Speed Enforcement

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Summary

Traffic law enforcement
Traffic law enforcement influences driving behaviour through two processes: general deterrence and specific deterrence. General deterrence can be described as the impact of the threat of legal punishment on the public at large. Specific deterrence can be seen as the impact of actual legal punishment on those who have been apprehended.

Effectiveness and limitations of speed enforcement
Generally, reviews report substantial positive effects of speed enforcement on both speeding behaviour and the number of crashes. The sizes of the reported effects of speed enforcement vary considerably. These differences most likely have to do with the type, intensity and location of the enforcement activities as well as the situation before the enforcement started.

Methods of speed enforcement
Speed enforcement is most effective when it is unpredictable and difficult to avoid, when there is a mix of highly visible and less visible activities, and when it is continued over a longer period of time. Furthermore, it is advisable to focus speed enforcement on roads, situations, and times where speeding is considered to affect the road safety level most.

Measures to support speed enforcement
Speed enforcement is not a stand-alone measure. To maximise its effect, it is best supported by other measures such as credible speed limits and publicity. It is also important that speed enforcement is embedded in a supportive framework of legislation and sanctions.

Organization of speed enforcement
Preferably, the police work together with partners to prepare, perform and evaluate (speed) enforcement activities. The main partners for the police are local road authorities, court officials, publicity organizations, and researchers. Local road authorities and researchers may assist the police in analysing the local road safety problem and determining priorities. Cooperation with court officials provides clarity about regulations for detecting and sentencing traffic offenders. Publicity organizations can organize supportive publicity programmes, in consultation with the police and the road authorities.

Future possibilities
New vehicle technology can be integrated in the system of enforcement. For example, electronic vehicle identification (EVI) can be made part of the enforcement system and support this system. When cars are equipped with black boxes, it is possible to enforce speeding at all times and places. On the long term, police enforcement as we know it may be largely replaced by new technological systems of speed control.

1. General introduction to traffic law enforcement

1.1 Police enforcement as part of a systems approach

Countries that have successfully reduced road traffic risk have embraced a 'systems approach' to road safety. A systems approach looks at the traffic system as a whole and at the interaction between road, vehicle, and road user in order to identify where there is potential for intervention [52]. It recognises that human beings make errors and that the road traffic system needs to accommodate for these errors. Inspired by the Haddon Matrix (http://www.tsc.berkeley.edu/newsletter/winter05-06/haddon.pdf) [31], the “systems” approach seeks to identify and rectify the major sources of error or design weakness that contribute to fatal and severe injury crashes, as well as to mitigate the severity and consequences of injury by:

- Reducing exposure to risk
- Preventing road traffic crashes from occurring
- Reducing the severity of injury in the event of a crash
- Reducing the consequences of injury through improved post-collision care

The Swedish Vision Zero [63] and the Dutch Sustainable Safety vision [66] are good examples of such a systems approach to road safety.

Within the systems approach, traffic law enforcement is one of the instruments to secure or improve traffic law compliance. In the literature the concepts of ‘traffic law enforcement’ and ‘police enforcement’ are often used interchangeably. However, the concepts differ in width. Traffic law enforcement is wider and covers the entire enforcement chain, from detection of a violation through to the penalty. Police enforcement refers to the actual work of detecting a traffic law violation, apprehending the offender, and securing the evidence needed for his prosecution. Police enforcement can only be effective if it operates in a supportive environment of laws, regulations, and a sensitive penal system. Consequently, the effectiveness of police enforcement cannot be seen in isolation from how the police collaborate with the other parties in the traffic law enforcement chain.

Within the area of police enforcement this web text focuses on speed enforcement. There are two reasons for this. First, the relationship between excess speed and unsafety is well-established and speed control is one of the major spearheads of road safety programmes world-wide. Second, speed enforcement merits special attention in view of the variety of policing methods used to prevent speeding violations and the continuing (technological) developments in this area. It should be kept in mind, however, that police traffic enforcement involves much more than just speed enforcement.

1.2 From laws and policy, to increased enforcement, to social benefits

Yannis et al. [69] describe the hierarchy of road safety enforcement. The legal and organizational framework enabling police enforcement provides the foundation for the actual policing operations. Such a framework will result in well-planned, intensified police controls on selected locations of the road network, resulting in an increase in the perceived risk of apprehension. As a result violation rates will decrease. Changes in road user behaviour will result in less traffic crashes and less traffic victims, and in reduced monetary costs for society (social benefits). The figure below describes this ideal scenario.

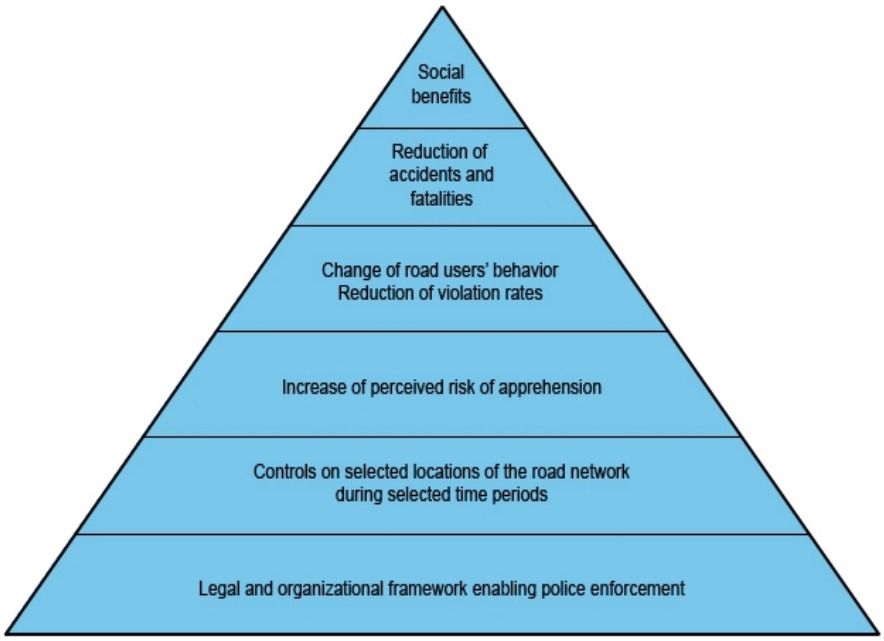

Figure 1: The hierarchy of road safety enforcement. Source: Yannis et al. (2004)

Rule 1:
To maximize the road safety effects, traffic law enforcement should first and foremost prevent violations that are proven to be related with the number or severity of crashes.

1.3 General deterrence vs. specific deterrence

It is generally accepted that traffic law enforcement influences driving behaviour through two processes: general deterrence and specific deterrence [71][44]. General deterrence can be defined as the impact of the threat of legal punishment on the public at large. Specific deterrence can be seen as the impact of the actual legal punishment on those who are apprehended. Thus, general deterrence results from the perception of the public that traffic laws are enforced and that there is a risk of detection and punishment when traffic laws are violated. Specific deterrence results from actual experiences with detection, prosecution, and punishment of offenders.

The general assumption underlying police enforcement is that it should primarily aim at general deterrence, which is first and foremost achieved by increasing the subjective risk of apprehension. The subjective risk of apprehension, and hence the effectiveness of police enforcement, is larger if police enforcement is [26]:

- Accompanied by publicity
- Unpredictable and difficult to avoid
- A mix of highly visible and less visible activities
- Primarily focused on times and locations with high violation (maximum feedback to potential offenders)
- Continued over a longer period of time

These general principles may need further region-specific tailoring to account for regional differences with regard to violation levels, road network status, and sometimes even social norms. Research has shown regional differences in the effectiveness of police enforcement [32][70].

