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Evaluation of speed monitoring measures



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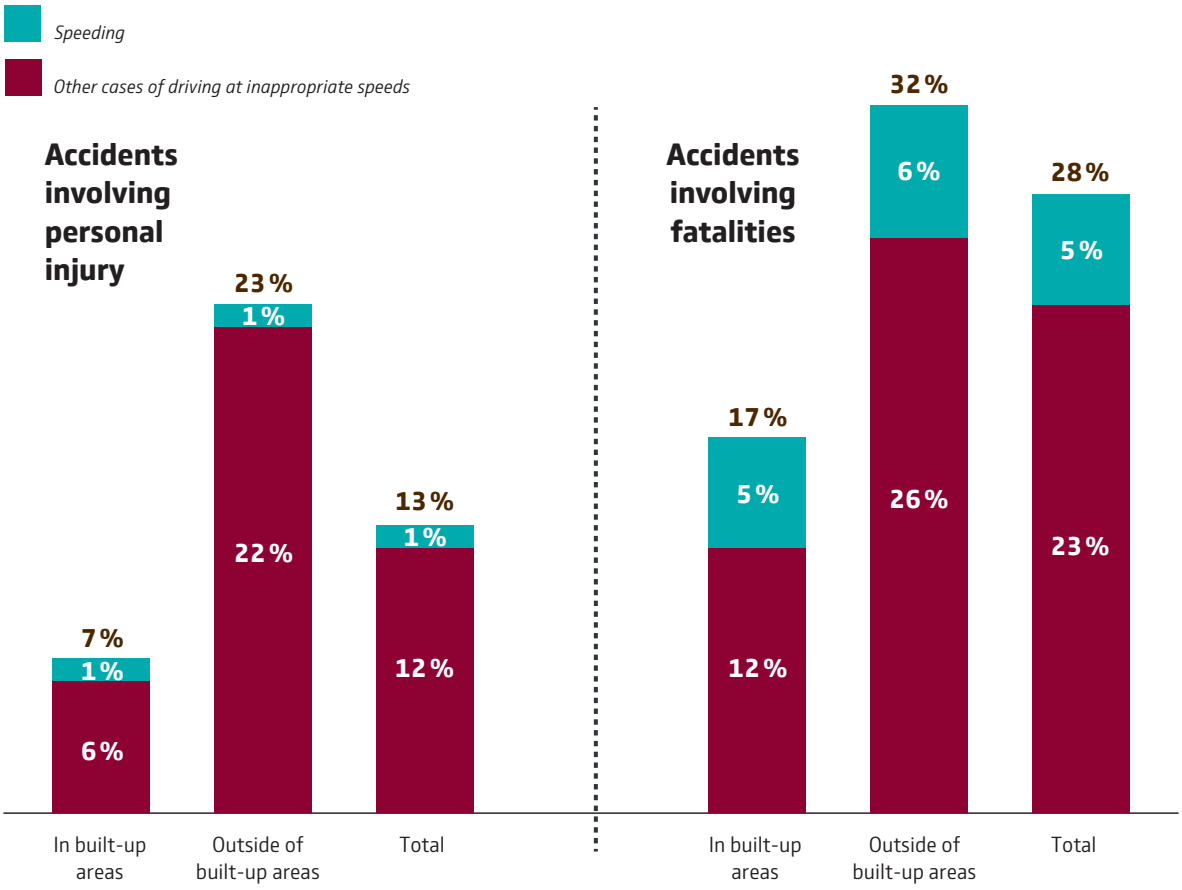
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Preliminary remark

Driving at "inappropriate speeds" is the most frequent cause of traffic accidents in Germany. Thus, speed is a contributory cause to approximately one in eight accidents involving injury caused either solely or jointly by drivers of motor vehicles (13 %) and this figure is twice as high for accidents involving fatalities. Outside of built-up areas, the situation is even more drastic: Here, inappropriate speed has been identified as the cause of almost a third of all fatal accidents caused either solely or jointly by drivers of motor vehicles (Figure 1). However, the question of the role of speeding cannot be reliably answered on the basis of the accident statistics because a subsequent assessment is often necessary in order to determine the vehicle speeds at the time of the accident. In many cases, the non-specific cause "other cases of driving at inappropriate speeds" is recorded. The real numbers hidden behind this formulation are therefore presumably very high. Quite irrespective of this, the proportion of accidents recorded as being due to "speeding" is particularly high, especially so with regard to fatal accidents (6 %).

