REDUCING TRAFFIC INJURIES RESULTING FROM EXCESS AND INAPPROPRIATE SPEED

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The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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Executive summary

1. The influence of speed as a factor in accidents and injury

Speed is at the core of the road accident problem because higher speed reduces the time available to avoid collision and makes the impact in a collision more severe. Environmental damage from exhaust emissions and traffic noise are also greater at higher than at moderate speeds. Speed management is therefore required to balance these disadvantages with the shorter journey times offered by higher speeds.

Research and international experience show that the frequency and severity of accidents tend to decrease with decreases in average speed. A 1 km/h decrease in average traffic speed results typically in a 3 per cent decrease in accident frequency. Variation in speed between vehicles within the traffic stream is also associated with accident occurrence.

Accident analysis confirms that the higher the impact speed, the greater the likelihood of serious and fatal injury. For car occupants in accidents with an impact speed of 80 km/h, the likelihood of death is about 20 times that at an impact speed of 30 km/h. For pedestrians, 5 per cent of those struck by a vehicle travelling at 20 miles/h (32 km/h) die, whereas at 30 miles/h (48 km/h) 45 per cent die, and at 40 miles/h (64 km/h), 85 per cent die.

This review draws upon research from many disciplines and best practice internationally to make recommendations to policy makers on ways of reducing the number and severity of casualties in accidents involving excess and inappropriate speed on different types of road.

Excess speed is exceeding the speed limit. Inappropriate speed is driving too fast for the prevailing conditions. These conditions may make it appropriate for drivers to choose speeds much lower than the legal limit.

The scope for savings is indicated by estimates that reducing average speeds by just 5 km/h could save over 11,000 deaths and 180,000 injury accidents annually in the EU. The corresponding extra travel time for a 10 km journey ranges from 1 minute 20 seconds when the original speed was 50 km/h to just 11 seconds when it was 130 km/h.

2. Factors affecting choice of speed

Average speeds of traffic on different kinds of road in different circumstances are the aggregate outcome of individual choices of speed by the drivers using the roads.

The factors that influence choice of speed can be influenced by engineering of roads and their immediate surroundings, by imposing and enforcing of speed limits, and by educating drivers. Because speeds are chosen by individual

drivers, measures to manage speed need to reduce the perceived advantages to them of excess and inappropriate speed, and increase the perceived disadvantages.

3. Design of infrastructure to encourage appropriate speed

Establishing a road hierarchy - Recognising that different roads have different functions and defining a road classification system or hierarchy that takes these into account is an important step towards making road transport more efficient and safer. It helps in the adoption of measures to increase safety, in particular to discourage excess and inappropriate speed.

High speed, high quality roads - No ways are yet known of using design to reduce inappropriately high speeds on high speed roads without being counter-productive to safety. On motorways and expressways, the use and enforcement of general speed limits and the introduction of local, where appropriate variable, speed limits seem to be the only ways to manage speeds.

Single carriageway rural roads - Use of single carriageway rural roads gives rise to many more casualties than does the use of motorways. These roads are of many different types. Consistency and continuity of design is often lacking and there can be large speed differences between different kinds of user. Where redesign is practicable, a range of engineering measures can encourage a steady, safe speed and make hazards perceptible. Elsewhere, speeds lower than the general limits for these roads are often required to increase safety.

Transition from high speed to low speed roads - Transition zones are required on the approaches to towns and villages on busy routes. Design features can be used to produce a cumulative influence on drivers' perception of appropriate speed culminating in a gateway feature marking the start of the speed limit for the built-up area. Other types of transition also require careful management of speed.

Local distributor and access roads - There is a range of well-established techniques to manage speed in urban areas ranging from discouraging traffic from entering certain areas to installing physical speed-reducing measures.

Experience in several EU Member States over the last fifteen years has shown that accident reductions of between 15 and 80 per cent can be achieved by comprehensive treatment of residential areas. Application of speed management measures in such areas throughout the EU could reduce total injury accidents by 5 per cent.

Safety audit - For the functional road hierarchy to be progressively strengthened, each road improvement or construction scheme should be subject to safety audit to check that its design and implementation are consistent with safety principles including encouraging appropriate speed, and safety audit should be extended to existing roads.

4. Speed limits

Research and international experience point to the effectiveness of speed limits, where perceived as realistic by drivers, in reducing the frequency and severity of road accidents and casualties, despite the fact that many drivers exceed speed limits. Speed limits also reduce fuel consumption, emissions and traffic noise.

Speed limits applying to cars on motorways in the EU range from 90 to 130 km/h. On single-carriageway rural roads they are between 70 and 100 km/h. Because much lower speeds are appropriate at particular times and places, these upper limits can usefully be supplemented by variable local speed limits operating in line with weather, traffic and road conditions. On urban roads they are typically 50 km/h with 30 km/h zones becoming common in residential areas. The prevailing levels of speed limits are widely accepted and complement other measures to manage speed.

Speed limits on urban roads are thus effectively harmonised across the EU, but those on inter-urban roads differ widely. A first step towards harmonising them would be for each Member State to impose its own general limit of 120 km/h or less on motorways, where the opportunities for managing speed by road design are least and speeds are highest - though the German Road Safety Council advocates flexible speed regulations on motorways.

5. Technological aids for speed limit enforcement

Speeding offences are the most common type of motoring offence and the perceived and actual risk of being caught is very small. Conventional traffic enforcement alone is insufficient to bring about lasting compliance with speed limits. More recently, technological development has offered new means of enforcement.

Speed camera technology - Experience in several Member States and elsewhere indicates that speed cameras which provide photographic evidence admissible in the courts of the commission of an offence are highly cost-effective. The well-publicised use of such equipment in areas where non compliance and associated accident risk are high has been shown to reduce accidents substantially and to be publicly acceptable. The strong deterrent effect can keep the number of recorded offences within the range that can be dealt with administratively.

Automatic policing system - It would be technically possible to detect traffic violations automatically and either send warnings to the drivers or automatically transfer fixed fines from their accounts, but it is less clear whether this would be politically, socially or legally acceptable.

Vehicle speed limiters - Another technical possibility is to impose the appropriate speed by limiting the speed of the vehicle, as is already being done in respect of international upper speed limits for heavy goods vehicles and coaches. Corresponding action is needed for cars and other light vehicles. Technically more

advanced vehicle speed limiters would be able to adapt the maximum speed to the prevailing conditions. The further development of speed limiting devices should be encouraged.