1.4 Targeted enforcement

In major reviews [44][22][48] it has been concluded that enforcement targeted at a limited number of high risk violations is more effective in reducing road crashes than non-targeted general enforcement. There are various reasons:

- Organizational: Given the limited amount of manpower and equipment of police, the enforcement managers will always aim to get maximum value from scarce resources. Focusing on a limited number of high risk violations is more efficient than a non-focused general enforcement approach
- Road safety: Focusing on one or more high risk violations such as speeding, drink driving, seat belt use and red light running is also justifiable given the scientific evidence of the relationships between these violations and road safety risk;
- Communication: it is easier to communicate to road users about a limited and specific number of violations than about traffic violations in general.

2. Speed enforcement

2.1 Speed enforcement as part of a speed management policy

Speed is at the core of the road safety problem. There is a strong relationship between speed and both the number of crashes and the severity of the consequences of a crash. If the number of speeding violations on European roads could be reduced, many lives would be saved (for more information, see the ERSO text on speeding).

There is no single solution to the problem of excess and inappropriate speeds. A package of countermeasures is necessary, increasing the effectiveness of each individual measure [49]. Police enforcement is one of the countermeasures. The most appropriate combination of measures is determined by the circumstances. Wegman & Aarts [66] propose an integrated, systematic and stepwise approach to speed management:

Step 1: Setting speed limits
A speed limit needs to reflect the safe speed on that particular road, related to road function, traffic composition, and road design characteristics. Furthermore, a speed limit needs to be credible, i.e. it must be logical in the light of the characteristics of the road and the road environment.

Step 2: Information about the speed limit
The driver must know the actual speed limit, always and everywhere. This can be done by either by the use of consistent roadside signing and road markings, or by the use of in-vehicle systems that inform drivers about the speed limit in force.

Step 3: Road engineering measures
At particular locations low speeds are crucial for safety. Examples are near schools or homes for the elderly, at pedestrian crossings, at intersections. At these locations, physical speed reducing measures such as speed humps, road narrowings and roundabouts can help to ensure cars maintaining a safe speed.

Step 4: Police enforcement to control the intentional speeder
If steps 1 to 3 have been applied, unintentional speed violations will have become an exception. Drivers who then still exceed the speed limit, do so intentionally. Police enforcement will remain necessary to control and punish that group of drivers.

Each of the steps 1 to 4 has to be accompanied by information to drivers on the problem of speed and speeding, what the speed limit system is based on and why, what additional measures have been taken and why, and on the (positive) outcomes of these measures.

2.2 Speed enforcement in relation to other road safety measures

Preferably, a road safety philosophy not only specifies possible road safety measures, but also specifies how different road safety measures, including road design, setting speed limits, enforcement, etc. are related to one another in a logical and hierarchical manner, and when and where certain measures must be taken, rather than others. For example, according to the Dutch Sustainable Safety vision, speed enforcement should always be considered in combination with other speed management measures. It should only be carried out when speeding demonstrably contributes to a bad safety record of a road, and when other measures (such as setting safe and credible speed limits, changing the road infrastructure, providing road users with adequate information about limits on road sections) are not possible or insufficient to make road users comply with the speed limits.

Research informs us that different measures can be effective in controlling speed. For example, Mountain, Hirst and Maher [46] compared speed and safety effects of engineering measures and enforcement by fixed speed cameras. Using a study design that controlled for trends in crashes, regression-to-the mean effects and changes in traffic volume, they found that engineering schemes including vertical deflections (speed humps, cushions) prevented 44% of personal injury crashes. Furthermore, they found that engineering schemes with horizontal features resulted in a decrease of 29% in personal injury crashes and speed cameras reduced the personal injury crashes by 22%.

The idea behind an integrated speed management approach is to seek for the best possible synergies between the various individual measures. Isolated measures will have an impact but are most likely not the most effective way to achieve a durable reduction in speed [49].

Rule 2:
To achieve collective safety benefits by reducing speeds, a systematic, integrated speed management policy is necessary. Speed enforcement is one of the elements of an integrated speed management approach.

2.3 General characteristics of effective speed enforcement

The general characteristics of traffic law enforcement, as discussed previously, can easily be translated to the specific domain of speed enforcement.

The most important requirement for speed enforcement is that it deters drivers from speeding; not only those drivers that have been apprehended for a speeding violation, but even more so, those who have not. This is called general deterrence. General deterrence is closely related to the risk of being caught as subjectively perceived by a driver. This subjective risk of apprehension can not only be increased by stepping up the intensity of actual speed enforcement, but also by making sure that, independent of the exact enforcement method, the speed enforcement activities are well-publicised, unpredictable and unavoidable, and sustained over a longer period of time.

Furthermore, for a maximum effect, it is advisable to focus the speed enforcement operations on roads, situations, and times where speeding is considered to have the largest effect on the road safety level. Ideally, the enforcement operations are based on a thorough analysis of crashes and the role of speeding therein.

Rule 3:
Speed enforcement gains in effectiveness if it is targeted towards prioritised roads, situations and times.

2.4 Public support for speed enforcement

According to the SARTRE survey [55] the public support for traffic enforcement in general and for speed enforcement in particular is high. The survey interviewed over 23,000 car drivers in 23 European countries to determine opinions and behaviours in traffic. It showed that:

- Three quarters (76%) of all interviewed EU drivers are in favour of increased enforcement of traffic rules

- Two-thirds (66%) of EU drivers are very or fairly much in favour of the use of automated speed cameras
- Three out of five (60%) EU drivers support higher penalties for speeding offences.

Since the SARTRE survey clearly concentrates on traffic safety issues, the respondents may have been tempted to give socially desirable answers. How would the public evaluate the speeding problem when it is compared with other social problems like crime? In that case, would there be less enthusiasm for speed management and speed enforcement? To answer this question Poulter and McKenna [53] examined the public perceptions of antisocial behaviours including speeding in traffic. The data was collected as part of the British Crime Survey, a face-to-face interview with UK residents on issues relating to crime. The section on antisocial behaviour required participants to state the degree to which they perceived 16 antisocial behaviours to be a problem in their area. Results revealed that speeding traffic was considered as the largest problem in local communities, regardless of whether respondents were male or female, young, middle aged, or old. The rating of speeding traffic as the largest problem in the community was replicated in a second, smaller postal survey, in which respondents also provided strong support for enforcement on residential roads, and indicated that travelling just above the speed limit on residential roads was unacceptable.

Even though these results suggest that speed enforcement is widely supported by the public, it is also a topic that evokes strong public and even political debate, in particular about the use of automatic speed cameras. Common complaints are that mostly minor offenders are caught, that it is not impartial, and that it is just used to fill the regional or national treasury. In other words, the credibility of traffic enforcement requires special attention and is one of the quality aspects of enforcement. Experience shows that speed camera enforcement programmes require clear and transparent rules to ensure public acceptability. The credibility of speed enforcement may be increased by setting credible speed limits, by policy guarantees that exclude profit considerations as a motive for enforcement actions, and by communication about the reasons for enforcement and positive behaviour and safety outcomes.