Outside of build-up areas, almost a third of all accidents involving fatalities are caused by driving at inappropriate speeds.

Figure 1 · Proportion of drivers involved in accidents assigned to the cause "speed" by location and severity



Source: German Federal Statistical Office 2021: Traffic accidents 2020, Table 6.1.
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Speed monitoring appears to be a suitable way of enforcing speed limits and preventing accidents. A research project undertaken by the German Insurers Accident Research (UDV) therefore examined the question of the effects of high speeds on accident occurrence and of whether fixed or mobile speed cameras can help improve road safety. The research project was conducted by the Institute for Highway and Railroad Engineering (ISE) at the Karlsruhe Institute of Technology (KIT).

Lessons from the literature

Over the last 15 years, the proportion of fatal accidents attributable to speed-related causes has fallen from around a half to approximately a third (German Federal Statistical Office 2019). However, it cannot be established that this is due to the use of speed cameras. What is more, detailed analyses of accident causes have shown that it is very difficult to attribute speed-related causes in accident reports, in particular in the case of accidents occurring at intersections, and that this is therefore clearly not done.

A number of studies have shown that impact speed during crashes is the most important factor determining the severity of road accidents (Peden et al. 2004 and Elvik et al, 2004). The slower the vehicles are travelling, therefore, the lower the probability of serious consequences is.

In Germany, speed limits can be introduced for a wide range of different reasons, including in the light of existing or expected road safety shortcomings. In addition, the General Administrative Regulations governing the German Road Traffic Regulations (VwV-StVO) require the road traffic authorities to take measures to enforce speed limits if speed-related accidents occur frequently and the majority of vehicles travel faster than is permitted.

The results of studies conducted as part of the intensified speed camera campaign have shown that one-off or yearly monitoring operations have no lasting impact on driving speeds (UDV 2016). While the implemented mobile speed monitoring measures do indeed reduce driving speeds, these subsequently very quickly return to their original level.

By contrast, studies of fixed speed cameras conducted on comparable stretches of road have shown that these permanently reduce driving speeds. Recent studies, conducted in particular in connection with a large-scale study of safety on roads outside of built-up areas (AOSI), have provided us with systematic analyses of the effect of speed monitoring measures on accident occurrence (Lippold et al. 2012 and Jährig 2012). These have shown that sequences of successive fixed speed cameras outside of built-up areas reduce accidents involving injuries as well as accident cost rates. It has also been possible to identify a reduction in accidents and accident severity within a range of approximately 1,000 m. However, many of these installations were spaced less than 2 km apart, greatly restricting the possibility of transposing the results to standalone cameras.

Methodology

To answer the research questions, the three sub-samples described below were formed. In each sub-sample, speed cameras were examined on open stretches of road as well as at intersections both inside and outside of built-up areas.

Measurements at existing fixed speed cameras

Concealed speed measurements were taken over a period of at least 24 hours at 30 fixed speed cameras that had already been in operation for some time. The aim was to compare accident occurrence during the periods before and after installation of the systems in the light of the measured speeds.

Measurements at newly installed fixed speed cameras

At a further nine fixed speed cameras installed during the project period, speeds before and after system installation were also measured. The main aim here was to assess the effect of speed monitoring on the road users' driving speeds. It was not possible to evaluate the effect of these systems on accident occurrence in this sub-sample because no accident data were available for the very short period of the project that remained following their installation.

Measurements at 20 locations with mobile speed cameras

Speed measurements were made on days with and without monitoring at 20 locations at which the responsible regulatory authorities regularly perform mobile speed monitoring. These measurements were intended to determine what effect mobile monitoring has on driving speeds and whether any effect that was found persisted outside of the monitoring periods. Because there was no clear before/after distinction for the locations with mobile monitoring, it was not possible to investigate the effect of mobile speed cameras on accident occurrence.

Methodology and organisation of the measurements

On the one hand, speed measurements were made in the direct vicinity of the cameras using side radar devices. On the other hand, a further four side radar devices were installed on the stretch of road before and after the speed camera. In this way, it was possible to assess driving speed in an area of 300 m (and sometimes as much as 500 m) before and after the location of the speed camera itself. The measurements were concealed. To this end, the devices outside of built-up areas were hidden in marker posts. In built-up areas, they were mounted in unobtrusive boxes on existing signposts or lighting masts.

Analysis of accident data

To evaluate the impact on safety, all accidents involving injury occurring during a period of three years before and three years after the installation of the speed cameras were considered (provided that sufficiently long periods were available). Accidents were assigned either to the core area (100 m before and after the camera location) or the more extended area (total area of up to 1,000 m before and after the camera location) and each of them was considered separately.

