SWOV Fact sheet

Speed cameras: how they work and what effect they have

Summary
As of August 2011, there are approximately 1,200 cameras in the Netherlands that are under the charge of the Traffic Enforcement Team of the National Public Prosecutor's Office. Almost 180 of these are digital cameras in fixed pole-mounted positions, nearly 400 are analog cameras in fixed pole-mounted positions, and slightly more than 600 are red light or speed cameras. In addition, each police district uses police cars with mobile speed cameras. The local Public Prosecution Service (OM) formally decides whether the cameras are to be employed.
Much research has been carried out into the effects of speed cameras. Although the methods applied in almost all of these studies have certain shortcomings, they generally present a consistently positive picture. International review studies report that speed cameras produce a reduction of approximately 20% in personal injury crashes on road sections where cameras are used. In the Netherlands, research also indicates positive effects on speed behaviour and road safety. Dutch drivers find speed cameras in fixed pole-mounted positions more acceptable than cameras in hidden police cars.

Background and content
This Fact sheet is about how speed cameras work and the effect they have. Speed cameras are cameras which register speeding offences and the identity of vehicle owners based on the vehicle registration number. The cameras are usually linked to radar or induction loop detectors in the road surface with which speeds are measured. Speed cameras can be installed in pole-mounted roadside cases (fixed position speed cameras), or in police cars (mobile speed cameras). They can also be mounted on gantries above the road or on tripods. Speed cameras can perform measurements at a fixed position or average speed measurements. Cameras with Automatic Number Plate Recognition (ANPR) are used for average speed measurements. This Fact sheet focuses on fixed and mobile speed cameras taking fixed-speed measurements. Other methods of speed enforcement, such as average speed measurement, laser guns, stopping drivers (on-the-spot fine), and video surveillance are not discussed in this Fact sheet. More information about these methods can be found in the SWOV Fact sheet Police enforcement and driving speed.

How do speed cameras fit into Dutch road safety policy?
Speed is an important factor in road crashes (see SWOV Fact sheet The relation between speed and crashes). Speed limits are violated on a massive scale in the Netherlands. On most types of roads the percentage of speeding violations varies between 20% and 40% (Van Schagen, Wegman & Roszbach, 2004). Many measures contained in the Sustainable Safety programme (30 km/h areas, 60 km/h areas, roundabouts), are aimed at reducing speed at traffic danger spots. Measures along the road (or in the vehicle) cannot always be realized at short notice; moreover, a small group of road users continues to consciously violate the speed limits despite these measures. For this reason, police enforcement is a supplementary measure used to manage driving speed and improve road safety.

When and where are speed cameras used?
In each police district a steering committee considers the location of speed cameras. The steering committee is represented by five parties: the local Public Prosecution Service (OM), the Traffic Enforcement Team of the National Public Prosecutor's Office (before January 2010 this was the Bureau for Traffic Enforcement of the Public Prosecution Service), the police, the road authority, and the province. The formal final decision on whether the cameras are to be used is made by the local Public Prosecutor's Office. The following guidelines are generally followed as criteria regarding the question of whether and where speed cameras are allowed to be used:
1. at places/on roads with a relatively high number of road crashes[1];

[1] This concerns absolute numbers of crashes and not high crash-rate roads (number of crashes per vehicle kilometre).

2. where there is an apparent, or at least plausible, connection between crashes and speed;
3. where there is a relatively high percentage of speed offenders.