Rule 4:
The credibility of traffic enforcement should be part of enforcement policy and is to be considered as an important quality aspect of enforcement**.**

3. Speed enforcement techniques and their effectiveness

There are two main methods of speed enforcement. The first one is to check drivers alongside the road and stop offenders. In the literature this is often called stationary enforcement or physical policing. Physical policing makes use of manned (visible or invisible) observation unit and a manned (visible) apprehension unit where the offenders are stopped. When physical policing is randomised in time and location over a large part of the road network, this type of enforcement is called random road watch or network-wide random enforcement.

The second method is to detect speed offenders by means of a speed camera and to send them a fine or a notification by mail. Speed cameras can be used fulltime at fixed locations (fixed cameras) or can be rotated over different locations (mobile cameras). Speed cameras can operate automatically (unmanned) or as part of a manned control (either in a visible or in a hidden car or van).

3.1 Physical policing

Physical policing has both advantages and disadvantages. The advantages are related to the fact that violators are immediately stopped by the police:

- The violator is given immediate feedback
- The police officer has the opportunity to explain why they are enforcing speed
- If violators are stopped at a spot which is clearly visible to other drivers, the subjective chance of apprehension is increased

The disadvantage is that physical policing is far more labour-intensive and that it is virtually impossible to reach the same enforcement level as with speed cameras. Hence the objective chance of

apprehension is much smaller. This is particularly true for speed enforcement by a patrolling police car. A patrolling police car follows the traffic stream and therefore has a relatively small chance of detecting a speed violator. If it does, it needs to follow that car for a sufficiently long time to determine the level of speeding reliably. Zaidel [72] criticizes conventional manpower-using methods of police enforcement of speed as being (too) selective, sporadic, inconsistent, and in the end, being rather expensive and ineffective.

In contrast to the foregoing criticism by Zaidel [71], there is evidence that even with time-consuming conventional manpower-using methods effective speed control over large areas is possible. A specific type of physical policing is the network-wide random enforcement or Random Road Watch (RRW). This is an enforcement resource management technique that randomly schedules levels of police enforcement with the aim of realizing long-term, widespread coverage of a road network. Violators are stopped by the police. Newstead et al.[47] evaluated an RRW programme in Queensland, Australia, applying a quasi-experimental study design and Poisson regression statistical analysis techniques. The estimated effects appeared to be largest on fatal crashes, with an estimated reduction of 31% on the roads included in the programme. The effects were smaller for less severe crashes. The effects became larger as time increased after the programme introduction. In the third year of the programme, savings, at state level, were some 12% on crashes of all severities and some 15% on the fatal road crashes. The cost benefit/cost ratio for the programme was estimated to be 55:1.

3.2 Speed cameras

Speed camera enforcement is most appropriate if crashes are clearly concentrated on specific road sections and are related to excess speed, and when the volume of traffic makes physical policing a time-consuming, less effective approach.

The best estimate is that automatic camera enforcement results in a crash reduction of 15 to 20% [19]. Individual evaluation studies differ widely in the reported effects. The actual effectiveness depends on many factors, such as the actual enforcement effort, the initial speed and safety level and the type and amount of supporting publicity.

Without having the pretension to be complete, Table 1 presents the findings of a number of studies of the effectiveness of different speed camera techniques.

Road type	Method type	Effect on crashes	Study and country
Urban	Fixed speed cameras	Minus 28%, all crashes	Elvik & Vaa (2004) Meta-analysis worldwide
Rural	Fixed speed cameras	Minus 18%, all crashes (* corrected estimate, not mentioned in original report)	Elvik & Vaa (2004) Meta-analysis worldwide
Urban	Fixed speed cameras	Minus 22%, personal injury collisions	Gains et al. (2005) UK
Urban	Mobile speed cameras	Minus 22%, personal injury collisions	Gains et al. (2005) UK
Rural	Fixed speed cameras	Minus 33%, personal injury collisions	Gains et al. (2005) UK
Rural	Mobile speed cameras	Minus15%, personal injury collisions	Gains et al. (2005) UK
Rural	Fixed speed cameras	Minus 20%, injury crashes	Elvik (1997) Norway
Rural	Mobile hidden speed cameras	Minus 21%, injury crashes involving a motor vehicle	Goldenbeld & Van Schagen (2006) Netherlands
Highways	Mobile speed cameras	Minus 25%, daytime unsafe speed related crashes	Chen (2000) Canada
Highways	Hidden speed cameras (*extra effect above visible cameras)	Minus 11%, all crashes	Keall et al. (2001) New Zealand

Table 1 Overview crash reduction effects studies speed enforcement

It can be seen in Table 1 that favourable results have been obtained both with visible cameras [16][25] and with hidden cameras [29][38].

Whether visible or invisible cameras should be preferred depends upon different considerations. For example, if it is very important that road users lower their speed on a specific section of the road, e.g. because of an intersection or a nearby school, it is more effective to have a visible speed camera, preferably accompanied by a warning sign. On the other hand, hidden cameras, and in particular hidden mobile cameras make speed checks less predictable. Hidden (mobile) speed cameras are often accompanied by a warning sign. This approach may increase the preventative effect, since drivers know that there is a chance of detection but they do not know when and where exactly. Whereas nearly every driver keeps within the speed limit when a camera is clearly visible, a small percentage of drivers may still violate the limit when they drive on a road with hidden cameras. On the other hand, clearly visible speed cameras drivers may tempt drivers to speed up again a few hundred metres after the camera, while they may be less tempted to violate the speed limit when they are aware of the possibility of a hidden camera check.

3.3 Average speed control

Average speed control (also called ‘section control’ or ‘point-to-point’ control) is a relatively new speed enforcement technique. Average speed control systems measure the average speed over a road section (usually 2 – 5 km). The vehicle is identified when entering the enforcement section, and again when leaving it. The average speed can be calculated based on the time interval between these two points.

Average speed control works 24 hours a day, 7 days a week, which means the chance of being caught is close to 100 percent. On a stretch of road where average speed control is employed, most

drivers obey the speed limit. On sections where speed limits were frequently exceeded in the past, average speed control can bring back the number of offences to a few percent, or even less than one percent.

Average speed control is still fairly new, not yet widely applied and not yet evaluated on a substantial scale. In Austria, Stefan [58] evaluated the use of average speed control on an 80 km/h motorway stretch running through a tunnel. In its first year of operation, a reduction in average speed by more than 10 km/h was recorded. Stefan estimated that after two years of operation average speed control reduced injury crashes by 33.3% and fatal and serious injuries by 48.8%. Taking into account both effects on road safety and road traffic emissions, Stefan computed a cost-benefit ratio of average speed control of 1:5.3. Positive results with section control were also obtained in the Netherlands. It was found that average speed control reduced the number of speed offenders to less than 1% at an enforced section of motorway [54].

3.4 Concluding remarks

Generally, reviews report substantial positive effects of speed enforcement on both speeding behaviour and the number of crashes [22][51] [71][72]. However, the effects of speed enforcement are by no means as clear cut as one would like. The sizes of the reported effects of speed enforcement, for instance, vary considerably. For example, Pilkington & Kinra [51] found that evaluation studies reported that the crash and casualty reduction in immediate vicinity of the speed camera locations varied between 5 and 69% for crashes, between 12 and 65% for injuries and between 17 and 71% for fatalities. These differences probably are influenced by the type, intensity and location of the enforcement activities as well as by the situation before the enforcement started.