Analysis of local circumstances

The environment around each study location was also analysed with regard to building-related or operational shortcomings. The intention was to ascertain whether any shortcomings that might be present have an influence on driving speed and/or accident occurrence. Potential shortcomings were identified using the process for the auditing of existing roads in accordance with the guidelines for road safety audits (RSAS 2019).

Results of the survey of authorities

A survey of 137 authorities showed that speed monitoring in Germany is a widespread practice. While speed cameras outside of built-up areas are generally operated by the district authorities, local or regional administrative authorities on all levels are responsible for operating installations in built-up areas (from municipality level through to district level). Mobile speed monitoring operations are mostly conducted in built-up areas. However, the survey also revealed some isolated mobile measurements made outside of built-up areas by district authorities.

All the authorities that participated in the survey mentioned accident prevention and the improvement of safety at accident black spots as at least one of the reasons for installing speed cameras. However,

a quarter of the authorities (23 %) said that they made use neither of accident analyses nor of prescribed accident limit values when deciding where to install their speed cameras. This proportion is particularly high among the lower road traffic authorities at municipal level. Of these, more than half make no use of such analyses or limit values when deciding where to locate their speed cameras (55 %).

Effect on driving speeds

Fixed and mobile speed cameras had very different effects on driving speeds. Whereas the speed limit (subject to a certain tolerance) was respected at all times by almost all road users in the presence of fixed speed cameras, mobile cameras had a much lesser effect, and then only during the period of monitoring.

Fixed speed cameras

In the immediate vicinity of the 30 existing speed camera installations included in the study, the speed limit was respected by the vast majority of road users. Subject to a tolerance of 5 km/h, the number of drivers exceeding the speed limit at the individual monitored locations was substantially less than one percent (Table 1). Speeds more than 10 km/h above the speed limit occurred rarely and speeds of more than 20 km/h above the limit almost never.

Furthermore, the before/after comparison at the fixed speed cameras installed during the project period showed that these fixed systems were effective in reducing the speeding observed prior to their installation (Table 2). This effect was particularly large at the cameras outside of built-up areas included in the study. At these locations, the proportion of drivers exceeding the speed limit within the tolerance of 5 km/h was reduced from 14 percent to 2 percent. In built-up areas, it was also possible to almost completely eliminate the (albeit lower level of) speeding within the permitted tolerance which had been present previously.

The effect of fixed speed cameras is restricted to a relatively short area before and after the installation location. This was shown by an analysis of the speed measurements made in the wider area around the cameras. Thus, the speed limit is often respected only for a total distance of approximately 250 m before and after the installation location. If the reason for the imposed speed limit is visible (e.g. an intersection), then drivers also tend to drive slowly for longer distances. However,

Almost no speeding in the presence of fixed speed cameras

Table 1 · **Speeding rates observed at existing fixed speed cameras**

Existing fixed speed cameras		Percentage of drivers exceeding the speed limit			
Speed exceeded by more than		> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h
Outside of built-up areas	Intersection	0.38	**0.13**	0.03	0.01
	Open road	5.35	**0.58**	0.13	0.00
In built-up areas	Intersection	3.17	**0.56**	0.16	0.05
	Open road	3.29	**0.51**	0.26	0.00

Proportion of drivers speeding is considerably reduced by fixed speed cameras

Table 2 · Speeding rates observed at newly installed fixed speed cameras

Newly installed fixed speed cameras		Percentage of drivers exceeding the speed limit											
		Before installation (km/h)				First measurement after installation				Second measurement after installation			
Speed exceeded by more than		> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h	> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h	> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h
Outside of built-up areas	Inter-section	36.86	**14.16**	5.81	0.42	10.19	**2.14**	0.66	0.00	8.85	**2.96**	1.58	0.21
In built-up areas	Inter-section	0.75	**0.30**	0.05	0.00	0.00	**0.00**	0.00	0.00	Not measured			
	Open road	17.12	**3.48**	0.77	0.07	2.11	**0.13**	0.01	0.00	7.88	**0.89**	0.07	0.00

the speed-reducing effect sometimes starts to wane as early as a distance of approximately 180 to 200 m before or after the protected area. In particular, in areas with a speed limit of 30 km/h over an extended distance, fixed speed cameras have only a localised effect.