In addition to these general criteria, more specific considerations also play a role per location and method, such as visibility, accessibility, and the possible effect on traffic flow. Policy regarding the approach to regional traffic hazards, and therefore also policy regarding infrastructural measures and the use of traffic law enforcement, is made within the said steering committee. A policy evaluation is undertaken every two years, when the use of enforcement (fixed position and mobile speed cameras) is reconsidered.
Concerning fixed position speed cameras specifically, in June 2011 the Traffic Enforcement Team has introduced guidelines for placement and usage, as well as for replacement of analog fixed position cameras by digital ones (LP Team Verkeer, 2011).
In short, the following basic rules are applied for the usage of speed cameras:
– speed cameras only at locations on the basis of criteria for road safety formulated previously;
– deployment of speed cameras always in combination with accompanying communication;
– new speed cameras that are to be placed contain pronounced police striping at the cases;
– deployment of speed cameras only as a final measure after influencing behaviour and adjusting infrastructure;
– digital cameras are permanently in use;
– red light cameras always enforce speed as well;
– speed cameras cover all lanes, or, where that is not possible, the most dangerous lanes;
– evaluation of enforcement through fixed position speed cameras takes place every three years, because of possible continuation.

In the decision to remove analog speed cameras or possibly replace them by digital ones, a fixed checklist is used consisting of questions. This checklist contains, among others, the following items:
- a road reconstruction may have taken place, reducing the road safety problems on the road to such a degree that (new) speed cameras are no longer needed;
- the road use intensity may have decreased so that a radar set or laser gun have possibly become better suitable than cameras;
- the degree to which the analog cameras were used before and the circumstances surrounding it;
- violation data.

How many speed cameras are there in the Netherlands?
In August 2011, approximately 1,200 cameras were under the charge of the Traffic Enforcement Team of the National Public Prosecutor's Office. 180 of these have digital cameras in fixed pole-mounted positions, nearly 400 have analog cameras in fixed pole-mounted positions, and slightly more than 600 are red light or speed cameras. In addition, an unknown but considerably a smaller number of cameras is under the charge of local or regional road authorities. In addition, mobile radar checks are carried out on a daily basis at various locations in each police district, using two or three police cars equipped with speed cameras.

How do speed cameras work?
Speed cameras are based on the so-called Doppler Effect (radar). The radar emits an (inaudible) sound wave and measures the reflection of these waves from moving objects. A vehicle moving within the beam reflects the radar wave and changes the frequency of the beam. The size of the frequency change depends on the speed of the object, enabling its speed to be calculated. When a violation is detected, the registration number of the vehicle in question is photographed. The data are sent to the Central Fine Collection Agency (CJIB), which sends the fine to the owner of the vehicle.
Digital cameras are increasingly being used in the Netherlands. These cameras use an invisible (infrared) flash. As all the data are filed digitally, it is no longer necessary to change the rolls of film. When a speed violation is detected, the vehicle registration number is read automatically and the vehicle class is ascertained. These data are stored in a digital file which is sent to the processing system of the relevant police district via a high security digital communications system, and from there to the CJIB. This digital system allows data to be processed more quickly and efficiently.

What effects do speed cameras have?
A great deal of research has been carried out regarding the effects of speed cameras. Although the exact results vary per study, almost all the studies have observed a reduction in speed and in the number of crashes at locations with camera surveillance. However, the effects are limited over both

distance and time. This is called a limited distance halo and a limited time halo. A review of the European Road Safety Observatory (2006) shows that the effects of speed cameras generally radiate from just a few kilometres to approximately ten kilometres past the camera location. When the cameras are easily visible, this so-called distance halo is larger. A combination of visible fixed cameras and hidden mobile cameras can also increase the distance halo. The largest effects are observed in the immediate vicinity of the camera. If camera surveillance is stopped, the effects disappear within a few days.

Although the individual effects of the speed cameras are limited as to time and distance, when combined over various locations and a number of years, they can jointly have a substantial road safety effect. This is because there is a very strong link between driving speed and road safety. We will enlarge upon the safety effects of speed cameras below, where we will distinguish between the results reported in recent international review articles and the results of Dutch research.