A recent TRL study [15] reviewed the literature on police enforcement. With respect to speed enforcement the review concludes that:

- Speed cameras are more effective than physical policing methods in reducing speeds and crashes
- Speed cameras are more effective in reducing crashes inside urban areas than on rural roads
- Fixed speed cameras are more effective in reducing speeds and crashes than mobile speed cameras

Rule 5:
Speed camera enforcement should be used for a large concentration of traffic crashes at high-volume traffic locations. Physical policing can be a good alternative to safety camera enforcement when crashes are scattered, and provided operations are randomised and applied to a large part of the network.

4. Additional considerations on speed enforcement

Despite the positive findings about speed enforcement mentioned in the previous section we need to be aware of a number of potential limitations of speed enforcement.

4.1 Time and distance halo effects

The one common finding in the literature is that automatic speed enforcement effects are limited in terms of both time [64] and space [10] [36]. 'Time halo' can be defined as the length of time that the effects of enforcement on drivers' speed behaviour continue after the enforcement operations have been ended. 'Distance halo' is defined as the distance over which the effects of an enforcement operation last after a driver passed the enforcement site.

Physical policing

With regard to time halo, the effects of physical policing methods vary largely, ranging from effects lasting 1 hour to up to 8 weeks after the police activity has ceased [15]. It was also found that less than 6 days of police activity at a given location will have little or no time halo effect after the enforcement effort has been stopped. With regard to distance halo, Elliott and Broughton [15] conclude that:

- The effects of visible and stationary policing on driving speeds are halved for every 900 metres downstream of the enforcement site
- The effects of police presence on driving speeds typically last between 2.4 and 8 km
- Police enforcement can have considerable larger distance halo effects (e.g. up to 22 km), if visible, stationary enforcement is used randomly on a large part of the road network, as such suggesting a large scale enforcement effort and high unpredictability of checks.

Speed cameras

- A few studies indicate that 500 metres is about the maximum distance halo of a speed camera. More studies, however, indicate a much larger distance halo effect, even up to 10 km [15].
- Larger distance halo effects seem to be associated with physical policing, especially if the policing method is 'randomised'. The minimum distance halo effect found at speed camera sites (500 m) is almost five times smaller than the minimum distance halo effect of physical policing (2.4 km) [15]
- When the roads are checked by 24-hour operating speed cameras, the effects on speed and safety are larger in sections within 1 km of the camera site than sections within 2 km [34].
- When visible and invisible mobile camera operations are used the effects are more widespread over the road network [39]
- The effects of visible camera operations along the road side tend to dissipate after 3 days [14].

4.2 Regression-to-the-mean

Some critics of speed cameras have specifically argued that crash reductions found at speed camera sites are an overestimation, since they include regression-to-the-mean effects. The regression-to-the-mean effect is the statistical phenomenon that roads with a high number of crashes in a particular period are likely to have fewer during the following period, even if no measures are taken; this is just because of random fluctuations in crash numbers. Since speed enforcement often takes place at roads with large numbers of crashes, the effects of the intervention may be overestimated if there is no appropriate statistical control.

However, research by Gorell and Sexton [30] showed that also after controlling for regression-to-the-mean, the estimated reduction in all injury collisions due to 77 speed cameras in London was 12%, and the reduction in fatal and serious injury crashes 21%. Similarly, after correction for regression-to-the-mean, Mountain et al.[46] found that, within a distance of 250 metres of the speed cameras, the overall effect of a sample of 62 speed cameras was a 25% reduction in all injury crashes.

4.3 Intrinsic vs. extrinsic motivation

Psychologists have pointed out that speed enforcement is essentially an extrinsic motivational approach that relies on negative, external factors like fear of punishment, to change drivers' speed behaviour. It would diminish the intrinsic motivation of drivers to conform to the law, i.e. because they want to. The use of punishment instead of reward can be considered as a one-sided psychological approach.

Ideally, traffic enforcement is supported by social norms in a society. Visible police enforcement operations then 'remind' road users of the importance of rules and urge them to comply with traffic rules. Whereas, at first, rule compliance may be extrinsically motivated by the aim to avoid punishment, later on drivers may actually change their personal belief about what is the right behaviour and internalise traffic rules.

Over the last four decades, under the combined influences of new laws, police enforcement, and public communication campaigns, many drivers worldwide have come to accept the rule 'no drinking and driving' as a strict, personal norm. This positive development towards an intrinsic motivation for a traffic rule is probably more difficult to achieve for speeding behaviour. For many drivers, the relation between personal speeding and crash risk is less evident than the relation between alcohol and crash risk. More information about the effect of speed on crash and crash severity may help to increase the intrinsic motivation to comply with the speed limit.

5. Measures to support speed enforcement

Speed enforcement is not a stand-alone measure. To maximize its effect and acceptance, it is best supported by other measures such as credible speed limits and publicity. It is also important that speed enforcement is embedded in a supportive framework of legislation and sanctions.

5.1 Safe and credible speed limits

To invoke road users to keep to the speed limits, it is essential that these limits are safe and credible. A credible limit means that it is considered logical by the road user, i.e. the limit corresponds to the expectations that a road's layout and traffic environment evoke. Whereas the idea may not be new and many countries have such a requirement in their speed limit regulations, there seems to be substantial room for improvement.

Correspondence between speed limits and road layout can be realised by fitting the layout to the limit or the limit to the layout. On some roads the limit may need to be raised, whereas on others it may need to be lowered. Another important consequence of the concept of credible limits is that at a place where one limit changes to another one, as for example is the case when leaving an urban area, road users should always be able to see a clear change in road layout. The ERSO text on Speeding gives further details about credible speed limits.

5.2 Publicity

The effect of speed enforcement, as indeed of all traffic enforcement activities is substantially increased if it is supported by targeted information to the road user [68]. The communication with road users should:

- Emphasize that safety is the goal of the enforcement activities
- Explain how and why speeding leads to more and more severe crashes
- Explain the enforcement method and procedures
- Preferably illustrate that the revenues of fines are used for the benefit of local road safety
- Provide feedback on the interim and final results of the enforcement activity, either in terms of traffic behaviour or safety.

5.3 Facilitating legislation

Legislation is the basis for traffic enforcement. Legislation not only determines what regulations are enforced, but also how they can be enforced. This is particularly true for automatic speed enforcement. In some countries, it is the driver who is legally responsible for an offence (e.g. Finland, Germany, Norway, Sweden and Switzerland). This means that the automatic camera has to identify the driver in order to prosecute a violation. Generally, this requires a photograph of both the vehicle number plate and the driver. In other countries, the vehicle owner is held responsible for an offence (e.g. Belgium, Italy, France, the Netherlands, the United Kingdom). In these countries, a photograph of the licence plate from the rear is sufficient. This is technically easier and less expensive. An additional benefit of the vehicle owner being responsible is that also speeding motorcyclists can be fined.

5.4 Appropriate sanctions

Sanctions are considered to be an essential element of effective enforcement. The possibility of a sanction ascertains the deterrent effect of enforcement. Despite the essential role, the effects of sanctions are still fairly unknown. It has been argued that in order to be effective, sanctions must be based on certainty and be imposed with minimal delay [71][28]. The argument of immediacy of punishment is deduced from the scientific field of learning theories and behaviouristic animal experiments. In practical terms, there is no evidence that instantly imposed sanctions (within a few days) are more effective than sanctions imposed with a short delay of one or several weeks.

