to summarize the events leading up to crashes between lorries turning right and cyclists. Various factors influence the behaviour of the cyclist and the lorry driver. In a situation where a lorry wants to turn right and a cyclist on the same road wants to go straight ahead, the cyclist in principle has the right of way. The problem is caused by the fact that although the lorry driver generally is aware that the cyclist has the right of way, he often sees the cyclist too late or not at all. The cyclist on his part is insufficiently aware of the limited view of the lorry driver. A survey among crash casualties involving lorries turning right revealed that cyclists were frequently unaware that the lorry wanted to turn right (Schoon, Doumen & De Bruin, 2008). In addition, cyclists often take the right of way without first making sure that they are actually given it.

What infrastructural measures can be taken?

As drivers of heavy lorries have a limited view of other road users which can also at lower speeds (30 km/h) lead to fatalities among cyclists, the aim should be to separate heavy freight traffic and cyclists. A far-reaching measure, for instance, would be to deny heavy lorries access to cities, towns and villages. This would mean, however, that it would be necessary to construct distribution centres outside urban areas. Heavy lorries can deliver the goods to these centres and lighter delivery vehicles

use the secondary roads to bring the goods to their final destination. This solution fits into the Strategic Road Safety Plan (Ministry of Transport, 2009). It goes without saying that such a far-reaching measure cannot easily be implemented. Research is required to make clear the pros and cons of different solutions. Other ways to separate the different types of traffic is to shift the times in which freight traffic is allowed access to urban areas to times at which few cyclists are on the road (Mesken & Schoon, 2011), and to determine routes for freight traffic along which cyclists are few (Schoon, Doumen & De Bruin, 2008).

In the short term, dangerous intersections could be adapted. This can be done by moving the stop line and the give-way road marking in such a way that the motorized traffic is positioned at some distance behind the cyclists; for example an expanded bicycle streaming lane. This gives the lorry driver a direct view of the cyclists who are waiting. If necessary, the cyclists can be given a separate green light.

Which measures have been taken to increase the lorry driver's field of vision?
In recent years, rules concerning mirrors have been the most important measures to improve the lorry driver's field of vision (see *Figure 1* for all these mirrors). A kerb mirror has been mandatory for lorries since the 1980s. This mirror gives a lorry driver a top view of the area immediately to the right of his cab.

The blind spot mirror was introduced in the Netherlands in 2002. All Dutch lorries had to be fitted with this mirror by January 2003. The mirror extends the field of vision of the normal mirror at the right-hand side of the lorry

Since January 2007 it has been mandatory for all new lorries in Europe to be fitted with a convex wide angle mirror, a convex kerb mirror and a front view mirror. The convex wide angle mirror provides the driver with the same view as the blind spot mirror and the wide angle mirror used to do in the previous Dutch configuration. The front view mirror gives the driver a top view of the area to the right-hand side and the front of his cab. This EU measure is mainly intended to give the driver a view of pedestrians crossing in front of his lorry. However, SWOV research indicates that such a mirror can also be useful when lorries turn right.

EU requirements allow a lorry to use a camera instead of a front view mirror. Research conducted for the Dutch Ministry of Transport revealed that drivers preferred a front view camera to a front view mirror (Buck Consultants, 2007). Such a camera is used more frequently than the mirror when turning right from stationary at traffic lights.
The adjustment of the mirrors on a lorry is very important, but difficult to perform if the lorry driver is alone in the vehicle. At various places in the Netherlands special mirror adjustment stations have been set up where lorry drivers are able to adjust their mirrors in accordance with guidelines.

Which additional vehicle technology measures can be taken?
Several 'intelligent' blind spot detection and warning systems have been developed to support a lorry driver when turning right. However, the practical application of such systems still has some catches. Commissioned by the Ministry of Infrastructure and the Environment, Connekt (an independent network of companies and authorities that links up parties to improve mobility in the Netherlands in a sustainable manner) together with the Netherlands Organization for Applied Scientific Research TNO and SWOV, investigated the possibilities. At the present state of vehicle technology, an *autonomous intervening* system still has too many drawbacks and risks (Connekt, 2010). A system that *warns* the lorry driver of a cyclist in the blind spot is possible. However, the challenge for such a system is in the timing: the system should not issue a warning until the situation becomes dangerous; otherwise the driver is confronted with false alarms too often and will eventually ignore the signal (Hoedemaeker et al., 2010). This means that the system should only give a warning signal when the driver intends to turn right and the cyclist in the blind spot is or will be in the path of the lorry. The driver, however, should still have sufficient time to react. Computer simulations carried out by the Netherlands Organization for Applied Scientific Research TNO show that this timing is indeed a challenge. If the cyclist is detected after the wheels of the lorry have already been steered into the bend, it was often found to be too late to prevent a crash in its entirety.