International reviews
In order to arrive at a reliable estimate of the effects of speed cameras on road safety, we have examined three recent review studies of international research. This research is primarily concerned with 'before' and 'after' comparisons between the number of crashes on road sections with cameras and road sections without cameras. Road sections are defined differently in all studies; often this concerns a road section of around 0.5-1.5 km in front of and behind the location of the speed camera. In addition, there are modelled comparisons between the crash trend of road sections with cameras and the general national trend. In the three review studies, the research results have been tested and combined with each other.

In addition to these three reviews, we would also like to mention the effects of an extensive evaluation study in Great Britain with its long history in the use of speed cameras. This evaluation (Gains et al., 2005), also distinguishes between fixed position and mobile cameras. The study showed a reduction in personal injury crashes of 24% with the use of fixed position cameras, and 21% with the use of mobile cameras.

The first review study is an analysis of international literature that was published in 2008 (Thomas et al., 2008). This study has only examined the effects of fixed cameras. It shows that the number of personal injury crashes on road sections where cameras were used was reduced by 20 to 25%.
The second review is also from 2008, and is a meta-analysis of studies on traffic law enforcement (Ercke, Goldenbeld & Vaa, 2009). This review distinguishes between the effects of mobile and fixed cameras. Ercke, Goldenbeld & Vaa reported a reduction in the number of personal injury crashes of 35% for fixed cameras, and 14% for mobile cameras. This analysis has also found that the effect was greater for fatal crashes than for personal injury crashes. The difference in effect is in accordance with general knowledge on speed management measures. Erke, Goldenbeld & Vaa find a total reduction of 29% in fatal crashes versus 14% in personal injury crashes; with speed camera enforcement they find a 33% reduction in fatal crashes versus 22% in personal injury crashes.

Like the British study, the meta-analysis of Erke, Goldenbeld & Vaa thus shows somewhat larger safety effects for fixed position speed cameras than for mobile cameras. A possible explanation for this difference is that fixed position cameras are used more frequently than mobile ones at locations inside built-up areas with heavy traffic and a high concentration of crashes. If the initial situation is less safe, then the effect of a camera will by definition also be higher.

It must be noted that a review of Australian and New Zealand enforcement projects (Delaney, Diamantopoulou & Cameron, 2003) shows that the effects of hidden mobile cameras radiate over a larger area than the effects of fixed position cameras. Hence, although fixed position cameras may often have a greater safety effect per specific location, hidden mobile cameras can reach a larger area.

The third review is by Wilson et al. (2006). They have examined 28 studies from various parts of the world, which qualify as poor or as reasonably good. Because of the great heterogeneity in results, the authors did not separate the effects for fixed and mobile cameras. Based on these studies, Wilson et al. concluded that the number of serious injury crashes (leading to deaths or hospitalisation) on roads and in areas with fixed or mobile cameras decreased by 11% to 44% compared to similar roads or areas without cameras. Research on the effects of cameras in larger areas finds reductions of 17% to

58%, in which most reduction is found between 30 and 40%. Studies measuring the effects over a longer period of time show that the positive trend remains or even becomes stronger. Although the authors qualify most of the examined studies as poor or reasonable at the very best (and not as very good), they do conclude that the consistency of the results shows a positive effect of cameras on road safety.

Dutch research
In the Netherlands as well, a number of research projects have been carried out on the effectiveness of speed cameras. The first study by Oei & Polak (1992) dates from the beginning of the 1990s. The study focused on a combination of fixed position speed cameras, advance warning and speed feedback signboards. The research examined an experimental road (with camera) and a comparable control road (without a camera) in the provinces of Gelderland, Utrecht, Noord-Brabant and Overijssel. It concerned roads with a speed limit of 80 km/h. The results showed that the average speed on the experimental roads dropped from 78 to 72 km/h, the standard deviation of speeds fell from 10 to 8 km/h, and the percentage of drivers who violated the speed limit decreased from 38% to 11%. The number of crashes on the experimental roads fell by 35%. Due to a possible *regression to the mean*, it cannot be ruled out that the safety effect observed was overestimated.