Another issue is the height of the fine. An overview of the literature [44] did not reveal consistent results on the effects of increasing punishment severity. More recently, Elvik and Christensen [20] evaluated the effects of increase of fixed speed and seat belt penalties in Norway. They could not find an effect on speeding. For seat belt wearing, however, they found an increase in wearing rate. The

authors suggest that the positive effect of penalties on seat belt use may partly be due to the increase in seat belt enforcement in Norway in the same period. The absence of any effect on speeding is attributed to the fact that the objective risk of apprehension is quite low on most parts of the road network. These findings suggest that increasing penalties may improve compliance with traffic rules, but only when the risk of apprehension is high. When the risk of apprehension is low, increasing fixed penalties does not make a noticeable difference for deterrence.
Although, as a general rule, the use of sanctions is necessary to achieve compliance, alternatives should much more be considered. In a Finnish experiment, it has been shown that stopping drivers and issuing them a speeding ticket was not more effective than a warning letter sent by mail [43]. Both a warning letter and a fine resulted in decreased speeds of sanctioned drivers of 9 to 10 km/h for a period of at least three months.

A survey study in the UK [5] indicated that drivers respond differently to speeding fines. Three separate groups were identified, whose size could be estimated:

- Those who now drive more slowly, including both at camera sites and elsewhere: 41 - 56%
- Those who now only slow down at camera sites, but not elsewhere: 30 - 32%
- Those not doing either: 14 - 15%

Thus, approximately one half the respondents were more speed sensitive soon after receipt of punishment, one third were more camera sensitive, and one sixth were neither. Punishment, in the form of a £60 fine and 3 penalty points, had a specific deterrent function for some drivers, but left others unremediated.

Rule 6:
To increase its effectiveness, speed enforcement must be supported by setting safe and credible speed limits, by publicity, by legislation facilitating effective enforcement, and by appropriate sanctions.

Rule 7:
Alternatives to negative sanctions (such as warning letters, educational courses, speed limiters) and the further development of these sanctions merit serious consideration of authorities, practitioners and researchers.

6. Organization of speed enforcement

6.1 Co-operation

Enforcement projects work best when they are targeted at dangerous road sections or dangerous road behaviour, are accompanied by various publicity and communication activities, and when they result in swift and appropriate penalties for traffic offenders. In order to maximize the potential of traffic law enforcement, the police must work together with various authorities and agencies to prepare, perform and evaluate (speed) enforcement activities.

The main partners for the police are the local road authorities, court officials, publicity organizations, and researchers. Local road authorities and researchers may assist the police in analysing the local road safety problem and setting priorities. Cooperation with court officials or public prosecution officials is necessary in order to have clarity about the guidelines for detection and sentencing of traffic offenders and the capacity to process a larger number of traffic offenders. Publicity organizations can organize special publicity programmes around the new enforcement project, but they will need to discuss the choices for the most effective media campaign strategy with police and local road authorities.

Ideally, co-operation between police and partners is grounded on a well-prepared plan that outlines agreements, task division, and shared and separate responsibilities. Goldenbeld et al. [28] put forth the following list of topics to be included in such an enforcement plan:

- A clear description of the aims and targets to be achieved by the enforcement activities
- Clear agreements with other parties, e.g. regional and local road safety authorities, municipalities, Department of Justice, fine handling authority, etc.

- Consideration of which groups of road users the publicity or enforcement activity can be specifically targeted at
- The support of enforcement activities by additional measures alongside the road such as adding or placing road signs or road markings or making them more visible
- A sensible choice of locations and times of enforcement operations
- Consideration of the best mix between highly visible police checks and more unexpected, less visible controls
- The set-up and execution of police checks according to time saving operational guidelines
- A well-considered build-up and build-down of activities over a longer period of time
- The choice of publicity strategy and message and publicity channels, including the informing the police officers involved in executing the enforcement operations
- Evaluation of the extent to which agreements are fulfilled and the extent to which expected effects of enforcement activities have been realised.

The agreements mentioned above necessitate the availability of good performance, outcome and output measures. The next section discusses this topic.

6.2 Performance, outcome and output measures

Police organizations have their own administrative recording system for policing activities. These days, increasing pressure is put upon police managers to justify the use of policing resources. Ideally, the monitoring system of policing activities provides data and arguments for this. For traffic enforcement and speed enforcement, a monitoring system should be aimed at showing relationships between policing resources (performance), effects on traffic behaviour, speed, (outcome) and, ultimately, effects on road safety (outcome). We can distinguish between performance measures and outcome measures [60]. Performance measures define what the police actually do on the streets, i.e.: how often, for how long and on which locations do they check speeding behaviour? Outcome measures should reflect the effects of enforcement on behaviour and on the consequences of behaviour, in the case of traffic enforcement, such as traffic crashes.

A further distinction can be made between outcome and output measures (Footnote; Swadley & McInerney do not make this distinction and list a number of infringements as an outcome measure). Outcome measures refer to intended outcomes, i.e. safer behaviour. ‘Output’ measures refer to administrative outcomes generated by policing activities such as for instance the number of tickets or the number of court cases that are a result of policing activities, but are not the main aim of these activities. Goldenbeld [27] argues that output measures such as the number of speed fines cannot be seen as a good indicator of the effectiveness or quality of police enforcement. Although there may be good administrative reasons to keep track of these data, the data is not very informative as to the quality of speed enforcement. Tables 2 and 3 provide the performance measures for speed cameras and non-camera operations as proposed by Swadley and McInerney [60].

Speed camera activity	Exposure measure
Number of vehicles checked	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled Per traffic count data at location
Total hours of enforcement	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled
Percentage of vehicles exceeding the speed limit or the enforcement limit	Against traffic count data at location Against speed monitor data for location
The number of separate speed checks (note: a speed check refers to camera operation for a certain time on a certain location; during one speed check several vehicles are checked)	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled
The number of locations for speed checks	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled
Hours per camera and total hours all cameras	

Table 2. Speed camera performance measures (Source: Swadley & McInerney, 1999)

Non-camera activity	Exposure measure
The number of personnel and hours of general traffic duty (including speed enforcement)	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled Per traffic count data at location
Kilometres travelled by marked police vehicles	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled
Kilometres travelled by unmarked police vehicles engaged in speeding enforcement activity	Per 10.000 registered vehicles Per 100.000 population in the area Per 100 million vehicle kilometres travelled

Table 3. Non-speed camera performance measures (Source: Swadley & McInerney, 1999)

The most direct form of outcome measurement is speed itself. Data from speed cameras is of limited use to evaluate effects on speed behaviour since it can be assumed that drivers will become familiar with camera sites and will alter their normal speed behaviour. Covert speed monitoring which is not connected with enforcement activities is necessary to obtain true and valid data on speed behaviour when enforcement activities are not present.

The SafetyNet report Safety Performance Indicators: Theory provides further detail on the method to set up reliable speed measurement.

Rule 8:
Speed enforcement operations gain in effectiveness if they have specified objectives and success criteria, and are monitored in terms of both process and product.

6.3 Funding

It is important that the public does not (falsely) perceive that fine revenues are the main aim of enforcement activities. This decreases public and political support for speed enforcement and can on the long term lower the effectiveness of speed checks. To avoid the public misperception that speed checks are performed for financial reasons, one would need:

- Clear rules stating that speed checks may only be performed at locations with above average numbers of crashes and where speed can be assumed to be a contributory factor to the crashes

- A transparent accounting of cost and fines generated by enforcement programmes
- The possibility to invest the financial revenues exceeding the costs of the enforcement programme in traffic safety or traffic mobility measures.