6. Publicity and education

There is a need through traffic education and driver training to enhance awareness of conditions under which people tend to drive with excess and inappropriate speed and understanding of the consequences of doing so.

Publicity campaigns are necessary to present information on legislative changes such as new speed limits and on new traffic management schemes, to enhance the deterrent effect of police enforcement, and to provide feedback on the effects on safety.

Technology offers the possibility of immediate feedback on inappropriate choice of speed by means of variable message signs which selectively display messages such as "Too fast", possibly accompanied by the vehicle licence number.

7. Recommendations

A range of recommendations are made for action by the European Commission, the European Parliament and Member States:

Implementing known measures

- Encourage identification and reinforcement of the road hierarchy according to functions of different roads, especially roads in built-up areas and single carriageway rural roads, to enable appropriate speeds to be encouraged on each road by physical adaptation backed up by the relevant speed limit.

- Encourage traffic calming in built-up areas, together with the use of 30 km/h or lower speed limits in residential areas where appropriate layouts can be achieved.

- Encourage safety audit of new road construction, road improvement schemes and existing roads.

- Select design speeds for the TERN which are consistent with appropriate speed limits chosen with safety in mind.

- Harmonise general speed limits on motorways throughout the EU by requiring each Member State to impose its own limit of 120 km/h or less.

- Determine an upper limit for the speed of cars and other light vehicles to be imposed by the mandatory fitting of vehicle speed limiters.

- Encourage the use of local and variable speed limits lower than the general limits on motorways and rural roads.

- Encourage international best practice in the enforcement of speed limits, including sharing of experience in order to establish how best to use speed cameras.

- Implement workable imposition of penalties upon nationals of each Member State for violations detected in other Member States.

- Promote information campaigns at the European level on the consequences of excess and inappropriate speed to encourage better understanding of the need for appropriate speed for safety.

- Adopt ECMT guidelines on car advertising.

- Encourage exchange of expertise in speed management among road safety practitioners in different Member States.

Research into further measures

- Continue to monitor actual speeds on roads of various types and attitudes to speed as in the SARTRE study (1993).

- Investigate the effect on accident occurrence of different speed limits for different classes of vehicle and other sources of variation in speed.

- Develop equitable procedures for follow-up of offences detected by speed cameras and analogous technology.

- Experiment with the implementation of Advanced Transport Telematics systems within the vehicle, in the road system and including roadside-to-vehicle communication with a view to achieving appropriate choice of speed.

- Develop more effective driver training to encourage appropriate choice of speed.

- Conduct transnational demonstration projects on infrastructure, enforcement, education, and publicity to encourage appropriate speeds, including use of internationally recognised symbols and images.

1. Aim and scope

The aim of this review is to formulate from international research findings and best practice a set of recommendations to policy makers on actions that could be taken to reduce the number of casualties related to excess and inappropriate speed of motor vehicles on different types of road.

Current knowledge about the influence of speed as a factor in accident occurrence and the resulting degree of injury, the factors which determine drivers' choice of speed, and the current situation in the European Union (EU) concerning the management of vehicle speed are outlined.

State of the art measures for management of speed in order to reduce the number of casualties in road accidents are reviewed, having regard to the associated environmental advantages of appropriate speed, notwithstanding some increase in journey times.

Recommendations are made for action across the EU.

2. The influence of speed as a factor in accidents and injury

Speed is at the core of the road accident problem because the higher the speed, the shorter the time available to avoid collision, and the more severe the impact when collision occurs. Fuel consumption, damaging exhaust emissions and traffic noise are all greater at high speeds than at moderate speeds. The fact that these disadvantages have to be set against the shorter journey times afforded by higher speeds implies a requirement for speed management. This requirement is reinforced by the fact that speeds are chosen by drivers as individuals, and the aggregate of their choices tends to produce higher average speeds than are socially optimal - as research in Sweden (Carlsson, 1976 in Johansson, 1990) has demonstrated. This review concentrates on speed management to reduce casualties, but the fact that it usually also reduces environmental damage and thus contributes to sustainable development and the quality of life makes success in speed management a still more worthwhile goal.

In this review, excess speed is defined as exceeding the relevant speed limit, whereas inappropriate speed is defined as driving at a speed unsuitable for the prevailing road and traffic conditions. This distinction is important because a speed limit only declares higher speeds to be illegal, and it remains for each driver to decide what speed, within the limit, is appropriate.

2.1 Effects of mean speed and variation in speeds upon accidents

Research shows that there is a clear relationship between changes in mean speed and concurrent changes in numbers of accidents. Finch et al. (1994) have brought together evidence about the effects of increases or decreases in average speed on accident frequency on various kinds of road in Denmark, Finland, Germany,

Sweden, Switzerland, the UK and the USA. From this evidence, it can be concluded that a 1 km/h increase in mean traffic speed typically results in a 3 per cent increase in accident frequency, whereas a 1 km/h decrease in mean speed results in a 3 per cent accident reduction.

This finding suggests that if average speeds throughout the EU were to be reduced by 5 km/h there would be about 15 per cent fewer injury accidents or 180,000 in the EU annually (based on IRTAD, 1994).

The effect of mean speed is even greater for fatal and serious accidents. Following raising of the speed limit on rural interstate highways in the USA, an increase of only 2-4 miles/h in mean speed resulted in an increase of between 19 and 34 per cent in fatalities - suggesting that for every 1 km/h change in the mean traffic speed there was an associated change of between 5 and 6 per cent in the number of fatalities on these roads. With speed camera enforcement in London, fatal and serious accidents have been reduced by about 40 per cent as a result of reductions of between 5 and 7 miles/h in mean speeds - a 4 per cent reduction in accidents for each 1 km/h fall in mean speed (Swali, 1993). These results suggest that an average speed reduction of 5 km/h should result in a reduction of about 25 per cent in fatal and serious casualties, or over 11,000 fatal casualties annually in the EU (based on IRTAD, 1994).

Variation in speeds between vehicles within the traffic stream is also associated with accident occurrence. Those who drive much faster or much slower than the average for the traffic stream are found to be more likely to be involved in accidents (Munden, 1967; West and Dunn, 1971). However, this relationship is hard to interpret because of other differences between drivers - for example, high speed drivers tend to be young and perhaps over-confident, whilst slower drivers tend to be older and perhaps over-cautious.