Some years later, the effect of mobile speed cameras was also examined too, in the province of Friesland (Goldenbeld & Van Schagen, 2005). The study included 28 roads with a speed limit of 80 km/h and with a high number of crashes. During the period 1998-2002, mobile cameras were deployed at different locations along these roads. This research compared the developments in speed behaviour and the number of crashes on these roads with the developments on 28 similar roads without speed enforcement. There was a reduction of the average speed from 82.6 to 78.6 km/h on the experimental roads, and a decrease in the percentage of offenders from 27.4% to 15.6%. The safety effect was comparable to that in Great Britain, namely a reduction of 21% of personal injury crashes involving fast traffic. In spite of the long research period, the question of regression to the mean may also apply to this study. Perhaps the real effect is therefore somewhat smaller.

The final Dutch study we will mention here, is an evaluation of the regional enforcement plans (Mathijssen & De Craen, 2004). This study showed that speed enforcement reduces speed on specific roads. It also showed that regions predominantly using mobile speed cameras with inconspicuous police cars registered a higher traffic safety rate than the regions which relied mainly on fixed position speed cameras. However, this result may also relate to other differences between the regions, and is therefore indirect proof at best.

Do speed cameras have adverse effects?
According to some, speed cameras can also have an adverse effect. In the first place, they refer to the supposed kangaroo effect. A kangaroo effect is created when drivers decelerate suddenly when they notice a speed camera, and then quickly accelerate again. This is thought to have an adverse effect on traffic flow, the environment, as well as road safety. However, no research has been carried out regarding the extent to which this phenomenon occurs, or its effects (European Road Safety Observatory, 2006). It is also sometimes claimed that due to more intensive camera surveillance at one location, the road safety hazard shifts to a different one (crash migration). A recent study of the safety effects of mobile cameras on rural roads (Jones, Sauerzapf & Haynes, 2008), has tested these claims and has found no evidence to support them. However, Thomas et al. (2008) do not rule out the possibility that the kangaroo effects and crash migration could affect road safety. For this reason, they recommend that this sort of undesirable behaviour should be prevented, or at least monitored when setting up a camera programme. Although the authors do not expand this subject further, possible undesirable effects can be reduced by measures such as information, making cameras more visible, and advance warnings of surveillance.

What do Dutch people think about speed cameras?
The average Dutch person is critical about the presence of the police in traffic, and the use of automated enforcement methods (Berkhout, 2008). However, their criticism seems to be aimed more at the way enforcement is carried out, than at the desirability of speed and camera surveillance (Goldenbeld, 2008). The annual 'perception study' (Poppeliers, Scheltes & In 't Veld, 2009; Intomart Gfk, 2010), shows which types of speed enforcement Dutch drivers find less or more acceptable (see *Table 1)*.

Type of speed enforcement	2004	2005	2006	2007	2008	2010
Fixed position speed camera	67	67	66	72	80	73
Hidden police car	48	45	46	51	58	44
Stopping drivers (on-the-spot fine)	80	77	78	79	86	77
Laser gun	48	47	48	50	57	43
Video car	68	66	66	70	76	62
Average speed check	69	70	69	72	76	69

Table 1. *Percentage of respondents who find certain types of speed enforcement (very) acceptable (Poppeliers, Scheltes & In 't Veld, 2009; Intomart Gfk, 2010). The terminology of the types of speed enforcement conforms to the study.*

Table 1 shows an increased acceptance of all types of speed enforcement during the years 2004-2008. Between 2008 and 2010 the acceptance of speed enforcement has decreased somewhat. The economic crisis and the price increase of traffic fines might have led to more negative attitudes towards speed enforcement. In 2010, 7 out of 10 drivers found the use of fixed position speed cameras, stopping drivers and average speed checks (very) acceptable. The degree of acceptance for less visible forms of enforcement, including mobile speed cameras in hidden police radar cars and laser guns is lower. In 2010 less than half of Dutch drivers found these methods acceptable.