Speed enforcement programmes can, for example, be funded on a 'cost recovery' basis. This means that the police, local road authorities, research and publicity institutes who are involved in the programme are allowed to recover the costs of speed enforcement from the fine revenue. In general this includes equipment costs, enforcement and processing costs, as well as communication costs for public information campaigns aimed at changing driver behaviour.

6.4 Possibilities for better organized enforcement in EU Member States

At the ESCAPE workshop on traffic law enforcement [44] consensus could be found on a list of priorities for better organized police traffic enforcement in the EU Member States:

A strong role for the police as adviser in traffic affairs
The police are the 'ears and eyes' of society, also in the field of traffic where the police develop very practical knowledge of how the traffic system actually works. Many traffic and enforcement problems may be avoided in the first place if traffic police is consulted in advance about infrastructural changes, planning of special events etc.

Quantitative targets
Setting targets is necessary to motivate, steer and evaluate police activities.

Solid criteria for planning of enforcement activities
Given scarce resources of traffic police there should be good criteria on which to base decisions about allocation of these resources to enforcement activities.

Yearly monitoring of traffic behaviours
Besides crash data, behavioural data provides input for planning of enforcement activities. Also, the targets for the traffic police may be behavioural targets, e.g. 85% of the front-seat occupants wear seat belts inside built-up areas.

Crash registration quality
Crash data is the most widely used and often only source of data that is used to plan, steer and evaluate police enforcement activities. Given this importance of crash data the quality of crash data registration should be a continuous concern for police, authorities and research institutes.

Evaluation
Evaluation of police enforcement activities is the only way to find out whether the activities were meaningful, successful, well planned, well-executed etc. Without evaluation of some kind, one cannot conclude anything about the value of the police activities.

European knowledge body
The knowledge gained from enforcement activities in some countries or in some regions should be freely available to every European force that wants to learn from the experience of others. For this purpose, it seems a good idea if there is some European body that collects the practical experience of various European police forces with enforcement activities and that makes this knowledge freely available by modern technological means (internet, electronic helpdesk etc.).

Enforcement guidelines.
It was pointed out that enforcement guidelines for police operations in the streets are very important for the quality of the actual police work. The organisation TISPOL is investigating whether European guidelines can be established.

Clear responsibilities of parties involved in road safety or enforcement activities.

The traffic police have a very specific responsibility in road safety or enforcement projects. However, other parties (road authorities, Government, crash-registration agency) are also involved in road safety work. The specific responsibilities of the partners in a project should be clear. In the Czech Republic, for instance, the traffic police are almost solely held responsible for all matters involving road safety. Clearly, too much responsibility is loaded on the shoulders of one organisation. Well-defined responsibilities ensure that every partner can be specifically held accountable for a specific performance. It was indicated that the police should not only be adviser but also be held directly responsible for certain outcomes.

There should also be qualitative targets, e.g. perceived environmental quality.
Not all qualities can be measured objectively.

7. Best practice examples

This section presents two best practices in the field of police enforcement, one from the United Kingdom and one from Australia/New Zealand. These two practices have been chosen because the United Kingdom and Australia/New Zealand have demonstrably achieved good results with enforcement. Also, in both practices the success can be attributed to a continuing and close cooperation between police, local government, and researchers, with a consistent focus on improving enforcement practices and learning from the past rather than just continuing fixed routines. In several evaluation and policy reports the policing practices in United Kingdom and Australia/New Zealand have been clearly described.

Best practices can show us what works well in a given system or context. However, it should be kept in mind that key elements of best practices are rooted in a specific legal, cultural and organizational tradition/context. It would be a mistake to assume that separate success elements of a strategy can simply be 'copied' to another country. Each country should for itself seek the best ways to apply or adapt the success factors in other countries to its own particular traffic system and traffic culture.

Further best practices in the areas of speed and traffic enforcement can be found in Lynam et al.[42] OECD/ECMT [49] and SUPREME [61][62].

7.1 United Kingdom

Organization
In the UK, camera enforcement is organized by partnerships between police, local authorities and the court [12]. These partnerships not only look at speeding but also at red light running. The cameras are called safety cameras; the partnerships are called safety camera partnerships. The objectives of Safety Camera Partnerships are to reduce death and serious injury by reducing the level and severity of speeding and red light running. The aim is to do this by preventing, detecting and enforcing speed and red light offences using, but not limited to, camera technology and driver education programmes. Some partnerships also include road safety engineering as a method of contributing to the aim. The programme is part of the UK government's Road Safety Strategy that seeks a 40% reduction in fatalities and serious injuries by 2010 and a 50% reduction in fatalities and serious injuries of children (compared to the average of 1994-1998).

Effects
Gains et al. [25] evaluated the Safety Camera Partnerships in terms of driving speed and crashes. They included 38 areas where a Safety Camera Partnership had been running for at least one year. The main results were as follows:

- Vehicle speeds went down. Vehicle speeds dropped by around 6% following the introduction of cameras. The number of cars exceeding the speed limit was reduced by 31%. At fixed camera sites this was 70%; at mobile camera sites 18%. The proportion of vehicles speeding excessively (i.e. by more than 15mph (24 km/h)) fell by 91% at fixed sites, and by 36% at mobile sites.
- Both casualties and fatalities went down. After allowing for the long-term trend, but without allowing for selection effects (such as regression to the mean) there was a 22% reduction in personal injury collisions at camera sites; the number of fatalities and severely injured decreased by 42%.

- There was a positive cost-benefit of around 1:2.7. In the fourth year, the benefits to society from the avoided injuries were around £258 million (€ 369 million) compared to enforcement costs of around £96 million (€137 million).

Success factors
Success factors for the camera safety partnerships were [42]
- Evaluation of both the effectiveness of management and financial control, and the effectiveness of crash reduction.
- Extension of trial partnerships programmes to general implementation.
- Sustained debate among researchers to establish conclusive evidence of effectiveness.

Procedures and guidelines
Each year, a Safety Camera Partnership has to submit its plans for the following year to the Department for Transport for approval. These plans detail the activities the Partnership proposes to undertake. Once being approved, the Partnership publishes its plans and makes sure that the location details of fixed cameras are made available to both the public and local media.

The Department for Transport issues an annually updated handbook, which contains clear rules and guidelines covering where and how safety cameras should be placed, and measures to be taken to ensure that drivers are aware of them (published on Department for Transport under the Road safety area). The handbook states, for example, that fixed cameras must be located only at sites where there have been at least four crashes per km involving fatalities or seriously injured casualties in the last three years. Additional sites may be considered after all possible sites meeting this criterion have been dealt with. All safety cameras should be bright yellow to ensure maximum visibility. The Department for Transport is now undertaking a review governing the use of mobile speed cameras. The Association of Chief Police Officers has asked for the review because they think the current guidelines are too restrictive. One relaxation being considered is to extend the maximum distance covered by mobile camera sites from 5 km to 20 km.

Funding mechanisms
The Partnerships are funded on a 'cost recovery' basis through money raised from fines. This money is reinvested into the road safety camera programme. The partnerships will only be reimbursed enough to cover the programme costs, including facilities and equipment costs as well as public information campaigns. The remaining fine revenues go to the National Treasury. The Partnerships do not make a profit; they have been set up as a transparent way of taking the funds from fines and using them to prevent collisions. There is no incentive to place cameras other than to improve road safety.