2.2 Speed and severity of injury

There is also a clear relationship between speed and the severity of injury. Accident analysis shows that the higher the impact speed, the greater the likelihood of serious and fatal injury. For car occupants in accidents with impact speeds of 50 miles/h (80 km/h) the likelihood of death is 20 times that of an impact speed of 20 miles/h (32 km/h) (IIHS, 1987). This relationship is particularly critical for the vulnerable road user. Whereas 5 per cent of pedestrians struck by a vehicle travelling at 20 miles/h (32 km/h) die; at 30 miles/h (48 km/h) 45 per cent die, and at 40 miles/h (64 km/h), 85 per cent die (Schweizerische Beratungsstelle für Schadenverhütung, 1976; Ashton and Mackay, 1979).

2.3 Gains and losses from changing speeds

The strong evidence that reducing speed reduces accidents and casualties raises the question whether the gains in safety, taken with the associated environmental advantages, are sufficient to justify the extra journey time resulting from

reductions in speed. Table 1 illustrates the extra time taken for a journey of 10 km as a result of reducing the average speed by 5 km/h.

Table 1: Extra time taken for a journey of 10 km when speed is reduced by 5 km/h

Original speed (km/h)	50	70	90	110	130
Extra time taken (minutes)	1.33	0.66	0.39	0.26	0.18

In the case of reduction of excess speed to levels permitted by the relevant speed limit, society has already decided by imposing the speed limit that the gains in journey-time obtainable by exceeding the limit are not justified in relation to the adverse effects of higher speed, including extra accidents and casualties.

In relation to the alteration of existing speed limits or to appropriateness of speed within the relevant limit, the expected changes in accidents and casualties, in environmental damage and in the quality of life, can be expected clearly to outweigh changes in journey times in appraisal of specific speed management measures.

3. Factors affecting individual choice of speed

The speed at which an individual driver chooses to drive a particular vehicle is the outcome of a complex process involving personal characteristics and circumstances as well as the type of road, its layout and surroundings, the amount and composition of the traffic, and the prevailing environmental conditions. The factors that influence individual choice of speed can be divided into three categories: road and vehicle, traffic and environment, and driver related factors, as in Table 2. The mean and variation of the speed on a particular road are determined by the choices made by all the drivers using it.

Table 2: Examples of factors affecting drivers' choice of speed

Road and vehicle related	**Traffic and environment related**	**Driver related**

Road: width gradient alignment surroundings layout markings surface quality Vehicle: type power / weight ratio maximum speed comfort	Traffic: density composition prevailing speed Environment: weather surface condition natural light road lighting signs speed limit enforcement	age gender reaction time attitudes thrill seeking risk acceptance hazard perception alcohol level ownership of vehicle circumstances of journey occupancy of vehicle

3.1 Road and vehicle related factors

Width, gradient, alignment and layout and their consistency are important determinants of speed choice on a particular stretch of road. They affect not only what is physically possible for a given vehicle, but also what seems appropriate to a driver. The latter is also affected by the surroundings of the road, especially the closeness of tall objects such as trees and buildings, through the rate of stimulation of peripheral vision. Some aspects of the standard of maintenance of the road are evident enough to drivers to affect speed choice, but other aspects that make lower speeds appropriate are not obvious to drivers.

Many journeys include transitions from a stretch of road where higher speeds are appropriate to another stretch where the appropriate speed is much lower, such as driving from a motorway on to a single-carriageway rural road or entering a village from open country. Design of the road and its surroundings can help drivers to make these transitions safely. The scope for traffic control systems to influence speed choice is increasing as technology develops.

Vehicle characteristics also affect speed choice, especially on high-speed roads. Increase in vehicle performance has probably contributed strongly to the long-term upward trend in average speeds on high-speed roads (Heidemann, 1990; ONSR, 1994). Vehicle speed limiters are used to limit the maximum speed of lorries and coaches, but they do not yet adapt to local speed limits or prevailing conditions. Different maxima for different types of vehicle can increase the variation in speeds in the traffic stream.

3.2 Traffic and environment related factors

Choice of speed by drivers of any one kind of vehicle on any one kind of road is influenced by traffic and environmental conditions, such as the amount and type of other traffic on the road, the prevailing speed of the rest of the traffic, the weather and light and surface conditions, signs warning of potential hazards, and speed limits and their enforcement.

It is very important that warning signs are placed and speed limits set so that they are perceived by drivers to make sense. For all but the highest speed limits, this means that the design of the road and the setting of the speed limit should be considered together.

3.3 Driver related factors

The actual effects of all the external factors on a particular driver's choice of speed are influenced in turn by motivational factors. Urgency or haste can naturally lead to decisions to drive faster. Other motives for increased speed include thrill seeking and demonstration of vehicle handling at high speed. Such motives often arise from peer group pressure on young drivers' choice of speed and they are still strengthened by car advertisements that emphasise misuse of speed, despite the

1989 ECMT resolution recommending that national governments should to take measures against advertising that conflicts with road safety (ECMT, 1989).
Closely related to all this is the distinction between perceived and acceptable levels of risk at different speeds in various situations. The acceptable level of risk depends partly on personal characteristics and partly on ad hoc decisions, for instance to try to arrive on time after an unexpected delay. The perceived level of risk depends among other things on previous experiences in risky situations, in particular personal experience or experiences of close associates with accidents, near misses or enforcement. If negative consequences of excess or inappropriate speed have not been experienced, a driver's perceived risk is lower and the choice of high speeds may easily become habitual. For example, drivers have been observed to approach bends on narrow roads, where they have regularly experienced no oncoming traffic, at speeds which would make a collision with any oncoming vehicle unavoidable (Svenson, 1978). Both perceived and acceptable levels of risk may be affected by alcohol.

An important short-term effect upon speed choice is the phenomenon of speed adaptation, where extended periods of travel at high speed typically lead to underestimation of actual speed. In one study, four hours driving at 70 miles/h led drivers to underestimate their speed by over 33 per cent (Schmidt and Tiffin, 1969).

3.4 Implications for speed management measures

Choice of speed by an individual driver can thus be seen as determined by a strongly subjective weighting of the advantages and disadvantages of different speeds, based on needs, motives, and real or perceived possibilities, in the light of personal characteristics, experiences, habits and social norms. Measures to manage speed can only be effective if they affect the weighting of advantages and disadvantages in such a way that the advantages of excess and inappropriate speed decrease and the disadvantages increase. Infrastructure design, speed limits and their enforcement, and education, training and publicity are approaches that can be used to influence one or more of the factors determining drivers' choice of speed.