Mobile speed cameras

The effect of mobile speed cameras is much less than that of fixed speed cameras. Although lower levels of speeding were observed at all the monitored locations during the monitoring period, the speed limit plus tolerance of 5 km/h was still broken by four to ten percent of road users even during the monitoring period (Table 3). Outside of built-up areas, every thirtieth to fortieth person drove more than 10 km/h too fast even during the monitoring period. What is more, even this relatively weak effect of mobile speed cameras is restricted to the monitoring period itself. Thus, immediately after the period of monitoring, levels of speeding had already returned to those observed prior to monitoring.

Impact of fixed speed cameras on safety

For methodological reasons, it was only possible to assess the impact of monitoring compliance with the speed limit at the already existing fixed speed cameras (see Methodology section). This assessment showed that at many of the corresponding locations there had been no noteworthy accident occurrence even prior to their installation. Only at approximately a quarter of them had there been more than three accidents with injuries in

Mobile speed cameras have a much smaller effect which is restricted to the monitoring period only

Table 3 · Speeding rates observed at locations with mobile speed cameras

Locations with mobile speed cameras		Speeding rates on day of mobile monitoring [%]											
		Before monitoring				During monitoring				After monitoring			
Speed exceeded by more than		> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h	> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h	> 0 km/h	> 5 km/h	> 10 km/h	> 20 km/h
Outside of built-up areas	Inter-section	27.61	**14.83**	6.34	0.76	18.18	**9.84**	3.28	0.06	26.93	**14.14**	6.05	0.63
	Open road	27.06	**11.56**	4.95	0.78	17.64	**5.96**	2.47	0.38	29.91	**12.30**	5.16	0.89
In built-up areas	Inter-section	32.65	**12.53**	4.28	0.96	22.11	**4.49**	0.76	0.10	31.74	10.54	3.72	0.40
	Open road	33.86	**10.92**	3.53	0.11	28.78	**8.38**	2.39	0.23	37.12	**13.5**	4.90	0.47

the core area (100-m radius) in the three years preceding installation. At 40 percent of the systems, there had been no accidents at all in the core area during the period preceding installation. These systems had therefore clearly been installed for reasons other than to reduce accident numbers at the location (e.g. noise prevention, complaints from residents or general preventive measures). The impact on safety of these systems could therefore not be assessed.

A clear reduction in accident numbers following installation was observed at the remaining systems where there had been at least one accident involving injury (A(I)) during the period preceding installation, in particular in the core area (Table 4). Above all, fixed speed cameras in the vicinity of intersections proved to be extremely effective, in particular at intersections without traffic lights outside of built-up areas. In particular, a fall in turning-off/turning-into and crossing accidents was observed at such locations (Table 5). Fixed speed cameras on open stretches of road proved to be particularly effective around bends, where it is particularly important to observe the speed limit due to vehicle dynamics. In such areas, in particular, a corresponding fall in road accidents could be observed following the installation of the systems.

In contrast to the generally very positive effect of the speed cameras on safety, an increase in longitudinal traffic accidents and, consequently, rear-end collisions was recorded in a radius of 100 m around the installation location (Table 5). It may be assumed that this increase in rear-end collisions is due to drivers unfamiliar with the locality braking abruptly when seeing the speed cameras, thus giving rise to rear-end collisions. However, this cannot be proved based on the available data. Nevertheless, the numerical increase in such accidents is considerably smaller than the observed reduction in accident numbers in general.

Clear reduction in accidents with injuries A(I) in the direct vicinity of speed cameras

Table 4 · Before/after comparison of changes in accident numbers at existing fixed speed cameras

Existing fixed speed cameras with A(I) before/after installation			Change in the number of A(I): before/after	
Location	Infrastructure	Number of systems	Core area (100-m radius)	Total area (1,000-m radius)
In built-up areas	Open road	7	**-32 %**	-3 %
	Intersection	2	**-50 %**	-22 %
Outside of built-up areas	Open road	2	**-38 %**	-7 %
	Intersection with traffic lights	6	**-48 %**	**+47 %**
	Intersection without traffic lights	2	**-100 %**	-46 %

In particular, the number of accidents involving personal injury A(I) decreased

Table 5 · **Before/after comparison by accident type and kind of accident at existing fixed speed cameras**