Apart from that, not all data point into the same direction. According to a different (written) national survey, the Periodical Regional Survey on Road Safety (Periodiek Regionaal Onderzoek Verkeersveiligheid), the acceptance of fixed position speed cameras has clearly increased between 2007 and 2009. In response to the measure 'placing more fixed position speed cameras', in 2007 56% of respondents was against it, and 28% was in favour; in 2009, 51% was in favour of it, and 37% against (Biervliet et al., 2010).

Information about surveillance and traffic laws is one way to improve public support. Information about surveillance can also increase the effectiveness of enforcement (Erke, Goldenbeld & Vaa, 2009). The Traffic Enforcement Team therefore uses the motto 'No enforcement without communication, and no communication without enforcement'. There is always communication regarding speed checks, often via motto signboards along the road and, for instance, via regional newspapers and websites. On the one hand, communication about enforcement is designed to increase people's awareness of the chance of being caught. On the other hand, the communication focuses on a greater understanding of the importance of traffic laws and police enforcement.

How does the effectiveness of speed cameras relate to other measures?

The positive effects of speed cameras do not automatically mean that the use of cameras is also per se the most obvious and most effective speed enforcement measure. Wegman & Aarts (2006) advocate a systematic and step-by-step approach to the speed problem (see also the SWOV Fact sheet Measures for speed management). The first priority is to make speed limits safe and credible. Then road users must be informed as well as possible about the speed limit in force via signboards, road markings and information systems. Next, extra infrastructural measures at specific locations and roads can ensure that the desired speed is actually achieved. Finally, as a last step, speed enforcement will be required for the group of road users who still violate the speed limits, including the use of speed cameras. Particularly in built-up areas, infrastructural measures can be more effective than speed cameras. Based on an analysis of British data, Mountain, Hirst & Maher (2005), concluded that on *30 mile/h* ('48 km/h roads), infrastructural measures (could) prevent twice as many personal injury crashes as speed cameras.

Apart from that, the ideas behind deploying speed cameras, and with that also the set-up and use of camera systems, turn out to be different in different counties. Belin et al. (2010) examined the policy philosophy behind the deployment of speed cameras in the Victoria (Australia) and Sweden. In Sweden, the idea is that there is a conflict between road design and speed of the road user, and that camera programs should be limited only to dangerous locations and should contribute to creating a social norm amongst road users that it is easier and safer to keep to the speed limit. Australia, on the other hand, works from the specific thought that continuous violation of the speed limit by drivers is the problem. Through increasing the objective chance of being caught and intensive information campaigns, road users should get the idea that they can be checked for speed at any time and at any

location. Sweden attempts to convince road users through providing information on a safe speed limit; Australia attempts to influence road users through mechanisms of general and specific deterrence.

Conclusions

The use of fixed position and mobile speed cameras has been found to provide positive safety effects worldwide. Although the methods of almost all the studies have certain shortcomings, they generally show a consistently positive picture. Two recent reviews of international studies (both from 2008), estimate an average decrease in personal injury crashes of approximately 20% on road sections where cameras were used. A recent overview of 2010 finds a decrease in serious personal injuries of 11-44% near camera locations, and of 30-40% for larger areas where camera activities are used. Research also points to the positive effects of speed cameras in the Netherlands.
Dutch drivers find clearly visible speed cameras at fixed positions more acceptable than hidden mobile speed cameras. Acceptance of both fixed position and mobile camera surveillance decreased in 2010 compared to 2008. Little research has been done on the undesirable side effects of speed cameras, such as sudden deceleration and acceleration in the vicinity of cameras, and the migration of crashes to other locations. However, experts do not exclude the possibility that such effects occur. It is therefore important to include an evaluation of possible side effects when planning camera projects. The positive effects of speed cameras do not automatically mean that cameras are also always the most effective measure for speed management and road safety improvement. In built-up areas in particular, infrastructural measures can be considerably more effective.

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