4. The current situation concerning speed management

Speed enters explicitly into the design of higher-speed roads through the concept of design speed and its implications for alignment. Design for lower speeds on urban roads is more a matter of detailed layout within an alignment determined by other considerations. Regulation of speed is by general speed limits for broad categories of road, supplemented by local and variable speed limits. Speed limits are enforced by a range of techniques, and violations that are detected and followed up lead to various penalties in different Member States of the EU. Compliance with speed limits is poor.

4.1 Design speeds and general speed limits

The design speed for a stretch of road can be defined in general terms as the highest speed that can be maintained there safely and comfortably when traffic is light. The exact definition in engineering terms differs from country to country, as do the values specified in design standards for the main types of inter-urban road. The range of values found in Member States (including those expected to join the EU in January 1995) are as follows.

Motorways:	100 - 140 km / h
Expressways*:	80 - 120 km / h
Single carriageway rural roads:	50 - 100 km / h

* usually high-speed dual carriageways with less restricted access than motorways

The general speed limit for cars on urban roads is effectively harmonised at 50 km / h throughout the EU. On inter-urban roads the ranges of general limits for cars are as follows.

Motorways*:	90 - 130 km / h
Expressways*:	90 - 120 km / h
Single carriageway rural roads:	70 - 100 km / h

* No general limit in Germany

These speed limits and the design speeds for inter-urban roads are shown in Appendix 1. It can be seen that for inter-urban roads the design speeds and general speed limits for cars are broadly consistent.

In most countries, general speed limits for all types of roads are set by national governments. Different local limits are either local, regional, or national decisions. In some countries local and regional proposals in certain categories have to be approved by the national government. On motorways and rural roads, maximum speed limits lower than those for cars generally apply to cars with trailers, buses and heavy commercial vehicles, and limits for the last two are being harmonised. In built-up areas, however, speed limits for these types of vehicles are identical to those for cars.

4.2 Enforcement and compliance

Techniques used to enforce speed limits range from car-following and radar measurement to speed cameras, laser devices and measurement from helicopters. In some Member States the driver must be identified before a penalty can be imposed, in others the owner of the vehicle is liable.

In most countries the penalty for a first offence is a modest fixed fine, but higher fines can be imposed in some countries by the courts. Several Member States have penalty points systems under which repeated proven speeding offences lead to disqualification from driving. A problem of equity arises from the fact that the enforcement agencies in any one Member State can find it more difficult to impose penalties on drivers from other Member States than on its own citizens.

Notwithstanding these enforcement techniques and penalties, compliance with general speed limits is poor, as is illustrated in Table 3. Speed limits are often exceeded with relatively little public disapproval of speeding. Drivers themselves readily admit to exceed the speed limit. This was found, for example, in a survey of young drivers in Spain (Martinez et al., 1990), and among a sample of UK drivers: 85 per cent reported exceeding the speed limit when the road is quiet and clear (Carthy et al, 1993).

Table 3: Percentage of cars exceeding general speed limits in different countries

	50 km/h* urban roads	**80/90 km/h rural single carriageway**	**100/110 km/h expressways**	**100-130 km/h motorways**
Denmark (Danish Rd Dir, 1994)		67		40
Finland (Mäkinen, 1990)		52	23	15
France (ONSR, 1994)	64	58	44	40
Great Britain (DoT, 1993)		7	39	56
Ireland (Crowley, 1991)		36		
Netherlands (SWOV, 1994)		40		20 / 55**
Spain (DGT, 1993)	71	16	22	25

* Monitoring of local 30 km / h limits in residential areas in Germany found 74 per cent of cars exceeding them (Blanke, 1993), and that of local 30 and 40 km / h limits in Catalonia 97-98 per cent (GdeC, 1992 / 1993).

** 20 per cent where the limit was 120 km / h and 55 per cent where it was 100 km / h

In the cross-national SARTRE survey (1993), 4.5 per cent of the drivers reported exceeding the speed limit in residential areas often, very often or always. For main urban roads, local rural roads, main rural roads and motorways the percentages were respectively 8, 10, 20 and 28. This survey also found that 36.5 per cent of the drivers enjoy driving fast, whereas only 4.1 per cent enjoy taking risks, indicating that driving fast is not seen as risky. Nevertheless more than three quarters of the respondents judged driving too fast to be often, very often or always an accident cause. As such, inappropriate speed was seen as the second major accident cause, just behind excess alcohol.

5. Ways of encouraging appropriate choice of speed

Ways of improving the unsatisfactory current situation in the EU concerning management of speed will now be discussed under the headings of infrastructure design, regulation and enforcement, and education, training and publicity. Measures of these three kinds are closely related in their effects, and need to be implemented in an integrated way so that they reinforce one another.

5.1 Infrastructure design to encourage appropriate choice of speed

Each road has its own mixture of functions. Taking account of different road functions by defining a road hierarchy is an important step towards the management of speed to make road transport more efficient and safer.

5.1.1 Road classification in relation to driving speed

At present, many roads in the EU are multifunctional and used by pedestrians and different types of vehicle users with substantial differences in speed, mass of vehicle and degree of protection. In many residential areas and on many main urban roads this produces an imbalance between the mobility of motor vehicle users and the safety of pedestrians and cyclists.

A road hierarchy can be established according to functions, taking account of land use, location of accidents, vehicle and pedestrian flows, and safety objectives including management of speed. This helps in the detailed design of each road to increase safety, in particular by encouraging appropriate choice of speed.

In a such system three main traffic functions can be distinguished:

- *Flow function*: allowing efficient throughput of traffic. Quality of flow is helped by continuity of design characteristics making higher speeds appropriate.

- *Distributor function*: making residential and other areas easily accessible. Quality of distribution is helped by intersections and connections, which give rise to discontinuities in flow and make relatively low speeds appropriate.

- *Access function*: allowing properties along the road to be reached. Frequent and diverse accesses and the proximity of surrounding development make low speeds appropriate.

Motorways perform exclusively the flow function, and this function predominates on other main inter-urban roads and on a few main urban roads such as ring roads. The distributor function is important in all extensive built-up areas, and access is necessary for all properties.

Besides these traffic functions urban roads can also have functions as places for other activities, for example a residential function. On roads in residential areas and town centres, activities take place which have nothing to do with transport, such as playing, shopping and entertainment. Especially low speeds are appropriate there to give pedestrians, playing children and cyclists the right level of protection.

Regarding the traffic and other functions, four safety principles are crucial:

- prevent use that does not match the functions for which the road is designed;

- prevent conflicting movements except at low speeds;

- prevent uncertainty amongst road users as to the traffic-related behaviour that is appropriate for them; and

- match apparent risk to actual risk.