Accident type / Kind of accident	Before		After	Change: before/after
	Number A(I)*	As proportion of accident occurrence	Number A(I)*	
Type 1: Driving accidents	9.0	14 %	7.5	-17 %
Type 2: Turning-off accidents	10.0	15 %	3.5	-65 %
Type 3: Turning-into/crossing accidents	20.0	31 %	7.5	-63 %
Type 4: Crossing-over accidents	1.0	2 %	1.0	0 %
Type 5: Accidents involving stopping. stationary or parked vehicles	1.0	2 %	0.0	-100 %
Type 6: Accidents in longitudinal traffic	19.5	30 %	22.0	**+13 %**
Type 7: Other accidents	5.0	8 %	4.5	-10 %
Total of all accident types	**65.5**	**100 %**	**46.0**	**-30 %**
Kind 2: Rear-end collisions	20.0	31 %	23.0	**+15 %**

* Values extrapolated to three-year period if data were only present for shorter periods

Consequently, the value of speed monitoring for preventing accidents involving injury clearly outweighs any increase in rear-end collisions potentially caused by the cameras.

It was not possible to evaluate the impact of speed cameras on crossing-over accidents because there had previously been practically no accidents of this type in the locations observed during the study.

The situational road safety audits revealed the presence of building-related or operational shortcomings in the vicinity of nearly half of the studied speed cameras (45 %). At approximately a fifth of the fixed cameras, building measures meant that there was no accompanying display of the corresponding speed limit (21 %). At a total of four fixed installations at intersections or crossings, priority was regulated by means of traffic signs, even though the local circumstances suggested that traffic lights would have been preferable (14 %). 55 percent of the installations exhibited no observable building-related or operational shortcomings. In general, it was possible to observe positive effects of speed monitoring in the immediate vicinity of the cameras (100-m radius) both at fixed installations with shortcomings and at those without. This is particularly true for fixed speed cameras at intersections.

At many locations, a fall in accidents involving injuries was also observed in the more extended area before and after the camera (radius of up to 1,000 m) (Table 4). However, an increase in accidents was also observed in the more extended area around several speed camera installations at intersections with traffic lights. However, it was not possible to identify any connection between the presence of the installation and the increase in accidents. Instead, the accidents in question tended to be due to the influence of traffic situations at neighbouring intersections.

Conclusion and recommendations

Fixed speed cameras are very effective if they are located in the right places

At fixed speed cameras, the speed limit (plus tolerance) is respected at all times by practically all drivers. As the before/after measurements at newly installed speed cameras showed, previously observed occurrences of speeding are effectively reduced.

However, the effect of fixed speed cameras is restricted to a relatively short area. In general, the speed-reducing effect falls off as little as 200 m before and after the protected area. On 30-km/h stretches, in particular, fixed speed cameras have only a very localised effect.

The installation of fixed speed cameras considerably reduces accident numbers in the immediate vicinity of the installation (100-m radius), in particular at intersections without traffic lights and at bends on open stretches of road. In some cases, a reduction in accident numbers was also observed in the more extended area around the installation (radius up to 1,000 m). Although a slight increase in longitudinal traffic accidents and rear-end collisions was observed following the installation of speed cameras, this was far outweighed by the general reduction in accident numbers.

As has been pointed out, many fixed speed cameras are installed in locations with no noteworthy accident occurrence. There had been practically no accidents in the immediate vicinity of 40 percent of the studied systems prior to their installation. If fixed speed cameras are to be used to reduce accidents involving injuries, they should therefore primarily be installed in locations where the accident occurrence merits this. Prior to installation, it is also necessary to check whether any noteworthy levels of speeding occur and whether the speed limit is displayed in an appropriate way given the specific conditions at the location.

Because the effect tends to be localised, the exact location of the installation must be carefully planned. The distance over which the effect persists can also be increased if road users are able to identify the purpose and relevance of speed monitoring.

At locations characterised by corresponding accident levels, fixed speed cameras are suitable as either a locally effective immediate measure (intermediate measure) or as a permanent measure. However, if such accident levels are indeed observed, it is always necessary to check whether there are any local building-related or operational shortcomings that can be eliminated.

The effect of mobile speed cameras is restricted to the monitoring period

The effect of mobile speed cameras is much less than that of fixed speed cameras. And even during the monitoring period, the speed limit was still not respected by many road users. Outside of built-up areas, every thirtieth to fortieth person drove more than 10 km/h too fast even during the monitoring period. What is more, the speed-reducing effect of mobile speed cameras is restricted to the monitoring period. Immediately after the end of the monitoring period, drivers were once again found to be driving as fast as they did before it. For methodological reasons, it was not possible to assess the effect of mobile speed cameras on accident occurrence. Further research will be necessary to ascertain this.

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