There are also systems that warn the cyclist instead of the lorry driver when a lorry intends to turn right, for instance Lisa2Alert. An often-heard argument against such systems is that they would make

the driver less alert. However, a questionnaire study among 30 drivers in Belgium (Riguelle, 2011) showed that drivers with a Lisa2Alert system gave priority as much or as little as drivers who did not have such a system. The system did not cause attention problems for the drivers. A test among 125 Belgian cyclists (Riguelle, 2011) indicated that 74% of the cyclists had heard the signal and 29% of them understood that the signal was meant to warn them for a truck that intended to turn right. Therefore, 19% of the entire group of cyclists, including the ones who had not heard the signal, understood the Lisa2Alert signal. According to the study, cyclists who had seen or heard but had not understood the signal, did not behave dangerously. The Belgian study concluded that the introduction of such a system will therefore only improve road safety if simultaneously considerable and repeated efforts are taken concerning education and public information.

A more principled argument against systems such as Lisa2Alert that is brought forward by, for example, the Fietsersbond (2011), is that they place the responsibility with the cyclist, despite the fact that he or she has right of way when going straight on and not the lorry turning right.

A practical objection to such warning systems is that the situation remains unclear as long as they have not been installed on all trucks. No signal could then either mean that the lorry continues to go straight on, or that the lorry is not equipped with such a system. Therefore, cyclists have to depend on well-placed indicators. The fact that cyclists are unaware of a lorry intending to turn right (Schoon, Doumen & De Bruin, 2008), could be due to the indicator not being very well visible for cyclists (the indicator is often placed too far to the rear of the lorry). In that case supplementary signals on the lorry are advisable, for example several indicators placed along the side of the cab.

Which measures can be taken in the area of public information and education?

Lorry drivers

For some time now road hauliers have been encouraged to introduce a ‘safety culture’ for their employees. This means that the employer makes clear to the drivers that safety has high priority. Among other things, this involves the company stimulating drivers to comply with prescribed driving and rest times, to use the mirror adjustment stations and to refrain from placing any objects in front of the windscreen of the cab. From September 2009, periodic further training has been mandatory for all European lorry drivers (under EU Directive 2003/59/EU). It will be mandatory for a driver to receive 35 hours of further training within a period of five years.

A study by DHV Consultancy and Engineering indicates that although the lorry driver training does pay attention to the blind spot issue, the topic is addressed only occasionally throughout the training (DHV, 2009). The study led to the inclusion of a question in the theory examination about the blind spot (which means the topic must also be discussed during the training). In addition, in a special closed off area all lorry drivers have to take a test in which they are asked to adjust their mirrors and to explain why this is important. The concept ‘blind spot’ has also been added to the examination matrix of the practical driving test, which means that during the examination it is now explicitly examined whether the candidate does everything in his power to prevent a blind spot crash (Schoon, 2012)

A SWOV report (Schoon, Doumen & De Bruin, 2008) suggests specific points of interest in the driver training: more attention needs to be given to an anticipatory driving style, the use of mirrors, and especially to a ‘second check’.

Cyclists

There are various educational projects for primary schools to make children aware of the blind spot hazard. In one of the projects drivers visit primary schools with their lorry. Together with the Cyclists’ Union, Transport and Logistics Netherlands (TLN), and the organization for business transportation EVO, the Dutch Ministry of Infrastructure and the Environment has drawn up a list of handy hints for cyclists about how to position themselves safely in the vicinity of lorries (see www.dodehoek.nl). These hints were used in an information campaign ‘Stay away from the blind spot’ which was carried out in 2009. Information about this ‘code of conduct’ for cyclists needs to be given a permanent place.

Conclusion

Crashes involving lorries turning right and cyclists usually have very serious consequences for the cyclist. The cyclist riding straight on has the right of way over the lorry turning right. However, lorry drivers regularly overlook the cyclist. For his part in the cyclist is often unaware that the lorry driver is unable to see him or that the driver wants to turn right. Collisions between lorries turning right and

cyclists continue to happen, despite various measures to enlarge the lorry driver's field of vision and to increase the awareness of cyclists by means of public information campaigns. The number of casualties of crashes of this kind could be reduced by creating a separate infrastructure for lorries. However, this far-reaching measure still requires research. In the meantime it will be necessary to reduce the number of crashes by means of other measures, such as infrastructural measures at junctions and permanent public information about a code of behaviour for cyclists. Other possible new developments for reducing the number of blind spot crashes include technical facilities to aid the lorry driver.

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