Where a road performs a mixture of functions, the appropriate speed is normally the lowest of the speeds appropriate to the individual functions. The design of the road concerned should unambiguously and consistently indicate this speed to the user and the speed limit should be set accordingly. Compliance will then be the natural choice for most drivers.

In many situations this means that existing roads serving mainly a flow function should be relieved of all other functions, whereas roads serving mainly access or residential functions should be relieved of flow and distributor functions. Inconsistencies between design and function should be minimised and where they occur they should be properly signed. A Dutch study concluded that a reduction of more than one third in the average number of injury accidents per million vehicle-km driven on all types of road in the Netherlands could be achieved in these ways (SWOV, 1993).

5.1.2 Speed management measures according to road functions

5.1.2.1 High speed, high quality roads

High-speed high quality roads are usually constructed as multilane motorways or expressways. They are designed to carry traffic over longer distances and to provide acceptably short travel times both for passenger cars and heavy vehicles. They therefore perform the flow function and the design allows for high speeds. But inappropriately high speeds, for example speeds which exceed the road's design speed, should be avoided for safety reasons. European countries (except Germany) therefore have general speed limits of between 90 and 130 km/h on motorways.

It is often thought that the geometric characteristics of a motorway affect drivers' choices of speed. In reality, however, there is no strong relationship between geometric design and the speeds chosen by drivers on motorways (e.g. Durth et al, 1987). Curves and narrow lanes have some downward influence on chosen speeds, but the net effect of each on safety is negative. In particular, tight curves are the reason for many accidents, particularly single vehicle accidents. There is thus no known way in which infrastructure design can be used to reduce inappropriately high speeds on high quality high speed roads without being counter-productive to safety. Separate lanes for slower vehicles, e.g. climbing lanes, can, however, help to reduce the problem of variation in speed.

On expressways and motorways, the use of general speed limits and the introduction of local, and where appropriate variable, speed limits seem to be the only ways to manage speed. General speed limits can achieve only a reduction of very high speed driving, and even this is hindered by poor compliance (see Table 3) that needs to be improved by greater enforcement. Nevertheless, experience with general limits is that they do reduce accidents and casualties substantially (Finch et al, 1994). Local speed limits displayed by posted or variable message signs and clearly related to the prevailing conditions offer the possibility of more sensitive speed management and higher compliance.

5.1.2.2 Single carriageway rural roads

Single carriageway rural roads include many different types of road, ranging from traditional, winding local roads to modern high quality roads with gentle curves and full cross sections. Use of these roads gives rise to many more casualties than does the use of motorways, both in absolute numbers and in relation to distance driven.

Consistency and continuity of design is often lacking and there can be large speed differences between different kinds of user. For many rural single carriageway roads, therefore, the general speed limits of 70-100 km/h cannot be considered as adequate speed management. Either lower speeds or re-design are required to increase safety.

In case of redesign, a range of engineering measures are available which aim to encourage a steady, safe speed and make hazards perceptible. These have been reviewed recently by the Dutch Ministry of Transport (DVK, 1992) and include

- providing a parallel road for slow moving traffic where appropriate, overtaking lanes and lanes for vehicles waiting to turn across the path of oncoming traffic;

- improving hazard perception by means of road lighting at junctions, roundabouts, improved vertical alignment, advisory speed limits at sharp bends and regular speed limit signs; and

- introducing deterrents to high speed, such as rumble strips.

The review also found that road improvements, particularly widening schemes, when they are not combined with safety measures, may increase accidents.

The most common way of adjusting road design to a particular level of speed has been through design standards, by choosing a design speed and using it in calculating horizontal and vertical curves, the minimum stopping sight distance and the passing sight distance. Of the last two, the former should be maintained along the whole length of the road, whereas the latter need only to be provided on certain stretches accounting for a sufficient proportion of the total length. Occurrence of sight distances between 50 and 100 per cent of the passing sight distance should be minimised (Durth and Levin, 1991).

Geometric design standards, and the assumptions on which they are based, have evolved in order to provide more homogeneous designs and in particular to introduce safety as an explicit criterion in relation to the chosen design speed.

5.1.2.3 Transition from high speed to low speed roads

The transition zone between a high speed and a low speed road or stretch of road presents a difficult speed management problem. Examples are leaving a motorway or entering a winding stretch of road from a long straight. Transition zones located on the approaches to towns and villages on busy routes have been the subject of particular study.

One principle is that measures in such transition zones must be complemented by measures along the through route within the urban area. A second principle is that these measures should be such that they achieve a cumulative effect culminating at a feature called the *gateway* to the town or village. The design problem is that the beginning of the transition zone looks like the adjoining rural road, but the end is generally marked by an abrupt change to the town or village streetscape. The solution relies on a driver's perception of appropriate speed being influenced by the relationship between the width of the road and the height of the nearby vertical elements such as trees and buildings.

Speeds are lower where the height of vertical elements is greater than the width of the road. This can be achieved progressively throughout the transition zone by a combination of carriageway narrowing and the introduction of trees and other vertical elements culminating in the gateway. Such visual measures need to be

supported within the transition zone by an effective speed reduction device, such as a rumble device (Webster and Layfield, 1993).

The gateway itself should mark the entry to the town or village, and should coincide with the start of the town or village speed limit. It should be conspicuous as the most prominent element in the transition zone, and visible over the stopping distance for the 85th percentile of the approach speed.

5.1.2.4 Local distributor and access roads

The development of speed management and traffic calming to deal with inappropriate speed in urban areas has been documented by Kjemtrup and Herrstedt (1992). These techniques comprise traffic management measures ranging from discouraging traffic from entering certain areas to installing physical speed reducing measures including roundabouts, road narrowings, chicanes and road humps (Webster, 1993). Such measures are often backed up by speed limits of 30 km/h, but they can be designed to achieve various levels of appropriate speed (Danish Road Directorate, 1989, 1991, 1993a).

Experience in several Member States over the last fifteen years has shown that accident reductions of between 15 and 80 per cent can be achieved by comprehensive area-wide treatments (Brilon and Blanke, 1993; Herrstedt et al, 1993; IHT, 1990a; CERTU, 1994). The results indicate that application of such speed management measures in urban areas throughout the EU might reduce the total number of injury accidents by 5 per cent.

On local distributor roads different categories of user should be separated where this is practicable. Design should achieve levels of speed that are compatible with local activity, even when there is little traffic.