Public acceptance
Local and national surveys conducted during the Partnership programme showed a generally positive attitude by the public to the use of safety cameras for targeted enforcement. However, there is an indication of some decline in support [42] (Table 4). The Department for Transport has responded by providing information on its website clarifying the rules governing the implementation of cameras and their use. The Parliamentary Advisory Committee on Transport Safety has also published a leaflet to dispel the negative myths about the use and effectiveness of cameras.

Statement about speed cameras	1998	2003	2004-2005
Cameras are intended to encourage drivers to stick to limits, not to punish them	83	80	76
Fewer collisions are likely to happen on road where cameras are installed	67	72	68
Cameras are an easy way of making money out of motorists	45	45	52
Cameras mean that dangerous drivers are more likely to get caught	78	68	61
Use of safety cameras should be supported as a means of reducing casualties	-	-	79
The primary aim of cameras is to save lives	-	-	68
There are too many safety cameras in our local area	-	-	22

Table 4. Percentage of drivers answering yes to statements (Source: Lynam et al., 2005).

7.2 Australia and New Zealand

Organization

In November 2001, the Victorian Government started the arrive alive!-road safety strategy with the aim of having reduced road trauma by 20 percent in 2007 (http://www.arrivealive.vic.gov.au/). Under this programme speed enforcement efforts were increased, with more mobile speed camera hours, new fixed speed camera locations and a reduction in the enforcement threshold. In Victoria, the four government agencies that form the "road safety partnership" are VicRoads, Victoria Police, the Department of Justice and the Transport Accident Commission (TAC). Each agency has specific responsibilities in the area of speed enforcement, but many of these responsibilities are undertaken in consultation or in partnership with the other road safety partners, local government and non-governmental organisations.

In New Zealand, the National Road Safety Committee (NSCR) is the principal inter-agency forum for communicating and agreeing top level strategy between agencies on matters related to road safety [41]. The Secretary for Transport, the Commissioner of the Police, the Chief Executives of Land Transport New Zealand, the Local Government New Zealand, the Crashes Compensation Corporation and Transit New Zealand all participate in this committee. The Director General of Health, the Secretary for Justice, and the Secretary for Labour are associate members. The Road Safety to 2010 strategy indicates the direction for road safety in New Zealand and describes the road safety targets for 2010.

Effects

Evaluation of the Victorian road safety strategy by the Auditor General Victoria showed favourable results [2]. In the years 2002-2005 there was a reduction in fatalities of around 16%, and approximately 8% in serious injuries. Many factors contributed to these changes, but it is very likely that reduced travel speeds have been a major contributor. The most significant trauma reductions were obtained in metropolitan Melbourne's low speed zones, where fatalities decreased by around 40% and serious injuries by 15%. This reduction corresponded with a reduction in free travel speeds in these zones. Travel speeds in both metropolitan Melbourne and country 100 and 110 km/h speed zones remained relatively stable over time, and likewise the trauma reductions on these roads were small. Finally, there have been large decreases in fatalities and serious injuries for pedestrians, where urban speeds are a major determinant of severity.

Overtly operated mobile speed cameras have been used in New Zealand since late 1993. Their operation has been confined to specific sites (called 'speed camera areas') which are mainly road

sections with a record of speed-related crashes. A trial of hidden speed cameras began in mid-1997 in 100 km/h speed limit areas in one of New Zealand's four Police regions. Although motorists could not see the cameras, publicity and warning signs alerted them that they were entering a speed-camera zone.Keall et al. [39] found an additional reduction of mobile inconspicuous cameras of 17% for injury crashes (not significant) and 31% for casualties in a 2-year period (significant), as compared to a conspicuous camera programme only, running elsewhere in New Zealand. In that study, the generalized effects of the extra hidden camera programme (extending to the whole trial area containing (publicly) open rural roads, including roads with and without conspicuous camera operations) were estimated as an 11% reduction in crashes and a 19% reduction in casualties (both significant).

Success factors

In Australia and New Zealand, speed enforcement activities are performed by partnerships between national, regional and local agencies that all have an interest in road safety. According to the association of Australian and New Zealand road transport and traffic authorities [3] the following elements of speed enforcement are very important for success:

- Finding a balance between crash based, intelligence driven targeted operations, and managed targeting to wider areas in a random nature. A complete reliance on a targeted approach to a small number of selected sites is not desirable since it will lead to predictability and lack of general deterrence. Monitoring performance and outcome measures. Recommended performance measures are the number of vehicles checked, total hours of enforcement, number of separate speed checks and number of locations checked per exposure measure (e.g. number of registered vehicles, population size or vehicle kilometres travelled in an area) as well as the number of hours of traffic enforcement conducted by specialised traffic personal or general duties police, also per exposure measure. Recommended outcome measures are, first, changes in crashes and driving speed, and second, changes in community attitudes and infringement rates. When assessing changes in crash rates, the contribution of other initiatives besides speed enforcement should be recognised, although quantification may not be possible. When looking at changes in crash rate, one would also need to take account of changes over time in crash reporting rates between jurisdictions
- To support enforcement operations by public campaigns. Public education campaigns are an effective means of heightening the impact of enforcement and an essential part of winning support for speed enforcement activity. Campaigns have to be carefully thought out in terms of current community perceptions, the target audience, attitudes and beliefs, the previous history of the issue, and the available time and resources. One single message should be delivered in each campaign. Pretesting can help to ensure that the right message is being delivered in the right format.
- To apply penalties that reflect community views on the seriousness of offences. Demerit points are an effective deterrent for speeding motorists. Loss of licence is an effective deterrent for excessive speeding.

Procedures and guidelines in New Zealand

The Safety Administration Programme (SAP) is the primary planning and funding programme for road safety activity undertaken by the New Zealand Police, Land Transport New Zealand and community groups [41]. In their annual programme, the SAP details specific projects, their objectives and the performance measures against which their result is to be assessed. The SAP is collaborative (built on strong partnerships nationally, regionally and locally), evidence-based (driven by analysis of comprehensive road safety data) and accountable (detailing desired outcomes and quantitative and qualitative performance measures).

The SAP plans and allocates resources for strategic enforcement at the national level, and is directly inspired by a risk targeted road policing model. The annual SAP and the risk targeted road policing model are elaborated on the local situation by way of quarterly/biannual road safety action plans (RSAPs). In general RSAPs:

- Are based on data from all key partners
- Are outcome focused, have local targets
- Set out responsibilities and contributions of all parties

- Have evidence based performance measures
- Include community, local and national campaigns

The RSAPs are implemented through crash books and risk targeted patrol plans. Crash books provide long-term risk profiles of roads and areas and risk target patrol plans allocate strategic enforcement hours by location and time. They are instruments to ensure that enforcement is directed toward higher risk locations, behaviour and times to maximize its effect.

In the area of speed control the SAP outlines the following desired outcomes:
- For rural roads with a speed limit of 100 km/h: a mean speed of 99 km/h and a 85th percentile speed of no more than 107 km/h
- For urban roads with a speed limit of 50 km/h: a mean speed of 55 km/h and an 85th percentile speed of no more than 61 km/h.

Qualitative performance measures are the extent to which speed control output is in accordance with the RSAPs and RTPPs, the satisfaction of local authorities and regions with police consultation process in the development of the RSAPs and RTPPs, the attention for targeted issues, and the percentage of road users who believe there is a high probability of detection of speeding.