Access roads and residential areas are often designed to achieve very low speeds. Speed limits in these areas are normally around 30 km/h, but in special cases a speed limit of 15 km/h or even lower (for a woonerf) is prescribed. The limit chosen is always dependent on physical self-enforcing measures to encourage compliance. Measures differ in cost, and the need to treat a vast total area in towns and cities throughout the EU favours inexpensive but effective measures (Engel and Thomsen, 1992).

It is important for local distributor and access roads to be treated consistently with one another and with roads performing predominantly a flow function in the same urban area. This can be achieved by means of a safety management strategy for each urban area as a whole (IHT, 1990a).

5.1.2.5. Local rural

These roads usually serve locally-based traffic in rural areas, but may include access roads for local residents, particularly around large urban areas. The large number of losses of control on these roads indicates inappropriate speed

(SETRA / CETUR, 1992). Junctions should be treated consistently, with visibility not unnecessary impeded. Roundabouts often improve safety. Alignments should, where possible, be homogenous, with a specified minimum visibility on bends, and shoulders provided to enable drivers to rectify losses of control.

5.1.3 Safety audit

For the road hierarchy to be strengthened progressively through adaptation of existing roads and appropriate new construction, each appreciable road scheme should be subject to safety audit (IHT, 1990b; Danish Road Directorate, 1993b; Romano, 1992) to check that its design and implementation is consistent with safety principles. The likely effects of a scheme on choice of speed and the consistency of its design with the speeds that drivers are intended to choose are important aspects of safety audit. The concept is being extended to existing roads.

5.1.4 Special circumstances

Roadworks often require a local speed limit lower than the normal limit for the road concerned. Workers on site as well as the passing traffic are at risk. In bad weather and in darkness the appropriate speed may well be lower than in daylight and good weather. The appropriate speed in freezing weather and in snow depends on the level of winter maintenance. There is evidence (Thoma, 1993) that drivers do not adjust their speeds to match these various circumstances, and variable speed limits implemented by means of modern technology should be used to help to achieve appropriate speeds in such conditions.

5.1.5 Social acceptability of infrastructure measures

Infrastructure measures in residential areas and on other local roads are the ones that affect people's daily lives most closely. Research shows that people appreciate the need for safety measures, including changing road layout to manage speed. In a UK questionnaire survey (Carthy et al, 1993), more than 75 per cent of respondents favoured measures to slow down traffic outside their homes and to prevent motorists from taking short cuts through residential areas. Responses revealed a discrepancy between what is thought to be useful and what is favoured. This discrepancy was largest for the implementation of road humps, but nevertheless, many were in favour of more humps.

When criticism is focused on safety principles it is often because the public feel that work is restricted to road improvements only (Brindle, 1992). More specific criticism can occur when actual schemes affect either people's direct living environment or the irregularly used routes. Other criticism may be directed towards the constraints imposed on drivers of public transport or emergency vehicles. In some cases, criticism may arise from detrimental side effects such as increased noise.

These reactions should not be ignored and previous experience can help to address them (OECD, 1990). Most important is that the local residents and user

groups are involved in any project from the earliest stages to its implementation, so that the objectives of the schemes can be defined, explained and adopted by those who are affected. Apart from safety objectives attention should be paid to protecting social and commercial life and the local environment.

5.2 Regulation and enforcement to encourage appropriate speed

5.2.1 Speed limits and their effectiveness

Speed limits can only address part of the problem of inappropriately high speed, because there will always be conditions under which the appropriate speed is lower than the general or local limit, and exceeding speed limits, at least by a small margin, is widespread.

Nevertheless, international experience of speed limits suggests they have an important role to play in management of speed, especially on those types of road where infrastructure design has limited influence on choice of speed. The imposition or lowering of speed limits has usually reduced the frequency and severity of road accidents, and raising them has usually had the opposite effect. Some examples of experience with changes in speed limits is given in Table 4. Although the change in observed speeds is consistently less than the change in the limit, the effect on fatalities is clear.

There is a consensus that drivers are more inclined to keep to the posted speed limit when they perceive the speed limit as being realistic for the road concerned. It is difficult to offer a precise rule about setting speed limits, but research indicates that drivers' choice of speed is dependent on the relationship between the design speed on the road and the posted limit.

One way which modern technology offers for keeping speed limits realistic under changing conditions is the use of variable message signs to indicate different speed limits at different times on the same stretch of road. Such a system on an Autobahn near Frankfurt reduced casualties by more than 40 per cent over a period in which they increased on other comparable stretches (Hessische Strassenbauverwaltung, 1991). The speed-reducing capacity of variable speed limits appeared to be largest if the reason for the current limit is indicated in the form of warning or advice (Tenkink, 1988 in Rooijers et al, 1992).

Table 4: Examples of effects of changes in speed limits (From: Finch et al, 1994)

Date	Country	type of road	limit change	speed effect	fatalities
1985	Switzerland	Motorway	130 km/h⇒ 120 km/h	5 km/h decrease in mean speeds	12% reduction
1985	Switzerland	Rural roads	100 km/h⇒ 80 km/h	10 km/h decrease in mean speeds	6% reduction
1985	Denmark	roads in built up areas	60 km/h⇒ 50 km/h	3 - 4 km/h decrease in mean speeds	24% reduction
1987	USA	Interstate Highways	55 mph ⇒ 65 mph	2 - 4 mile/h increase in mean speeds	19-34% increase
1989	Sweden	Motorways	110 km/h⇒ 90 km/h	14.4 km/h decrease in median speeds	21% decrease

5.2.2 Enforcement and associated publicity

Speeding offences are the most common type of motoring offence and are committed regularly by many drivers with very small perceived or actual chance of being caught. Police enforcement is an important way of encouraging compliance with speed limits by increasing the perceived chance of being caught. This is related not only to the actual chance but also to visibility and media coverage of the enforcement activities and personal experience of them (Rooijers et al, 1992).

Numerous studies, (e.g. Vaa, 1993) indicate that conventional traffic enforcement tactics alone are insufficient to bring about lasting compliance with speed limits. Indeed, Scandinavian studies show that in order to achieve an acceptable level of compliance, half of the staff time spent on traffic enforcement would have to be focused on speed (Mäkinen, 1990), which is hardly practicable. However, modern technology now offers new methods.

5.2.2.1 Speed camera technology

Experience in several Member States and elsewhere indicates that speed cameras which provide photographic evidence admissible in the courts of the commission of an offence are highly cost-effective. The well-publicised use of such equipment in areas where non compliance and associated accident risk are high has been shown to reduce accidents substantially and to be publicly acceptable. In West London, results show mean speeds 5-7 miles/h lower and serious and fatal accidents reduced by about 40 per cent (Swali, 1993).

These devices are estimated to cost one-fifteenth of the cost of a single-officer police patrol car and can handle 900 offences an hour in contrast to 5 for the single-officer car, but the administrative and sometimes legal follow-up work is correspondingly increased. Publicity is, therefore, essential to maximise the deterrent effect and prevent overloading of these administrative systems. And the procedures themselves may need to be modified. In the Netherlands, for example, a change in the law has enabled the follow-up of offences such as speeding to be extensively computerised, enabling half a million cases of excess speed on motorways to be followed-up in 1993, more than 80 per cent of them detected by cameras. The use of cameras will be most cost-effective and is likely to be most acceptable to the public if it is concentrated where the occurrence of accidents related to excess speed is highest, but experience needs to be gained and shared in order to establish how best to use camera technology (CSS, 1993).

5.2.2.2 Automatic policing

The least staff-intensive form of enforcement would be a fully automatic policing system that detects traffic violations by comparing the motion of each vehicle with its current situation and either sends warnings to the drivers or automatically transfers fixed fines from their accounts. Although this is technically possible, it is less clear whether it would be politically, socially or legally acceptable

(Rothengatter, 1991, 1994). A less radical step would be to require every vehicle to carry a device which would record its speed just before any collision.

5.2.2.3 Vehicle speed limiters

As well as simply encouraging appropriate speed, which still involves choice by the driver, it is also possible to impose the appropriate speed by limiting the speed of the vehicle - as the maximum speeds of coaches and heavy lorries are already being limited. In a separate report (ETSC, 1993) on the role of car design on reducing traffic injuries, ETSC has recommended further study to establish appropriate maximum speed and performance limits for cars in the EU in relation to driver and vehicle capabilities and to road design speeds. In addition, it is important to test the implementation of intelligent speed control technology, adjusting a vehicle's speed capabilities not only to the speed limit in any given area, but also to the prevailing road and traffic conditions. Such technology could in principle address the problem not only of excess speed but also of inappropriate speed within the speed limit.

5.2.3. Social acceptability of regulation and enforcement measures

There seems to be a general consensus across the EU for a speed limit of 50 km/h on urban main roads without special facilities for vulnerable road users, and strong support in some Member States for a limit of 30 km/h in residential streets. The cross-national SARTRE survey (1993) found that 67 per cent of respondents thought that 50 km/h or lower was desirable in urban areas in general (between 48 and 91 per cent in individual Member States). On average, 28 per cent thought that a maximum limit of 30 km/h was desirable in residential areas (between 7 and 68 per cent in individual Member States). Almost 80 percent of the respondents favoured a harmonised speed limit of 50 km/h in towns (between 62 and 90 per cent in individual Member States).

For motorways, 57 per cent were in favour of a harmonised speed limit of 120 km/h (between 30 and 78 per cent in individual Member States). Only 7 per cent of the respondents were in favour of having no speed limits at all on motorways, and even in the former West Germany only 30 per cent were in favour of this. Although the German Road Safety Council advocates flexible speed regulation on motorways, as indicated in the statement in Appendix 2, a first step towards harmonising limits on inter-urban roads would be for each Member State to impose its own general limit of 120 km/h or less on motorways, where the opportunities for managing speed by road design are least and speeds are highest.

In general it can be concluded that the principle of speed limits is accepted by the public, but the desired levels of limit on inter-urban roads differ appreciably between countries.

Acceptability of police enforcement of speed limits has also been studied. A survey in the UK (Carthy et al, 1993) found that one third of respondents were in favour of much more speed enforcement on motorways and another quarter were

in favour of slightly more. For built-up areas 40 per cent thought much more speed enforcement was necessary and another 40 per cent slightly more. The SARTRE survey asked about continuously operating speed limiting devices fitted to cars: an average of 38 per cent were in favour (between 19 and 56 per cent in individual Member States). Limiting the maximum speed of vehicles as part of a European harmonisation policy was favoured by 43 per cent (between 31 and 62 per cent in individual Member States). It can be concluded that measures that take away drivers' opportunity to choose their own speed are not yet as acceptable as police enforcement of speed limits.

5.3 Education, training and publicity to encourage appropriate speed

5.3.1. Traffic safety education and driver training

The effects of traffic safety education in schools or during driver training on later speed choice have not been studied as such. Knowledge, attitudes and risk perception related to alcohol and traffic are, at least in some Member States, included in secondary school curricula. Although it is difficult to assess the effect of this on actual driving separately from those of other measures, public opinion about alcohol in traffic has changed greatly in recent years. Like driving after drinking, excess and inappropriate speed should be considered as anti-social behaviour and there is a need to enhance awareness of conditions under which people tend to drive with excess or inappropriate speed, and understanding of the consequence of doing so.

5.3.2. Publicity

Publicity is one of the few ways to reach adult road users. Rooijers et al. (1992) formulated the goal of publicity regarding speeding as follows (page 15): `to persuade car drivers to change their behaviour by influencing their attitudes, norms and perceived advantages and disadvantages'. An OECD study (1993) has recommended the greater use of marketing and social marketing of traffic safety. Three main forms of publicity can be distinguished: general mass media publicity, localised publicity actions and feedback signs. Publicity directly related to enforcement of speed limits has already been discussed in Section 5.2.2.

General *mass media publicity* on its own without additional enforcement has been shown hardly to affect speed choice (Rooijers et al, 1992). The authors suggest that this is because the safety and environmental benefits of speed reduction are abstract and in the short term not perceptible to the individual, whilst the advantages of driving faster such as lower journey time and greater pleasure, are concrete and direct (See also Clayton, 1990). It is an open question whether mass media publicity can contribute to longer term changes in attitude to speed choice; the prospects of doing so may perhaps be enhanced by emphasising the environmental benefits of appropriate speed, and avoiding encouraging inappropriately fast driving when publicising new high speed roads. Speed management schemes should be publicised just as positively as building of high speed roads.

Local publicity has some influence on speeding if it fulfils a number of prerequisites (Rooijers, 1986):

- the message should consider the characteristics of the target group, including their attitudes and level of knowledge, and have a personal relevance to them;

- for publicity concerned with speeding at a particular site, the message should be given at the site; and

- the difference between target speed and actual speed should not be too large.

Feedback on actual speed can either be individual or collective. An example of individual feedback is a roadside sign that lights up when a vehicle passes too fast, with the message "Too fast", possibly with the licence number of the vehicle. An experiment in the Netherlands found that speed was reduced by 6 km/h and accidents by 35 per cent, and the percentage breaking the speed limit of 80 km/h dropped from 40 to 10 (SWOV, 1994). Advancing technology offers increasing possibilities for providing individual feedback both within and outside the vehicle.