Public acceptance
In Victoria, telephone surveys in 1999 and 2002 asked licensed drivers to report on their knowledge of and attitudes towards speed enforcement methods, specifically speed cameras [57].
On the positive side, from 1999 to 2002, fewer drivers reported that they often drove 5-9 km/h over the speed limit, fewer drivers agreed with the statement 'There's not much chance of being caught speeding' and more drivers reported knowledge of the facts that speed cameras operated from different cars and that speed cameras did not always operate from a fixed location. Better knowledge and better compliance with speed limits did not go hand in hand with more positive attitudes towards speed cameras. On the contrary, there was an increase in agreement with the statement that speeding fines were only for revenue raising purposes. In 2002, 71% of the sample reported that speeding fines were mainly for revenue raising. The researchers attribute this negative development to 'propagation of comments in the media supporting this idea'.

In 2007, 75% of New Zealand adults agreed with the statement 'Enforcing the speed limit helps to lower the road toll' [45]. In 2007, 61% agreed or strongly agreed with the statement 'Using speed cameras helps lower the road toll'. This has fluctuated around 60% in the years after 2001. 64% agreed that 'the way speed cameras are being operated is fair'. Also, 63% said they supported or strongly supported the use of hidden cameras. Support for hidden cameras increased from 56% in 2004, when the question was first asked.

Rule 9:
Cooperation and partnerships between police, local authorities and data experts provide the best guarantee for problem-oriented, outcome-focused and evidence-based speed policing operations.

8. Future possibilities for speed enforcement

8.1 Relationships between speed enforcement and new technologies

The (near) future will bring new technologies that may affect speed enforcement operations, such as black box technologies, Intelligent Speed Assistance (ISA) or Electronic Vehicle Identification [24]. The questions is how these new technologies relate to the more conventional ways of speed support and control, such as changes to road environment and police enforcement. According to Wegman and Goldenbeld [67] there are three possible, non-exclusive, relationships:

1. New technologies co-exist with conventional measures. While cars are increasingly being equipped with new technologies, police checks of speeding may continue or even intensify.
2. New technologies are integrated in existing measures and make them more efficient. For example, enforcement may increasingly use information from EVI and as such support enforcement operations.

3. New technologies do something existing measures cannot do and will tend to replace conventional methods. For example, when a car is equipped with a black box that monitors driving speed, speed enforcement can be done at all times and places.

Zaidel [72] sketches a Utopian view in which speed enforcement by the police is largely replaced by speed enforcement based on technology. According to Zaidel, this could be realised if:

- Speed compliance is associated with the vehicle rather than a driver
- In-vehicle devices and communication technology monitor vehicle speed at all times and keep a record of distance travelled while speeding
- Vehicles owners are given redeemable credits for distance travelled at requested speed and are surcharged for distance travelled while speeding
- Companies and fleet owners are evaluated by authorities with respect to the aggregated speeding performance of their vehicles; and
- A marketing mechanism is created whereby non-speeding generates direct and indirect benefits to vehicle owners as well as to businesses.

The advantages of this system of speed control, as stated by Zaidel, are that it is self-enforcing, fair, self sustainable, provides immediate feedback and reduces the need for conventional speed control. However, there may be some doubt as to whether the general public would welcome such a system.

8.2 Black box

Black boxes can monitor and store various driving behaviours, including steering movements, accelerating and decelerating and also driving speed. Theoretically and technically it would be possible to compare the information of the speed limit in force and the actual driving speed and use this as a source of information for detecting and enforcing speed limit violations.

The European SARTRE survey showed that 28% of more than 24,000 interviewed drivers were "very much" in favour of black box systems that would provide evidence about speeding or dangerous behaviour for enforcement [55]. An expert workshop organized by the ESCAPE-consortium identified the following preconditions for increasing the acceptance (by agencies and the public) of 'intelligent', vehicle-based enforcement systems such as the black box [44]:

- A Europe-wide registration of car owners
- Vehicle owner responsibility
- Decriminalisation of most traffic offences or administrative law
- Assurance to the public that the hidden purpose is not revenue making
- Fully automated detection and processing of violations
- Modern digital and wireless technology
- Warning before intervention or recording of offence
- Consideration of duration and frequency of individual’s non-compliance
- Transparency of controlling strategy, use of revenues, etc
- Extra benefits for vehicle owners (e.g. theft protection), drivers (e.g. navigation) and road operators (e.g. better traffic management)
- Research to prove the effects on safety.

8.3 Electronic Vehicle Identification (EVI)

Electronic Vehicle Identification (EVI) is a system that uniquely identifies a vehicle electronically. More specifically it can be defined as an electronic device that allows the unique, remote and reliable communication of identifying parameters of a vehicle [24]. It would typically comprise a secure in-vehicle data storage element, suitable and secure interfaces and a vehicle-to-infrastructure data communication element. EVI can be used for many application such as crime prevention (prevention vehicle theft), vehicle tolling, access control (e.g. overview of cross border traffic). It can also be used for enforcement purpose, not only of speeding, but also of red light running and tail gaiting.

8.4 Intelligent Speed Assistance (ISA)

Intelligent Speed Adaptation (ISA) is an in-vehicle system that uses information on the position of the vehicle in a network in relation to the speed limit in force at that particular location. ISA is meant to support drivers and help them to comply with the speed limits everywhere in the network. In that way ISA aims to prevent speeding violations (see also the ERSO text on Speeding).

If large scale voluntary adoption of ISA will reduce the bulk of speed violations, this not only supports speed enforcement but may shift the emphasis of enforcement from general deterrence to specific deterrence. Instead of keeping speeds of the general driving public down - a task then taken over by generally accepted technology - the police can focus more on detecting extreme or repeated speed offenders.

Rule 10:
To the extent that new technologies facilitate voluntary speed control, police speed enforcement can direct itself more at detecting extreme or repeated speed offenders.

9. In conclusion: Ten Rules of speed enforcement

Rule 1:
To maximize the road safety effects, traffic law enforcement should first and foremost prevent violations that are proven to be related with the number or severity of crashes.

Rule 2:
To achieve collective safety benefits by reducing speeds, a systematic, integrated speed management policy is necessary. Speed enforcement is one of the elements of an integrated speed management approach.

Rule 3:
Speed enforcement gains in effectiveness if it is targeted towards prioritised roads, situations and times.

Rule 4:
The credibility of traffic enforcement should be part of enforcement policy and is to be considered as an important quality aspect of enforcement.

Rule 5:
Speed camera enforcement should be used for a large concentration of traffic crashes at high-volume traffic locations. Physical policing can be a good alternative to safety camera enforcement when crashes are scattered, and provided operations are randomised and applied to a large part of the network.

Rule 6:
To increase its effectiveness, speed enforcement must be supported by setting safe and credible speed limits, by publicity, by legislation facilitating effective enforcement, and by appropriate sanctions.

Rule 7:
Alternatives to negative sanctions (such as warning letters, educational courses, speed limiters) and the further development of these sanctions merit serious consideration of authorities, practitioners and researchers.

Rule 8:
Speed enforcement operations gain in effectiveness if they have specified objectives and success criteria, and are monitored in terms of both process and product.

Rule 9:

Cooperation and partnerships between police, local authorities and data experts provide the best guarantee for problem-oriented, outcome-focused and evidence-based speed policing operations.

Rule 10:
To the extent that new technologies facilitate voluntary speed control, police speed enforcement can direct itself more at detecting extreme or repeated speed offenders.

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