Collective feedback gives information about the average speed of all drivers on a particular stretch of road and the percentage of people who comply with the speed limit. Since people are inclined to conform to the majority the message is most effective if the percentage compliance is high.

5.3.3. Social acceptability of educational measures

There is evidence that the acceptability of educational measures is high, but the effectiveness is considered to be low (Carthy et al, 1993).

6. Recommendations

ETSC urges the European Commission, the European Parliament and Member States to act quickly and resolutely to reduce traffic injuries resulting from excess and inappropriate speed. Where the competence lies rather with national, regional or local government, the European Parliament and the Commission are urged to encourage action by their own example, by issuing guidance, and by means of financial incentives associated with EU funding. The following recommendations are for implementation of known measures and for research into further measures.

6.1 Implementing known measures

- Encourage identification and reinforcement of the road hierarchy according to functions of different roads, especially roads in built-up areas and single carriageway rural roads, to enable appropriate speeds to be encouraged on each road by physical adaptation backed up by the relevant speed limit.

- Encourage traffic calming in built-up areas, together with the use of 30 km/h or lower speed limits in residential areas where appropriate layouts can be achieved.

- Encourage safety audit of new road construction, road improvement schemes and existing roads.

- Select design speeds for the TERN which are consistent with appropriate speed limits chosen with safety in mind.

- Harmonise general speed limits on motorways throughout the EU by requiring each Member State to impose its own limit of 120 km/h or less.

- Determine an upper limit for the speed of cars and other light vehicles to be imposed by the mandatory fitting of vehicle speed limiters.

- Encourage the use of local and variable speed limits lower than the general limits on motorways and rural roads.

- Encourage international best practice in the enforcement of speed limits, including sharing of experience in order to establish how best to use speed cameras.

- Implement workable imposition of penalties upon nationals of each Member State for violations detected in other Member States.

- Promote information campaigns at the European level on the consequences of excess and inappropriate speed to encourage better understanding of the need for appropriate speed for safety.

- Adopt ECMT guidelines on car advertising.

- Encourage exchange of expertise in speed management among road safety practitioners in different Member States.

6.2 Research into further measures

- Continue to monitor actual speeds on roads of various types and attitudes to speed as in the SARTRE study (1993).

- Investigate the effect on accident occurrence of different speed limits for different classes of vehicle and other sources of variation in speed.

- Develop equitable procedures for follow-up of offences detected by speed cameras and analogous technology.

- Experiment with the implementation of Advanced Transport Telematics systems within the vehicle, in the road system and including roadside-to-vehicle communication with a view to achieving appropriate choice of speed.

- Develop more effective driver training to encourage appropriate choice of speed.

- Conduct transnational demonstration projects on infrastructure, enforcement, education, and publicity to encourage appropriate speeds, including use of internationally recognised symbols and images.

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Appendix 1

Design speeds for inter-urban roads and general speed limits for cars in Member states of EU (km/h)

Member State	Motorways		Expressways*		Single carriageway, rural roads		Urban roads
	design speed	speed limit	design speed	speed limit	design speed	speed limit	speed limit
Austria	130	130	100	100	100	100	50
Belgium	120	120	120	90 / 120	100	90	50
Denmark	110-120	110	90-100	90	70-100	80	50
Finland	100-120	100 / 120	80-100	100	80	80	50
France	120	130	60-100	110	60-100	90	50
Germany	100-120	no max.	70-100	no max.	50-100	100	50
Great Britain	120	112	120	112	100	96	48
Greece	120	120	100	100	60	80	50
Ireland	120	112	120	96	100	96	48
Italy		130				90	50
Luxembourg		120				90	50
Netherlands	120	120	120	100	80-100	80	50
Portugal	120-140	120	90-120	100**	variable	90	50**
Spain	120	120	120	120	variable	90 / 100	50
Sweden	130	100		90 / 110		70 / 90	50

* Usually high speed dual carriageways with less restricted access than motorways

** In force as from 1 October 1994

Appendix 2

Opinion of the German Road Safety Council concerning the regulation of speed on motorways

For some time it has been observed that a marked and constant rise in the frequency of accidents on German motorways has been accompagnying an increase in the volume of traffic. As a result, the debate about introducing speed regulations on motorways has been rekindled.

The German Road Safety Council (DVR) is of the opinion that a decisive criterion for road safety on all roads, i.e. including motorways, is driving at appropriate speed. The German Road Safety Council therefore advocates a flexible speed regulation for motorways, which will encourage people to drive at appropriate speeds depending on traffic density, weather conditions and the time of day, by means of speed guidelines adapted to the prevailing conditions.

Moreover, flexible speed regulations allow more efficient use of existing road capacity by maintaining the flow of traffic. Estimates predict a 10 to 15% increase in utilization of capacity. Previous experience of flexible speed regulations shows that they can indeed achieve both effects, i.e. reduction of the frequency of accidents and of traffic jams. Conversely, international experience of fixed speed limits reveals that they do not automatically lead to the appropriate behaviour desired by legislators. Furthermore, fixed speed limits are ill-suited to promoting appropriate driving behaviour since they tend to encourage drivers to exploit the limit to the full.

The costs of establishing a comprehensive system of flexible speed regulation should be compared with the impact on accident trends and road capacity described above. Hardly any other measure is capable of attaining similar effects within such a comparatively short time. To this end, a graduated programme should be introduced, whereby electronic systems should first of all be established on notorious accident blackspots, e.g. areas prone to traffic jams and major building sites.

Whenever guidelines pertaining to traffic volume or weather conditions do not apply, the opportunity should be taken to apply the recommended speed of 130 km/h. This will be a constant reminder to keep to the recommended speed limit.

A comprehensive, flexible speed regulation inevitably increases road-users' alterness and makes them deal consciously with the different road conditions. Ultimately, this is expected to lead to increased understanding and acceptance, and thereby change road users's behaviour. All measures aim to make people aware of the constant need to adjust their driving speed to a level appropriate to the prevailing conditions.

Besides the road safety aspects, the German Road Safety Council is also aware of the environmental aspect in the current debate on driving speeds, and therefore in the interests of finding an integral solution of the problem anticipates an approach which will involve all policy areas and take all the relevant factors into consideration.

Deutcher Verkehrssicherheitsrat e.V., 1991, confirmed 1994